4.5 Bimetallic traps of same capacity are acceptable in place of Balanced Pressure Thermostatic traps but not vice versa. Suitability of trap for design conditions shall be ensured.

5.0 DOCUMENTATION

5.1 No documents shall be submitted with the offer.

5.2 Detailed dimensioned cross section drawing with parts, materials, weight, etc. shall be submitted through EIL eDMS for records/information.

6.0 TESTS AND INSPECTION

6.1 IBR steam traps shall be hydrostatically tested as per IBR regulations (latest edition). Other steam traps shall be hydrostatically tested to twice the design pressure for which the traps are suitable. For air traps test pressure shall be 1.5 times the design pressure.

Hydrostatic testing of assembled SS/CR Manifolds and Compact Steam Trap Assemblies shall be as per MR or at two times the design pressure, if not specified in MR.

Test pressure shall be maintained for a sufficient length of time not less than 10 minutes. Test pressure shall be released only after physical checking of all the joints and attachments are completed, to permit thorough inspection of all joints and connections for leakage or signs of failure. Any joint found leaking during a pressure test shall be retested to the specified pressure after repair.

Seat leakage for all valves shall be performed as per BS EN-12266-1. Leakage rate shall be category-A.

6.2 In case cast material is specified for trap in the datasheet, radiography of trap shall be as follows:

a. For carbon steel and stainless steel upto Class rating 300, 10% of traps shall be radiographed, with a minimum of one number against each type, size, rating and material.

b. For all ratings in alloy steel and Class rating 600 and above in carbon steel/stainless steel, traps shall be 100% radiographed.

6.3 Radiography of BW joints shall be as follows :

a. For carbon steel and stainless steel upto Class rating 600, 10% of joints shall be radiographed, with a minimum of one number against each type, size, rating and material. Joints for weld-on flanges shall be 100% radiographed.

b. For all ratings in alloy steel and Class rating 900 and above in carbon steel/stainless steel, BW joints shall be 100% radiographed.

6.4 Positive Material Identification (PMI) shall be performed as per the scope and procedures as defined in the 'Standard Specification for Positive Material Identification (PMI) at Supplier's Works' (No. 6-81-0001).

6.5 Test reports shall be supplied for all mandatory tests as per the relevant material specifications/requisition. Test reports shall also be furnished for hydrotest and any other supplementary tests as specified in the requisition.

6.6 Material test certificates (physical properties, chemical composition & heat treatment report and any other testing as per MR) of the pressure containing parts shall be furnished for the steam traps supplied. Material test certificates for the other parts shall also be furnished for verification during inspection.

6.7 EIL/Client's authorised representatives reserve full right to witness stagewise inspection of all mandatory/applicable supplementary tests. However, for IBR items, the tests/inspection shall be by IBR authority or IBR authorized representative.

6.8 Refer Specification 6-81-0134, 6-81-0004, 6-81-0005 for Inspection & Test Plan for Steam Traps, Valves and Fittings respectively.

7.0 MARKING AND DESPATCH

7.1 Vendor shall securely attach on the body a metal tag stamped with item code, Tag no. (If mentioned in requisition), size, rating and special conditions like 'IBR'. Wherever nameplate is provided, marking can be done on the same. Direction of flow shall be marked integrally on the body.

7.2 Paint or ink for marking shall not contain any harmful metal or metallic salts such as zinc, lead or copper which cause corrosive attack on heating. IBR traps shall be painted with red stripes (25mm width).

7.3 All items shall be dry, clean and free from moisture, dirt and loose foreign material of any kind.

7.4 All items shall be protected from rust, corrosion and mechanical damage during transportation, shipment and storage.

7.5 Rust preventive on machined surfaces to be welded shall be easily removable with a petroleum solvent and shall not be harmful to welding.

7.6 Each end of trap shall be protected with the following materials :

Flange Face	:	Wood or Plastic Cover
Bevelled End	:	Wood or Plastic Cover
SW & SCRD End	:	Plastic Cap

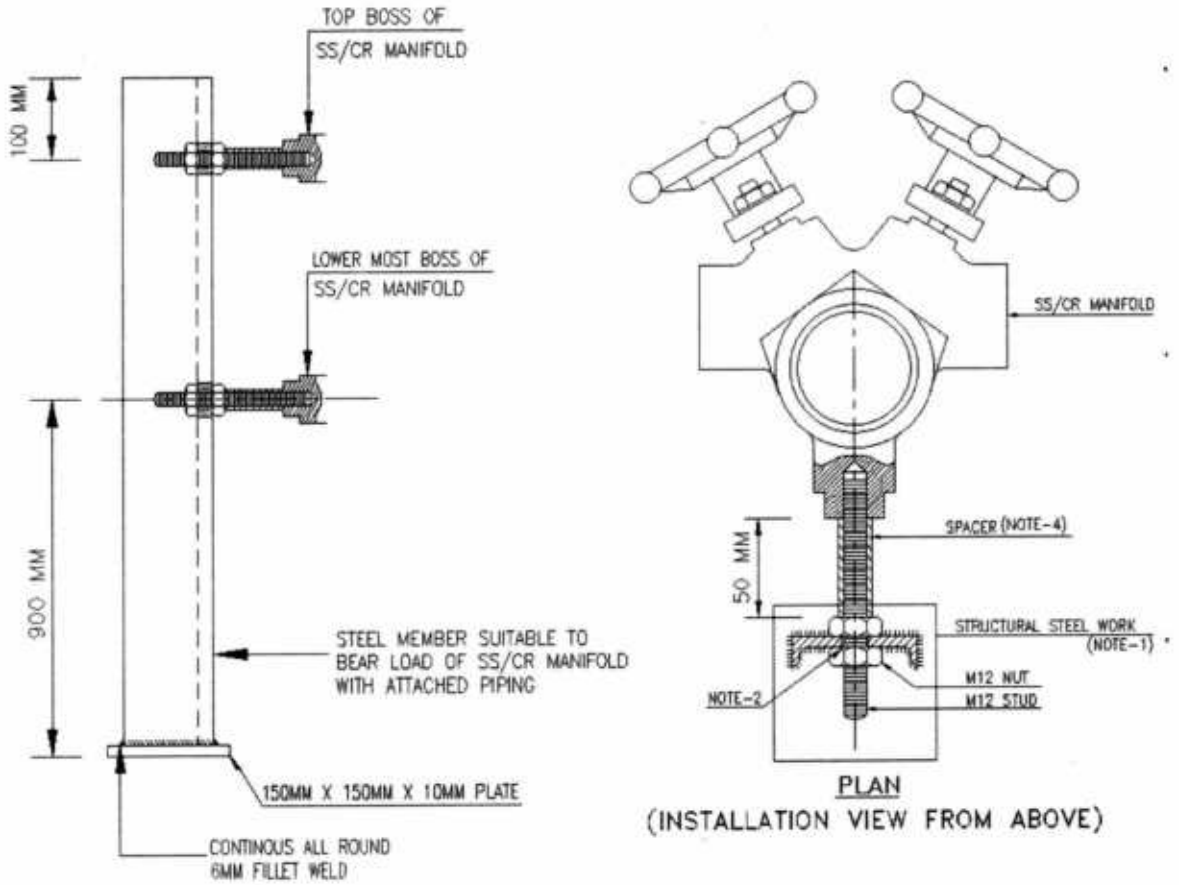
7.7 End protectors of wood / plastic to be used on flange faces shall be attached by at least three bolts and shall not be smaller than the outside diameter of the flange. However plastic caps for SW & SCRD end steam traps shall be press fit type. End protectors to be used on bevelled end shall be securely and tightly attached.

8.0 ATTACHMENTS FOR MR

Format No3-16-43-0094	:	Data Sheet for Steam Traps
-	:	Job Specific Process data sheet for Process steam trap/Air trap (as applicable)

9.0 REFERENCES

6-81-0001	:	Specification for PMI at Supplier's Works
6-81-0004	:	Inspection and Test Plan for Valves
6-81-0005	:	Inspection and Test Plan for fittings
6-81-0134	:	Inspection and Test Plan for Steam Traps
6-78-0001	:	Specification for Quality Management System Requirements from Bidders
6-44-0066-A1	:	Supporting arrangement for SS/CR manifolds



NO. OF CONNECTIONS	NUMBER OF SUPPORTING STUDS	THREADED CONNECTIONS TO BE USED	DIA OF OPENING IN SUPPORTING STEEL (EXCEPT FOR TOP MOST STUD) (NOTE-2)
04	2	TOP MOST	--
		LAST	M12+3 MM
08	2	TOP MOST	--
		LAST	M12+4 MM
12	4	TOP MOST	--
		THIRD	M12+3 MM
		FOURTH	M12+4 MM
		LAST	M12+6 MM

NOTES:

1. Support steel, base plate, studs, nuts, spacer shown in above detail is in vendor's scope of supply along with SS/CR manifold.
2. Except for topmost support, openings in structural steel shall be larger than the supporting stud (Refer table above).
3. Material of studs & nuts shall be ASTM A193 GR. B7 and A194 GR. 2H respectively.
4. Spacer may be cut from 0.5 Inch pipe.
5. Base plate & structural steel material shall be IS-2062.

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TECHNICAL NOTES FOR STRAINERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	05.04.2022	REVISED AND ISSUED AS STANDARD SPECIFICATION	PK	SH	GB	SM
2	20.01.2020	REVISED AND ISSUED AS STANDARD SPECIFICATION	PK	SH	MI	RKT
1	23.09.2014	REVISED AND ISSUED AS STANDARD SPECIFICATION	SH	AK	RN ATD	SC
0	29.06 2009	ISSUED AS STANDARD SPECIFICATION	PK	RN	SC	ND

Abbreviations:

AARH	:	Arithmetic Average Roughness Height
AISI	:	American Iron and Steel Institute
ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
BW	:	Butt Weld
DP	:	Dye Penetrant
FLGD	:	Flanged
FN	:	Ferrite Number
H2	:	Hydrogen
HAZ	:	Heat Affected Zone
IBR	:	Indian Boiler Regulations
MOC	:	Material of Construction
MP	:	Magnetic Particle
NACE	:	National Association of Corrosion Engineers
PMI	:	Positive Material Identification
SCRD	:	Screwed
SW	:	Socket Weld
UNC	:	Unified Coarse
WN	:	Weld Neck

Piping Standards Committee

Convenor : Mr. G. Balaji

Members :
Mr. Udayan Chakravarty
Mr. R. Giridhar
Mr. K. Anjaneyulu (S&ME)
Mr. S. Ghoshal (SMMS)
Mr. S.C. Maity (Structural)
Mr. G.K. Iyer (Projects)
Mr. P.K. Rai (Construction)

CONTENTS

1.0 PURPOSE & SCOPE

This specification covers the design and construction, IBR requirements, documentation, testing, inspection, marking and despatch requirements for Strainers. Vendor shall supply Strainers in accordance with the technical notes and details specified in the Data Sheet for strainers. Supplier shall strictly comply with MR/PR stipulations and no deviations shall be permitted. Post order Concession/ Deviation as mentioned in Cl. 5.17 of Specification for Quality Management System Requirements from Bidders (6-78-0001) is not applicable.

2.0 DESIGN & CONSTRUCTION

2.1. All codes and Standards for manufacture, testing and inspection etc. shall be of latest editions.

2.2 The material of construction shall be as per the data sheet. The internals specified in the strainer schedule shall include mesh and mesh frame. Supporting attachments that are welded to the body shall have metallurgy equivalent to body. For parts not mentioned in the data sheet, vendor shall guarantee the material used for the service conditions specified.

For flanged strainers, MOC of end flanges shall correspond to the material specified in the Data sheet.

For welding of dissimilar materials required for strainer assembly, welder qualification procedure shall be done prior to welding.

2.3 The material composition, physical properties, heat treatment, mandatory test reports, dimensions and tolerances shall confirm to the applicable codes/standards/specifications as specified in the requisition.

2.4 Design shall be based on EIL Std 7-44-0300 for temporary strainers, EIL Stds7-44-0303/0304 for T-type permanent strainers and Manufacturer's std. for Y-type strainers.

2.5 Dimension Standards for various components are as follows:

Body	-	ASME B16.9/B16.11
Flanges	-	ASME B16.5/B16.47 Series B
Gaskets	-	ASME B16.20/B16.21
Bolts & Nuts	-	ASME B18.2.1 & B 18.2.2 respectively

2.6 Ends of body shall either be Flanged, BW, SW or Screwed as specified in the data sheet.

2.6.1 The ends for strainers shall correspond to the following standards:

FLGD	-	ASME B16.5/B16.47 Series B
BW	-	ASME B16.25
SW	-	ASME B16.11
SCRD	-	ASME B16.11

2.6.2 Bevel end details for BW strainers shall be as per ASME B16.25. Contour of bevel end shall be as follows:

Material	Wall Thickness	Weld Contour
Carbon Steel (Except Low Temp. Carbon Steel)	Upto 22 mm	Figure 2 Type A
	> 22 mm	Figure 3 Type A

Material	Wall Thickness	Weld Contour
Alloy Steel, Stainless Steel & Low Temp. Carbon Steel	Upto 10 mm	Figure 4
	> 10 mm &Upto 25 mm	Figure 5 Type A
	> 25 mm	Figure 6 Type A

2.7 Flange face finish shall be normally specified in the strainer data sheet. The interpretation for range of face finish shall be as follows:

Stock Finish	:	1000 µ in AARH max.
Serrated/Smooth Finish/125AARH	:	Serrations with 125 to 250 µ in AARH
Extra Smooth Finish/63 AARH	:	32 TO 63 µ in AARH

2.8 For strainers with ring type joint flanged ends the hardness shall be as follows:

Flange Material	Min. Hardness of Groove (BHN)	Max. Gasket Hardness (BHN)
Carbon Steel	140	90
1% Cr to 5% Cr, 9% Cr	150	130
Type 304, 316, 321, 347	160	140
Type 304L, 316L	150	135
Inconel UNS N06625	220	200
Incoloy UNS N08825	210	190
Duplex SS UNS S32205, UNS S31803	250	230

2.9 For strainers with flanged ring type joint ends, the hardness shall be recorded in the test report.

2.10 Ends of screwed strainers unless otherwise specified shall have taper threads as per ASME/ANSI B1.20.1 (upto 1.5" NB) & IS 554 (for 2" to 6" NB).

2.11 All 2" and higher size Y type strainers shall be provided with 3/4" screwed plug for drain connection. For less than 2" this shall be 1/2" size.

For Y type, SW end Strainers (size 1.5" & below) to MNF`STD, blind end is also acceptable with threaded plug cover instead of flanged end. In this case, plug shall be of forged material equivalent to body material.

2.12 For Y type strainers, cast strainers with integrally cast flanges and with end cover / blind flange in cast/forged construction is acceptable.

2.13 For flanged end strainers, weld-on flanges(WN) are acceptable.

2.14 Pressure drop calculations shall be furnished by vendor along with the offer, wherever specified in the data sheet.

2.15 Stainless Steel Strainers

2.15.1 All Austenitic Stainless Steel items shall be supplied in solution annealed condition.

2.15.2 For all Austenitic Stainless Steel items Inter-granular Corrosion Test shall be conducted as per following:

- ASTM A 262 Practice 'B' with acceptance criteria of '60mils/year (max.)'

OR

- ASTM A262 Practice E: The bent specimen shall be examined under 20X magnification. The acceptance criteria is that there will be no crack or fissure in the bent specimen. The bent specimen shall also be subjected to metallographic examination at 250X magnification to ensure no crack or fissure. The photograph of the bent specimen along with comments shall be submitted for review.

2.15.3 When specifically asked for in MR for High Temp. application of some grades of Austenitic Stainless Steel (like SS 309, 310, 316H etc.) ASTM A 262 practice 'C' with acceptance criteria of "15mils/year" shall be conducted.

2.15.4 All types of SS321 or SS347 material shall be in stabilized heat treated condition. Stabilizing heat treatment shall be carried out subsequent to normal solution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900 °C and 4 hours respectively.

2.16 IBR Requirements

2.16.1 For SW / BW end carbon steel strainers under IBR, the chemical composition shall conform to the following :

Carbon (Max)	:	0.25%
Others (S, P, Mn)	:	As per IBR regulations

2.16.2 Strainers coming under the purview of "IBR" (Indian Boiler Regulations) shall each be individually accompanied by original IBR certificate in Form III-C, duly approved by IBR authority / local authority empowered by the Central Boiler Board of India. Photocopy of original certificate duly attested by the local boiler inspector where the supplier is located is the minimum requirement for acceptance.

2.17 In case of T-type strainer, body construction shall be 'Seamless' unless otherwise specified in the data sheet.

2.18 Welded Tees shall not be of fabricated (Stub-in/stub-on) type.

2.19 Strainers with welded body shall be in normalized condition& 100 percent radiographed by X-ray.

2.20 All 1Cr-0.5Mo & 1.25Cr-0.5Mo strainers shall be normalized and tempered. All 2.25Cr-1Mo, 5Cr-0.5Mo, 9Cr-1Mo & 9Cr-1Mo-V welded strainers shall be normalized and tempered & 100 percent radiographed by X-ray.

2.21 Weld joints shall be stress relieved as per the requirement specified in the Strainer MR Attachment.

2.22 NACE/HIC Requirements

2.22.1 Strainers under "NACE" category or those designated as "HIC1" shall meet the requirements of NACE MR-0103 unless otherwise specified.

2.22.2 Strainers made from plates and designated as "HIC1" shall meet the HIC requirements of EIL specification 6-79-0013 unless otherwise specified.

2.23 Strainers of Hydrogen service category shall meet the requirements as specified in clause 4.0 below.

2.24 Galvanized strainers shall be coated with zinc by hot dip process conforming to IS 4736 / ASTM A153.

2.25 Gaskets

2.25.1 Non-metallic gaskets shall conform to B16.21 (corresponding to B16.5) up to 24" and B16.21 (corresponding to B16.47 Series 'B') beyond 24", unless otherwise specified.

2.25.2 Spiral wound gaskets shall conform to B16.20.

2.25.3 Ring type and spiral wound gasket shall be self-aligning type.

2.25.4 Ring Joint gasket shall be Octagonal type and shall conform to B16.20.

2.26 Bolting

2.26.1 All bolts shall conform to B18.2.1, nuts to B18.2.2. Reference shall also be made to B16.5 for studs.

2.26.2 Threads shall be unified (UNC for upto 1"dia and 8UN for > 1"dia) as per ANSI B.1.1 with class 2A fit for studs and M/C bolts and class 2B fit for nuts.

2.26.3 Nuts for Bolts & Studs shall be the American Standard Hexagon Heavy Series.

3.0 DOCUMENTATION

3.1 No documents shall be submitted with the offer.

3.2 Detailed dimensioned cross section drawing with parts, materials, weight, etc. shall be submitted through EIL eDMS for records/information.

4.0 SPECIAL REQUIREMENTS FOR HYDROGEN SERVICE

4.1 Method of Manufacture

4.1.1 All carbon steel strainers having wall thickness 9.53 mm and above shall be normalized. Carbon content shall be limited to .35% max. and silicon .35% max. The normalizing heat treatment shall be a separate heat treatment operation and not a part of the hot forming operation. Normalizing shall be done after final cold draw pass for all thicknesses if cold drawn.

4.1.2 All alloy steel (Cr-Mo) strainers shall be normalized and tempered. The normalizing and tempering shall be a separate heat treatment operation and not a part of the hot forming operation. The maximum room temperature tensile strength shall be 100,000 psig.

4.2 Impact Test

For all carbon steels and alloy steels with wall thickness over 20 mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 per heat of material and per heat treating batch. Impact test specimen shall be in accordance

with ASTM A370. Impact energies at 0° C shall average greater than 27J (20 ft-lb) per set of 3 specimens, with a minimum of 20 J (15ft-lb).

4.3 Hardness of weld and HAZ shall be 200 BHN (max) for carbon steel and 225 BHN (max) for alloy steel.

5.0 TESTING & INSPECTION

5.1 All strainers shall be hydrostatically tested at the lower of twice the design pressure and 1.5 times the class rating as per ASME B16.5 at ambient temperature.

5.2 All BW joints shall be 100% Radiographed and Fillet welds shall be 100% DP/MP checked.

5.3 Positive Material Identification (PMI) shall be performed as per the scope and procedures as defined in the 'Specification for Positive Material Identification (PMI) at Supplier's Works' (No. 6-81-0001).

5.4 All welded Tees indicated in the MR as "Cryo" & "LT" shall meet Impact test requirements of ASME B31.3. The Impact test temperature shall be (-)196°C &(-)45°C for Stainless Steel & Low Temperature Carbon Steel respectively unless otherwise mentioned in the MR.

5.5 The stage wise inspection of non-IBR Strainers shall be done by EIL inspector before despatch. EIL/Client's authorized representatives reserve full right to witness stagewise inspection of all mandatory/applicable supplementary tests. However, for IBR items, the tests/inspection shall be by IBR authority.

5.6 Material Test Certificates (Physical Properties, Chemical Composition and heat Treatment Report) shall also be furnished.

5.7 Test reports shall be supplied for all mandatory tests as per the relevant material specifications/requisition. Test reports shall also be furnished for hydrotest and other supplementary tests as specified in the requisition.

5.8 Refer Specification 6-81-0133 for Inspection & Test Plan for Strainers.

6.0 ACCEPTABLE DEVIATIONS

6.1 Following alternative body materials are acceptable :

- AISI 420/AISI 410/A743 Gr.CA40/A743 Gr.CA15 in lieu of ASTM A105.
- A182 F22 in lieu of A182 F11.
- AISI 420/A182 F11 in lieu of A182 F1.

6.2 Cast strainers with integrally cast flanges are also acceptable in lieu of equivalent forged material. All castings offered in place of forgings shall be radiographed.

6.3 Forgings of equivalent material shall be acceptable in place of castings.

6.4 In the case of T type strainers, 'Seamless' body is acceptable in place of "Welded" body. 'Welded' body shall not be acceptable in place of 'Seamless'.

7.0 MARKING & DESPATCH

7.1 Each Strainer shall be legibly & conspicuously stamped on the body, in accordance with the requirements of applicable standards along with special condition like IBR, CRYO, NACE,

H2 etc. Vendor shall also mark on the body the direction of flow, Location/Tag No. and Line Number mentioned in MR attachment.

7.2 All items shall be dry, clean and free from moisture, dirt and loose foreign material of any kind.

7.3 All items shall be protected from rust, corrosion, and mechanical damage during transportation, shipment and storage.

7.4 Rust preventive, on machined surfaces to be welded, shall be easily removable with a petroleum solvent or shall not be harmful to welding.

7.5 Paint or ink for marking shall not contain any harmful metal or metallic salts such as Zinc, Lead or Copper which causes corrosive attack on heating.

7.6 Strainers under "IBR", "CRYO", "NACE" & "H2" shall be painted in Red, Light Purple, Canary Yellow and sea green strips respectively for easy identification. Width of strip shall be 25 mm. Strainers coming under the purview of "IBR", "CRYO" , "NACE" & "H2"(hydrogen) shall be painted with one circumferential stripe of colour red, light purple brown, canary yellow & white respectively for easy identification. Width of stripe shall be 12mm for sizes less than 3" and 25mm for sizes 3" and above. Stripe shall be located one end near to the bevel/socket/screwed/flanged end.

7.7 After testing, one coat of inorganic zinc silicate (minimum DFT 65 to 75 microns) shall be applied as primer over the external surface for carbon steel / alloy steel strainers.

7.8 Each end of strainer shall be protected with the following materials :

Flange Face	:	Wood or Plastic Cover
Bevelled End	:	Wood or Plastic Cover
SW & SCRD End	:	Plastic Cap

End protectors of wood / plastic to be used on flange faces shall be attached by at least three bolts and shall not be smaller than the outside diameter of the flange. However plastic caps for SW & SCRD end strainers shall be press fit type. End protectors to be used on beveled end shall be securely and tightly attached.

8.0 ATTACHMENTS FOR MR

Format No.3-1643-0093: Data sheet for Strainers

9.0 REFERENCES

6-81-0001	:	Specification for PMI at Supplier's Works
6-81-0133	:	Inspection and Test Plan for Strainers
6-78-0001	:	Specification for Quality Management System Requirements from Bidders

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TECHNICAL NOTES FOR SAMPLE COOLERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	28.03.23	REVISED & ISSUED AS STANDARD SPECIFICATION	PK	SH	GB	SM
2	30.03.18	REVISED & ISSUED AS STANDARD SPECIFICATION	PK	SH	MI	RN
1	21.03.13	REVISED & ISSUED AS STANDARD SPECIFICATION	UK	SH	RN	ATD DM
0	23.07.07	ISSUED AS STANDARD SPECIFICATION	RN	ATD	DM	VC

Abbreviations:

AARH	:	Average Arithmetic Root Height
AS	:	Alloy Steel
ASME	:	The American Society of Mechanical Engineers
ASTM	:	The American Society for Testing and Materials
CS	:	Carbon Steel
DFT	:	Dry Film Thickness
DP	:	Dye Penetrant
eDMS	:	Electronic Document Management System
GTAW	:	Gas Tungsten Arc Welding
MP	:	Magnetic Particle
MR	:	Material Requisition
PR	:	Purchase Requisition
SS	:	Stainless Steel

Piping Standards Committee

Convenor: Mr. G. Balaji

Members:
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Mr. R. Giridhar
Mr. K Anjaneyulu (SMED)
Mr. Rajesh Chitara (SMMS)
Mr. SC Maity (Structural)
Mr. Harsh Vardhan (Projects)
Mr. Pankaj Kumar Rai (Construction)

CONTENTS

1.0 PURPOSE & SCOPE

This specification covers the design, fabrication, documentation, inspection & testing, marking and dispatch requirements for Sample Coolers. Supplier shall supply Sample Coolers in accordance with these technical notes, standards and drawings attached with the Material/Purchase requisition. Supplier shall strictly comply with MR/PR stipulations and no deviations shall be permitted.

All codes and standards for manufacture, testing, inspection etc. shall be of latest editions as on issue date of RFQ.

2.0 DESIGN & FABRICATION

2.1 All codes and standards referred in drawings, documents etc shall be of latest editions on the date of offer submission.

2.2 Material, dimensions and tolerances shall conform to the applicable codes/standards/specifications as specified in the requisition.

2.3 Supplier shall refer Data Sheet for Sample Coolers for additional details not covered in standards/specifications/drawings attached with the requisition.

2.4 Unless otherwise specified dimension standard for end connections shall be as under

Flanged ends	:	ASME B 16.5
Socket Welding ends	:	ASME B 16.11
Screwed ends	:	ASME B 16.11/ASME B1.20.1
Bevel ends	:	ASME B 16.25

2.5 The interpretation for range of face finish shall be as follows:

Stock Finish	:	1000 µ in AARH max.
Serrated Finish/125 AARH	:	Serrations with 125 to 250 µ in AARH
63 AARH	:	32 TO 63 µ in AARH

2.6 Screwed Pipe ends shall have external taper pipe threads conforming to ASME B1.20.1.

2.7 As far as possible, coil shall be made from single straight pipe. However, one butt-weld joint is permitted. Welding shall be done by GTAW process. The AS/CS coil shall be normalized and tempered after bending. Solution annealing for stainless steel coil shall be carried out after bending. The butt welded joint in the coil, if any, shall be radiographed. All other welds shall be 100% MP tested for CS /AS and DP tested for SS components.

2.8 External surface of sample coolers shall be brushed/ mechanically cleaned. After testing, one coat of inorganic zinc silicate (DFT 75 microns) shall be applied as primer over external and internal surface of the shell as well as over the carbon steel / alloy steel coil surface.

3.0 INSPECTION AND TEST

3.1 Material test certificates (Chemical composition, physical properties and heat treatment) shall be furnished for all pressure containing parts. Material test certificates for other parts shall also be furnished for verification during inspection.

3.2 Test reports shall be supplied for all mandatory tests as per relevant material specifications. Test reports shall also be supplied for hydrostatic test and any other supplementary test as specified in the requisition.

3.3 Sample cooler body shall be filled with water and leak tested at ambient temperature. The coil shall be hydrostatically tested at the lower of the pressure specified in Data Sheet for Sample Coolers and 1.5 times the class rating at ambient temperature. In case of SS coil, water used for hydrostatic test shall have maximum chloride content of 25ppm.

3.4 Positive Material Identification (PMI) shall be performed as per scope and procedure as defined in 'Specification for Positive Material Identification (PMI) at Supplier's Works (6-81-0001)' for other than CS components.

3.5 Refer Specification 6-81-0132 for Inspection & Test Plan for Sample Coolers.

4.0 DOCUMENTATION

4.1 No documents shall be submitted with the offer. However, drawings shall be furnished alongwith final documentation for records through EIL eDMS (electronic Document Management System).

4.2 In addition to document submissions through eDMS, 6 hard copies and 2 soft copies (in CDs/DVDs) of the final documentation shall be submitted along with the delivery of items.

5.0 MARKING & DESPATCH

5.1 Each sample coolers shall have corrosion resistant metal tag firmly attached to the body marked with Tag No., Line number, Job No. & P.R. number, coil material & thickness (e.g. ASTM A106 Gr.B, S160) by punching or etching.

5.2 All sample coolers shall be dry, clean and free from moisture, dirt and loose foreign materials of any kind. All nozzles shall be properly closed with wooden plank to avoid ingress of foreign matter. All sample coolers shall be protected from rust, corrosion and mechanical damage during transportation, shipment and storage.

6.0 REFERENCES

Format No 3-1643-0096:	Datasheet for Sample Coolers.
6-81-0001:	Specification for PMI at Supplier's Works
6-81-0132 :	Inspection and Test Plan for Sample Coolers
6-78-0001 :	Specification for Quality Management System Requirements from Bidders
6-78-0003:	Specification for documentation requirements from suppliers

साइटफ्लो संकेतकों (साइट ग्लासेज) हेतु तकनीकी टिप्पणियाँ

TECHNICAL NOTES FOR SIGHT FLOW INDICATORS (SIGHT GLASSES)

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	28.03.23	REVISED AND ISSUED AS STANDARD SPECIFICATION	PK	SH	GB	SM
2	30.03.18	REVISED AND ISSUED AS STANDARD SPECIFICATION	PK	SH	MI	RN
1	21.03.13	REVISED AND ISSUED AS STANDARD SPECIFICATION	UK	SH	RN	ATD DM
0	28.09.07	ISSUED AS STANDARD SPECIFICATION	RN	ATD	DM	VC

Abbreviations:

AARH	:	Arithmetic Average Root Height
ASME	:	The American Society of Mechanical Engineers
DFT	:	Dry Film Thickness
eDMS	:	Electronic Document Management System
MR	:	Material Requisition
PMI	:	Positive Material Identification
PR	:	Purchase Requisition
PWHT	:	Post weld Heat Treatment

Piping Standards Committee

Convenor: Mr. G. Balaji

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CONTENTS

1.0 GENERAL

1.1 Supplier shall supply 'Sight Flow Indicators' in accordance with the Technical Notes and details specified in the data sheet for 'Sight Flow Indicators'. Supplier shall strictly comply with MR/PR stipulations and no deviations shall be permitted.

1.2 All Codes and Standards for manufacture, testing and inspection etc. shall be of latest editions as on issue date of RFQ.

2.0 DESIGN AND CONSTRUCTION

2.1 The 'Material of construction'and 'Type' of Sight flow indicator shall be as per the Data sheet for Sight Flow Indicators (Format No 3-1643-0097).Supplier shall ensure suitability of the material used for the service conditions specified for the parts not mentioned in the datasheet.

2.2 The material composition, physical properties, heat treatment, mandatory tests, dimensions and tolerances shall conform to the applicable codes/standards/specifications as specified in the requisition.

2.3 For cast body 'Sight flow indicators', flanges shall be cast integrally with body. For forged 'Sight flow indicators', weld on flanges (weld neck type) with 100% radiography are also acceptable.

2.4 Sight flow indicators shall be suitable for horizontal as well as vertical flow (from top to bottom as well as from bottom to top) installation.

2.5 Ends shall be as specified in the data sheet. Flanged ends shall be as per ASME B16.5.Flanges shall be either cast integral or butt welded with the sight glass body. Flanged end face finish shall be as specified in the data sheet. The interpretation for range of face finish shall be as follows:

Stock Finish	:1000 µ in AARH max.
Serrated/Smooth Finish/125 AARH	:125 to 250 µ in AARH
Extra Smooth/63 AARH	:32 TO 63 µ in AARH

3.0 TESTS AND INSPECTION

3.1 Sight flow indicators shall be hydrostatically tested for body with glass at a gage pressure no less than 1.5 times the 38°C Class rating pressure as per ASME B16.5.

3.2 Positive Material Identification (PMI) shall be performed as per the scope and procedures as defined in the 'Specification for Positive Material Identification (PMI) at Supplier's Works' (No. 6-81-0001).

3.3 Test reports shall be supplied for all mandatory tests as per the relevant material specifications/requisition. Test reports shall also be furnished for hydrotest and any other supplementary tests as specified in the requisition.

3.4 Material test certificates (physical properties, chemical composition & heat treatment report) of the pressure containing parts shall be furnished for the Sight Flow Indicators supplied. Material test certificates for the other parts shall also be furnished for verification during inspection.

3.5 All butt welded joints shall undergo radiography. All welds for Sight flow indicators for piping classes having requirement of PWHT (as indicated in Data sheet for Sight flow indicators) shall be post weld heat treated as per ASME B31.3.

3.6 Radiography Requirement for Castings:

Sight Flow Indicator castings shall undergo radiographic examination (%) as specified below:

3.6.1 For Hydrogen / Hydrogen bearing Hydrocarbons, Oxygen, NACE services & Stress relieved Piping classes for 150 Cl. Rating & 300 Cl. Rating : 50%.

3.6.2 For LT/CRYO services: 20%.

3.6.3 Radiography requirement for castings for categories not mentioned at 3.6.1 & 3.6.2 above shall be as follows:

Class Rating	Material	Qty
150 &300 (Notes a & b)	All Materials	10%
600 & above	All Materials	100%

Notes:

a) Radiography is not required for
- Category-D services as per ASME B31.3.
- 'Fire water', 'Demineralised Water'&'Cooling water'services

b) For stabilized grades of SS 100% radiography is required for castings of all ratings.

3.6.4 Number of castings to be radiographed shall be minimum one number against each size, rating, material and special requirement (H2, NACE, PWHT etc). Various items from the MR shall be clubbed on this basis and quantities so arrived shall be considered for calculating the number of items which shall be radiographed on the basis of percentage as specified.

3.6.5 Radiography procedure, areas of casting to be radiographed shall be as per ASME B16.34. Radiography shall be done by X-ray/ γ-ray to get the required sensitivity.

3.7 Sight flow indicators specified as 'NACE' shall meet the requirements of NACE MR-0103, unless otherwise specified.

3.8 Refer specification number 6-81-2091 for Inspection and Test Plan for Sight Glasses.

4.0 MARKING AND DESPATCH

4.1 Supplier shall firmly attach corrosion resistant metal tag to the body with details stamped with 'Tag no'.,'line no'., 'size', 'rating' and 'special conditions (wherever specified)' like 'H2', 'NACE' etc. by punching or etching. Marking on name plate instead of metal tag is also acceptable.

4.2 All Sight Flow Indicators shall be dry, clean and free from moisture, dirt and loose foreign material of any kind.

4.3 All items shall be protected from rust, corrosion and mechanical damage during transportation, shipment and storage. After testing, one coat of inorganic zinc silicate

(minimum DFT 70 microns) shall be applied as primer over the external surface for carbon steel/ Low alloy steel Sight flow indicators.

4.4 Rust preventive on machined surfaces to be welded shall be easily removable with a petroleum solvent and shall not be harmful to welding.

4.5 Each end of Sight Flow Indicators shall be protected with the following materials :

Flange Face : Wood or Plastic Cover

End protectors of wood/plastic to be used on flange faces shall be attached by at least three bolts and shall not be smaller than the outside diameter of the flange.

5.0 DOCUMENTATION

5.1 Detailed dimensional drawing shall be submitted for information before start of manufacture. Catalogues/ detailed dimensional drawings giving details of 'Sight Flow Indicator' construction and material specifications for all parts shall be furnished alongwith final documentation for Purchaser's record. Supplier to note that no documents shall be submitted with the offer. All documents/drawings shall be submitted through EIL eDMS (electronic Document Management System)

5.2 In addition to document submissions through eDMS, 6 hard copies and 2 soft copies (in CDs/DVDs) of the final documentation shall be submitted along with the delivery of items.

6.0 REFERENCES

Format No 3-1643-0097:	Data sheet for Sight Flow Indicators (Sight Glass)
6-81-0001:	Specification for Positive Material Identification (PMI) at Supplier's Works.
6-81-2091:	Inspection & Test Plan for Sight Glasses.
6-78-0001:	Specification for Quality Management System Requirements from Bidders.
6-78-0003:	Specification for documentation requirements from suppliers

स्प्रिंग सपोर्ट असैम्बली के लिए तकनीकी टिप्पणियाँ

TECHNICAL NOTES FOR SPRING SUPPORT ASSEMBLIES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	08.01.25	REVISED & ISSUED AS STANDARD SPECIFICATION	PK	SH	GB	MN
3	28.03.23	REVISED & ISSUED AS STANDARD SPECIFICATION	PK	SH	GB	SM
2	30.03.18	REVISED & ISSUED AS STANDARD SPECIFICATION	PK	SH	MI	RN
1	21.03.13	REVISED & ISSUED AS STANDARD SPECIFICATION	UK	SH	RN ATD	DM

Abbreviations:

AS	:	Alloy Steel
ASME	:	The American Society of Mechanical Engineers
ASTM	:	The American Society for Testing and Materials
BS	:	British Standard
CS	:	Carbon Steel
eDMS	:	Electronic Document Management System
IS	:	Indian Standard
MR	:	Material Requisition
SS	:	Stainless Steel

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CONTENTS

1.0 PURPOSE & SCOPE

This document covers supply, material, fabrication, testing and inspection requirements for 'Spring Support Assemblies' with helical, hot coiled & heat treated compression type springs. Detailed design of spring assemblies is Supplier's responsibility. Supplier shall guarantee proper functioning of the Spring Assemblies under specified load & travel conditions. Items not indicated clearly in Supplier's offer but required as per this requisition shall be considered in Supplier's scope of supply. Supplier shall strictly comply with MR/PR stipulations and no deviations shall be permitted.

All codes and standards for manufacture, testing, inspection etc. shall be of latest editions as on issue date of RFQ.

2.0 TECHNICAL REQUIREMENTS:

2.1 Material Requirements:

Unless otherwise specified, the material of construction shall be as follows.

Clamp (CS)	IS 2062 Gr.A/B
Clamp (AS) – Note 1	ASTM A 387 Gr.11/22 or SS 316 / 321.
Clamp (SS)	SS 316 / 321
Lugs (CS) – Note 2	IS 2062 Gr.A/B
Lugs (AS) – Note 3	ASTM A 387 Gr.11/22
Lugs (SS) – Note 3	SS 316 / 321
Protection shield at pipe or elbow	Same as Pipe material specified in Spring Schedule or Equivalent Plate material
Eye rod (CS Forged / Rolled Bar)	IS 1875 Cl-II/IIA / ASTM A 105 / IS 2062 Gr.A/B
Hanger Rod (CS)	IS 1875 Cl-II/IIA / ASTM A 105 / IS 2062 Gr.A/B
Turn Buckle	IS 1875 Cl-II/IIA, ASTM A 105 for sizes $\leq$ M30. For sizes > M30 these may be fabricated type of equivalent material (refer clause 2.8.)
Plates 5, 10, 12, 20, 25 mm etc.	IS 2062 Gr.A/B.
Stud / Bolt for CS Clamps	ASTM A 193 Gr.B7
Stud / Bolt for AS Clamps	ASTM A 193 Gr.B16
Stud / Bolt for SS Clamps	ASTM A 193 Gr.B8
Nuts for CS Clamps	ASTM A 194 Gr.2H

Nuts for AS Clamps	ASTM A 194 Gr.7
Nuts for SS Clamps	ASTM A 194 Gr.8
Spring Coil	BS 970 EN 42, 45-45A, 47, 50 Cr.V4, 51 Cr.Mo.V4, 52CrMoV4, 51CrV4, SUP7 (JIS G 4801) IS-4454 Pt2-Gr.FD-SiCr, BS EN 10089 GR.51CRV4, BS EN 10270-2 FD SiCr, A229/A689 Gr. G6150, IS-4454-Part 1 Gr. SH to be used up to 40 mm coil dia. only.
Casing	IS 1239-1 (Medium) / IS 2062 Gr. A, 5.00 mm thk. (Min.) / API 5L Gr. A/B ERW, 5.00 mm (Min.) / IS 3589 Gr. 330 ERW, 5.00 mm (Min.)
Name Plate	SS / Aluminum
Load Indicator	SS / Aluminum
Welding Electrode	IS 814
Other Bolts / Nuts	IS 1367 Cl. 4.6 / IS 1367 Cl. 4.0
Roller / Ball arrangement (Note – 4)	SS 304 / 316 / SAE 52100

Notes:

1. In case of Alloy Steel Clamps Supplier can alternately supply SS Clamps.
2. Lug material for both pipe side & structure side attachments
3. Lug material for pipe side attachment.
4. Balls shall be provided in a semi encapsulated type enclosure with separators for each ball. The balls shall be protruding above the enclosure so that the pipe support plate rests on the balls & the balls remain at the same location and move on their axis in case of movement of pipe. Sliding of balls in case of pipe movement is not acceptable.

2.2 Design & Manufacturing Requirements.

2.2.1 Design & manufacture of Hot coiled helical compression spring shall be to BS 1726, Part 1 / MSS-SP-58 & ASTM A 125. All requirements of the specification must be met.

2.2.2 Unless otherwise stated all joints shall be of welded construction and shall be in accordance with IS 816 / ASME Sec IX.

2.2.3 All weld sizes shall be 6 mm or 0.8 times the thickness of metal (whichever is more) to be connected.

2.2.4 All bolt holes shall be minimum 2 mm larger than the bolt dia.

2.2.5 All threads shall be metric type to IS 4218 – Standard Coarse Pitch, alternatively ISO Metric threads may be employed.

2.3 The springs shall be coiled, ensuring that the coils are uniformly spaced and are parallel to the axis of the spring.

2.4 The springs shall have their ends ground flat and smooth at right angles to the axes of the springs over the full circumference so that they stand perpendicular when placed on a horizontal plane.

2.5 All springs shall be enclosed in a robust casing of specified material with two 6 mm dia holes or equivalent at lowest point 180 deg apart for drainage.

2.6 The entire spring assembly including attachments & preset locking device shall be designed for 2 times the service load or the hydro test load whichever is higher and shall be of the nut–bolt type for variable spring assemblies and pin type for constant spring assemblies. The springs shall also have suitable features so that they can be locked in any position within the range of load capacity of the hangers.

2.7 Each spring shall be factory preset to the load as per the approved vendor drawing.

2.8 All springs shall be supplied with lengths as specified in the MR. Deviation in lengths is not acceptable. Each Can type spring shall also be provided with a means of adjusting the installed length by a minimum of 25 mm. Rod and turnbuckle assembly shall be designed for +/- 50 mm adjustment over the specified length of spring support assembly. Turnbuckles shall be made from forged material for sizes up to M30 and for sizes above M30 they can be forged type or machined from rolled bar or fabricated type. In case of Can type springs, if required, the specified height may be achieved with the suitable attachments like stools, structural arrangements by the Spring vendor.

2.9 All springs shall have an affixed load and travel plate on which hot and cold positions are clearly marked. The load on the spring at any instant shall be indicated by an integral pointer on a load position plate. Pointers or scales shall be provided on at least two sides of spring to ensure readability from the platform.

2.10 All hanger type spring assemblies shall allow minimum 4 Deg. Horizontal movement of pipe in any direction. For both hanger & can type springs, vendor to ensure that the spring will be suitable for the horizontal movement specified in the spring schedule. Variable springs shall have max 15% load variation on operating load unless otherwise specified. However for constant springs deviation from specified load shall not exceed 5%. Supplier may offer springs with lesser % load variation than specified above. The value of spring constant if specified is the maximum value spring can have. Supplier may offer springs with up to 6% lesser spring constant but not vice versa. Where both preset load & spring constant are specified in MR, the same shall be complied irrespective of maximum % load variation.

2.11 If both upward and downward travel are mentioned in spring schedule, springs shall be designed accordingly considering travel in both upward and downward directions.

2.12 All springs shall be provided with a means of positively and firmly locking the piston plate for hydrostatic testing of the pipe.

2.13 Teflon / Graphite pads for reducing lateral frictional force shall be provided when specified in the requisition. Wherever temperature is greater than 204°C, only graphite pad shall be used. Thickness of Teflon / Graphite pads shall be minimum 10 mm / 12.7 mm respectively. Retainer plate of 8 mm / 10 mm thickness respectively shall be welded around the pads so that the pads are projected minimum 2 mm above the retainer plates. It must be ensured that the low friction material is bonded with the steel base plate and remains in place at the specified load conditions by using suitable adhesives. Adhesives used for pads should be capable of withstanding the line temperatures. Additionally two or more countersunk screws may also be installed to avoid dislocation in case of Graphite pads.

2.14 The hanger support, except for the spring shall be designed with a safety factor of 5.

2.15 All Constant & Variable spring supports weighing more than 45 Kg. shall be provided with lifting lugs.

2.16 All spring coils shall be neoprene or polyeurethane coated to prevent corrosion. Alternatively, equivalent or superior coating of spring coil is also acceptable. However, corrosion protection of spring through electroplating is not acceptable.

2.17 All Alloy Steel Springs shall be shot-peened.

2.18 Springs with free height to mean diameter ratio of more than 4 shall not be used without external guiding arrangements.

2.19 Drawing showing arrangement of spring hangers shall be considered for overall guidance. The individual components shall be designed by the Supplier to meet the requirements of the requisition.

2.20 Protection shield, if indicated in support arrangement drawings, shall be under the supplier's scope of supply.

3.0 PAINTING & GALVANIZING:

The spring support shall be thoroughly scrapped and Wire brushed on all surfaces to remove dust, mill scales etc. All external & internal surfaces other than spring shall be given two coats of Zinc Chromate Red Oxide Primer to IS-2074 followed by intermediate paint of 2 coats of Epoxy-High Build coating cured by polyamide hardener @ 100 microns DFT/coat and finish paint of 1 coat of Acrylic Polyurethane @ 40 microns DFT/coat.Total DFT of the coating system shall be 300 microns minimum. All threaded parts / components shall be galvanized to ASTM A153 / A123 / IS-1573 / IS-1367, Part XIII.

4.0 DOCUMENTATION

4.1 All document submissions to EIL shall be through EIL eDMS (electronic Document Management System)

4.2 After placement of order and before commencement of manufacturing, Supplier shall obtain approval on design calculations and detailed dimension drawings complete with material for different parts only if specified in the material requisition. The detailed dimensional drawing submitted by supplier shall also include individual spring assembly weight. Vendor shall submit drawings unit wise for approval.

4.3 Material test certificates (physical properties) report, Heat treatment report (wherever specified or required as per code) and chemical composition shall be furnished for all materials other than coil. For coil material, chemical composition load travel, cramp test certificate shall also be furnished.

4.4 Test reports for each spring for all mandatory tests and other supplementary tests as specified in the requisition shall be submitted.

4.5 Final Documents to be provided, in addition to submission through eDMS, along with delivery of the springs.

- 2 Hard Copies and 2 Pen drives of As Built drawings of spring assemblies.
- 2 Copies and 2 Pen drive of Catalogues, Operation Manual & Installation Procedure.

5.0 TESTING & INSPECTION

5.1 Testing of springs shall be as per BS-1726 Part 1.

5.2 A compression test shall be made by pressing the spring solid at least three times in succession. The spring should thereafter conform to dimensional requirements.

5.3 A cramp test shall be made by holding the spring compressed to the minimum working compressed length for a period of not less than 12 hours with full load. The spring shall show a reduction of not more than 5% in its free length.

5.4 The manufacturer shall conduct tests to establish the spring rate, and the measurement shall be carried out within 30% to 70% of the maximum travel of the spring (free height minus solid height). The actual load test shall be conducted on the spring supports in the final assembled condition and shall be witnessed by the purchaser's representative.

5.5 All alloy steel springs shall be examined by magnetic particle method.

5.6 Refer Specification no 6-81-0137 for 'Inspection & Test Plan for Spring Support Assemblies'.

6.0 MARKING AND DESPATCH

6.1 In addition to standard marking /stenciling, each spring support shall be marked with MR number and Spring Number / Tag Number by etching or punching on the casing or on a SS/Aluminum tag attached firmly to the support.

Hangers shall be assembled to the degree practical, taking into account shipping and handling limitations,Items separated from the original assembly shall be properly tagged and marked in the packing list clearly as "loose".

6.2 All items shall be dry, clean and free from moisture, dirt & loose foreign material of any kind.

6.3 All items shall be properly packed in Wooden boxes / Crates and shall be protected · from rust, corrosion and mechanical damage during transportation, shipment & storage.

7.0 REFERENCES

3-1643-0717:	Spring Schedule
3-1643-0717A:	Spring Schedule (Spring Support Types)
6-81-0137 :	Inspection and Test Plan for Spring Support Assemblies
6-78-0001 :	Specification for Quality Management System Requirements from Bidders
6-78-0003:	Specification for documentation requirements from suppliers

टैंक बोटम प्लेट के लिए
कैथोडिक संरक्षण प्रणाली विनिर्देशन

SPECIFICATION
FOR
CATHODIC PROTECTION SYSTEM
FOR TANK BOTTOM PLATE

Rev.	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
					Approved by	
1	15.10.24	REAFFIRMED	PTR	NSB	RC	MN
0	15.10.18	ISSUED AS STANDARD SPECIFICATION	PTR	NSB	BRB	RKT

Abbreviations:

AC	Alternating Current
AJB	Anode Junction Box
BS	British Standards
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CIMFR	Central Institute of Mines and Fuel Research
CJB	Cathode Junction Box
CP	Cathodic Protection
CPPSM	Cathodic Protection Power Supply Module
CPTR	Cathodic Protection Transformer Rectifier
CTE	Coal tar enamel
Cu/CuSO4	Copper/Copper Sulphate
DC	Direct Current
ERTL	Electronics Regional Testing Laboratory
FBE	Fusion Bonding Epoxy
HV	High Voltage
HMWPE	High Molecular Weight Poly Ethelene
IS	Indian Standards
$\mu A/mm^2$	Micro-ampere per square millimeter
mA/mm^2	Milli-ampere per square millimeter
MMO	Mixed Metal Oxide
NACE	National Association of Corrosion Engineers
PDB	Power Distribution Board
PE	Polyethylene
PVC	Polyvinyl Chloride
RMU	Remote Monitoring Unit
TSP	Tank to Sand Potential
VDR	Vendor Data Requirement

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CONTENTS

1.0 SCOPE

This specification covers the philosophy to be adopted for the design and engineering of the cathodic protection system for the Tank bottom plate (external surface) including corrosion survey of the electrolyte (sand).

2.0 APPLICABLE CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards as a minimum:

i)	NACE	:	SP0193-2016, External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottom
ii)	BS	:	EN 16299:2016, Cathodic Protection of External Surface of Above Ground Storage Tank Bases in Contact with Soil or Foundations
iii)	VDE	:	0150, protection against corrosion due to stray currents from DC installations.
iv)	IS/ IEC: 60079	:	Electrical Apparatus for Explosive Gas Atmosphere
v)	IS/ IEC: 60529	:	Classification of Degree of Protection Provided by Enclosures
vi)	OISD-GDN-180:		Lightning Protection

2.2 The equipment shall also confirm the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.3 In case of imported equipments, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.4 In case of any contradiction between various referred standards/ specifications/ data sheet and statutory regulations, the most stringent requirement shall prevail and Owner's/EIL's decision in this regard shall be final and binding.

3.0 SYSTEM IMPLEMENTATION

All work to be performed and supplies to be effected as a part of CP system shall require specific review by Owner or his authorized representative. Major activities requiring review shall include but not be limited to those mentioned in vendor data requirement (VDR) form attached with MR/Tender.

4.0 CORROSION SURVEY

4.1 General

4.1.1 The corrosion survey includes the measurement of sand resistivity survey and chemical analysis for design of CP system which shall be carried out by Contractor. The corrosion survey shall also include collection of additional data as required for completeness of the job.

4.1.2 To carry out sand resistivity measurement, Wenner's 4-pin method or an equivalent soil/sand box method approved by Owner/ Owner's representative shall be used. Survey instruments shall have maximum AC and DC ground current rejection feature.

4.1.3 Care shall be taken to ensure that the resistivity readings are not influenced by the presence of foreign structures/piping, and earth currents (if any) etc.

4.2 Report

On completion of all field work, a report incorporating all the results generated from surveys and details of additional data collected (e.g. nearby structures, details of hazardous area classification, location proposed for CPTR units, power source details etc.) shall be prepared. The report shall also contain detailed interpretation of survey results and resistivity data, to form a design basis for cathodic protection. This report shall also include various drawings prepared in connection with the above work. Soil resistivity values shall be plotted on semi-log graph sheets.

5.0 CATHODIC PROTECTION DESIGN PARAMETERS

A distinctly independent impressed current cathodic protection system shall be provided to protect the external surfaces of the Tank bottom plates as specified.

Unless otherwise stated in the data sheets, the following parameters shall be used for design of permanent cathodic protection system:

5.1	Protection Current Density Range	:	10-30 mA/m2 (at 25 ^{0}C operating temperature)
5.2	If operating temperatures of Bullet exceed 25 deg. C, protective current density shall be corrected @ 0.5mA/ m2/ deg. C.		
5.3	Sand resistivity	:	200 Ohm-m
5.4	Tank plate natural potential	:	(-) 0.45 V (w.r.t. Cu/CuSO4 ref. cell)
5.5	Anode	:	Ti-MMO wire anode
5.6	Current capacity of anode	:	30 mA/m (for design purpose)
5.7	Design life of CP system	:	30 years, unless specified elsewhere

5.8	Anode ground bed loop resistance including anode to ground resistance, anode and cathode cable resistances	:	1 Ohm (max.)

5.9 Scheme for Cathodic Protection System of a Tank bottom plate (external surface)

5.9.1 Each Tank bottom plate CP system shall be independent and exclusive. The scheme defined below shall be applicable.

5.9.2 Impressed Current Cathodic Protection (CP) System shall be provided for sand side corrosion prevention of Tank bottom plate.

5.9.3 Anodes employed for CP System of Tanks shall be mixed metal oxide coated on titanium wire anode, piggyback connected with anode lead cable, factory pre-packed with coke breeze.

5.9.4 The anode strings shall be located under the Tank in sand bed. Specific installation requirements of String Anode shall be as follows:

- Anode strings shall be distributed in loops shall be installed in the sand cushion under the tank at a separation distance of 1000mm from the Tank bottom external surface.
- Separation distance between consecutive String anode strings shall be uniform and shall be maximum 1000 mm.
- Two consecutive anode strings shall form a continuous loop.
- Two consecutive anode loops be connected to different AJBs located opposite-along the Tank centreline.
- The above anode distribution is based on the assumption that temperate of the sand at 1000mm distance from tank bottom external surface shall be below 75 deg.C

5.9.5 Highest of number/length of anodes calculated as per design parameters defined under clause 5.1 to 5.8 and that worked out as per clause 5.9.4 shall be provided.

5.9.6 Free ends of each string anode shall be terminated to AJB.

5.9.7 Cathodic Protection Transformer-Rectifier unit (CPTR Unit) of suitable rating (25V/25A or 50V/50A or 75V/75A) shall be installed to energize the anode strings for Vessels.

5.9.8 CPTR Unit shall have two outgoing positive header cables, which shall be terminated to 2 nos. AJBs to be installed on opposite sides of the Tank along its diameter.

5.9.9 CPTR Unit shall have one out going negative header cable, which shall be connected cathode junction box cum test stations (CJB) located at Tank for the drainage connection and potential measurement.

5.9.10 Two drainage cables and two measurement cables from each Tank shall be terminated to its CJB.

5.9.11 Minimum 5 no.s Cu/CuSO4 Permanent Reference cells shall be provided for each Tank which shall be able to measure the complete potential profile of the Tank.

5.9.12 Power supply for the CPTR Unit shall be drawn from the nearest Substation.

5.9.13 The reference cell cables and the measurement cables from each Tank shall be routed through the respective Monitoring Junction Box (MJB).

5.9.14 If required, a MJB may be integrated with CJB and a single/composite Cathode junction box cum Reference cell junction box (CRJB) may be provided.

5.9.15 The CPTR unit shall preferably have the built-in RMU module. In case RMU is not integral part of CPTR unit, then a separate RMU panel may be provided and both the equipments (CPTR Unit and RMU) shall be connected with communication cables for status monitoring and control purpose.

5.9.16 For monitoring of Tank to sand potentials, monitoring cables of reference cells shall be laid between MJB and CPTR unit & RMU. For CPTR unit at least three reference cells shall be connected and for RMU all the Reference cell cables shall be connected.

5.9.17 All Cable laying shall be done on existing cable route which shall be overhead cable trays/ cable trenches wherever possible. Underground Cable laying in paved/ unpaved areas shall be done through RCC trench/directly buried trenches respectively, wherever overhead cable trays/ cable trenches are not available.

5.9.18 Connection of drainage cables and measurement cables to the Tank shall be done by Thermit welding.

5.9.19 Minimum 3 no's of perforated HDPE pipes under the Tank shall be installed for measuring potential using portable reference cells. The HDPE pipes shall be installed at 120^0 apart from each other. The HDPE pipe shall be covered with geotextile cloth and shall be of 75mm diameter, slotted of 50 mm (2 inch) in length 0.15 mm width, 4 kg/cm2 pressure rating, sealed at one end. These HDPE pipes shall be installed perpendicular to each other and at a separation of 300mm from the tank bottom surface.

6.0 CATHODIC PROTECTION DESIGN CRITERIA

Cathodic protection system shall be designed to meet the following criteria:

6.1 The Tank to Sand Potential (TSP) measurements shall be between (-) 0.85V (OFF) and (-) 1.20V (OFF) with respect to a copper/copper sulphate reference electrode.

6.2 A minimum polarization shift of (-) 100 millivolts can be accepted as an adequate level of cathodic protection for the Tank with the approval of Owner in exceptional cases. Discretion to use any of the criteria shall solely rest with owner/owner's representative.

6.3 A positive potential swing of 50 millivolts or more shall be considered sufficient to indicate the presence of an interaction/ interference situation requiring investigation and incorporation of mitigation measures by the Contractor.

7.0 SYSTEM DETAILS

7.1 The system shall include the following major equipment/ sub-systems unless otherwise specified in project specifications:

- Power Distribution Board
- CPTR units.
- Remote monitoring unit
- MMO Anodes
- Anode junction box
- Cathode junction box
- Measurement Junction box
- Permanent reference cells
- Cables

7.2 All equipment shall be new and procured from EIL approved manufacturers. Equipment offered shall be field proven. Equipment requiring specialized maintenance or operation shall be avoided as far as possible. Prototype equipment shall not be accepted.

7.3 All equipment/ materials shall conform to the relevant specifications included in the tender document.

7.4 The CPTR unit and RMU etc. shall be located in safe non-hazardous areas. However all junction boxes shall be flame proof, Temperature class T3 (min.) & suitable for Gas Group specified in datasheet.

7.5 The electrical and electronic equipments installed in hazardous area shall be flame proof type and shall meet the requirements as per IS/ IEC: 60079 and shall be weather proof IP-65 as per IS/IEC:60529.

7.6 Hazardous area certificate from CIMFR or equivalent test house of country of origin, applicable PESO approval certificate, BIS license and original drawings referred in type test certificate shall be shown to the Inspection agency during inspection. The Certificate and BIS license must be valid at the time of dispatch.

7.7 Power Distribution Board

Power Distribution board (PDB) shall be provided incase multiple CPTR units are envisaged. PDB shall be fed through 1 no. 415V±10%, 50Hz±3% TPN feeder from Owner's substation and shall have required no. of outgoing feeder rated for 240V, SPN or 415V, TPN feeders.

7.8 CP Transformer Rectifier Unit

The Cathodic Protection Transformer Rectifier Unit (CPTR unit) shall confirm to the requirements mentioned in datasheet and shall be installed in non-hazardous area as specified in data sheets.

7.9 Anode Beds/Loops

Anodes shall be supplied complete with tail cables, which shall be long enough for termination on their associated anode lead junction boxes without intermediate joints. Exact lengths and termination details shall be indicated in construction drawings.

Potential gradient around the anodes shall be within safety requirements with regard to interference on foreign structures and its effective boundary shall be defined.

7.10 MMO Anodes

Anodes shall be mixed metal oxide coated titanium wire anodes. The MMO wire anodes shall be piggyback connected with anode lead cable, factory pre-packed with coke breeze. The detail specification shall be as mentioned in data sheet.

7.11 Anode Junction Box

All cable tails from individual anodes shall be terminated onto the respective anode junction boxes, which shall be further connected to the positive cable coming from CP power source. Each anode circuit in junction shall have provision for measurement and control of individual circuit/anode current through variable resistors, shunts and links of suitable ratings.

7.12 Cathode Junction Box

Cathode junction box shall be provided near the Tank for connection of the negative drainage cables to the Tank. The negative of the CP power source shall be connected to the incoming circuit of the cathode junction box.

The incoming circuit and each out going circuits shall have provision for measurement and control of current through variable resistors, shunts and links of suitable ratings.

7.13 Monitoring Junction Box

All the reference cells provided under the Tank shall be connected to monitoring junction boxes. Measurement and control cables from monitoring junction box shall be connected to CPTR unit and RMU unit.

7.14 Permanent Reference Cells

Unless otherwise agreed, High purity copper/copper sulphate reference cells with proven high reliability shall be provided for stable Tank to sand potential measurement.

7.15 Cables

7.15.1. All the Power Cables i.e. Cables from Power feeder to PDB, PDB to CPTR Unit, PDB to RMU unit, and Positive/Negative Header cables shall be with annealed high conductivity stranded copper conductor, PVC insulated, 650/1100 V grade, armoured, PVC sheathed conforming to IS 1554 part-I.

7.15.2. Anode lead cable shall be of 1CX16mm2 stranded copper conductor, 7 strands, insulated (Refer Sr. no. 1 or Sr. no. 2 of Table-1), unarmoured, with a double insulation system. The primary insulation shall be 0.04 inch thick irradiated cross-linked polyvinylidene floride (PVDF) or Ethylene Chlorotrifloroethylene (ECTFE) 1100 Volt grade. The secondary insulation shall be 0.065 inch thick HMWPE (Refer Sr. no. 3 of Table-1) sheathing jacket over the primary insulation.

Table-1

Sr no.	Insulation type	Insulation Specification*	
1.	polyvinylidene floride (PVDF) Irradiation cross linked	Tensile Break Streangth	4500 PSI (min)
		Break Elongation	50%
		Flexural Strength	8600 PSI (min)
		Resistivity	$2X10^{14}$ (min)
		Dielectric Constant	8 (min) at 100Hz
2.	Ethylene Chlorotrifloroethylene (ECTFE)	Tensile Break Streangth	6500 PSI (min)
		Break Elongation	100%
		Resistivity	$1X10^{15}$ (min)
		Dielectric Constant	2.5 (min) at 1MHz
3.	High Density Molecular Weight Polyethylene (HMWPE)	Color	Black
		Density	0.941 gm/cm^3
		ASTM D1248, Type 3, Class C, Category 5 or IEC 60502-1	
		Temperature rating	90°C

* Standard Test Method ASTM D638 shall be used to determine the tensile strength, Flexural Strength and Break Elongation. For the resistivity and dielectric contant tests, standard test methods ASTM D257and ASTM D150 shall be utilized.

7.15.3. The cables for reference cells, potential measurements shall be of copper conductor, HMWPE insulated, Aluminium backed by mylar/ polyster tape shielded, HMWPE sheathed, armoured, HMWPE over all sheathed type.

भूमिगत वेसल्स के लिए
कैथोडिक संरक्षण प्रणाली विनिर्देशन

SPECIFICATION
FOR
CATHODIC PROTECTION SYSTEM
FOR UNDERGROUND VESSELS

Rev.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
1	15.10.24	REAFFIRMED	PTR	NSB	RC	MN
0	15.10.18	ISSUED AS STANDARD SPECIFICATION	PTR	NSB	BRB	RKT

Abbreviations:

AC	Alternating Current
AJB	Anode Junction Box
BS	British Standards
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CIMFR	Central Institute of Mines and Fuel Research
CJB	Cathode Junction Box
CP	Cathodic Protection
CPPSM	Cathodic Protection Power Supply Module
CPTR	Cathodic Protection Transformer Rectifier
CTE	Coal tar enamel
Cu/CuSO4	Copper/Copper Sulphate
DC	Direct Current
ERTL	Electronics Regional Testing Laboratory
FBE	Fusion Bonding Epoxy
HV	High Voltage
HMWPE	High Molecular Weight Poly Ethylene
IS	Indian Standards
$\mu A/mm^2$	Micro-ampere per square millimeter
mA/mm^2	Milli-ampere per square millimeter
MMO	Mixed Metal Oxide
NACE	National Association of Corrosion Engineers
PDB	Power Distribution Board
PE	Polyethylene
PVC	Polyvinyl Chloride
RMU	Remote Monitoring Unit
VDR	Vendor Data Requirement
VSP	Vessel to Sand Potential

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Dr. Sudip paul (Structural)
Mr. Brij Raj Meena (Projects)
Mr. Rajesh Sinha(Inspection)

CONTENTS

1.0 SCOPE

This specification covers the philosophy to be adopted for the design and engineering of the cathodic protection system for the underground Vessels (external surface) including corrosion survey of the electrolyte (sand).

2.0 APPLICABLE CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards as a minimum:

i)	NACE	:	SP-0285 Corrosion Control of Underground Storage Tank Systems by Cathodic Protection
ii)	BS	:	EN 13636:2004, Cathodic Protection of Buried Metallic Tanks and Related Piping
iii)	VDE	:	0150, protection against corrosion due to stray currents from DC installations.
iv)	IS/ IEC: 60079	:	Electrical Apparatus for Explosive Gas Atmosphere
v)	IS/ IEC: 60529	:	Classification of Degree of Protection Provided by Enclosures
vi)	OISD-GDN-180	:	Lightning Protection

2.2 The equipment shall also confirm the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.3 In case of imported equipments, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.4 In case of any contradiction between various referred standards/ specifications/ data sheet and statutory regulations, the most stringent requirement shall prevail and Owner's/EIL's decision in this regard shall be final and binding.

3.0 SYSTEM IMPLEMENTATION

All work to be performed and supplies to be effected as a part of CP system shall require specific review by Owner or his authorized representative. Major activities requiring review shall include but not be limited to those mentioned in vendor data requirement (VDR) form attached with MR/Tender.

4.0 CORROSION SURVEY

4.1 General

4.1.1 The corrosion survey includes the measurement of sand resistivity survey and chemical analysis for design of CP system which shall be carried out by Contractor. The corrosion survey shall also include collection of additional data as required for completeness of the job.

4.1.2 To carry out sand resistivity measurement, Wenner's 4-pin method or an equivalent soil/ sand box method approved by Owner/ Owner's representative shall be used. Survey instruments shall have maximum AC and DC ground current rejection feature.

4.1.3 Care shall be taken to ensure that the resistivity readings are not influenced by the presence of foreign structures/piping, and earth currents (if any) etc.

4.2 Report

On completion of all field work, a report incorporating all the results generated from surveys and details of additional data collected (e.g. nearby structures, details of hazardous area classification, location proposed for CPTR units, power source details etc.) shall be prepared. The report shall also contain detailed interpretation of survey results and resistivity data, to form a design basis for cathodic protection. This report shall also include various drawings prepared in connection with the above work. Soil resistivity values shall be plotted on semi-log graph sheets.

5.0 CATHODIC PROTECTION DESIGN PARAMETERS

A distinctly independent impressed current cathodic protection system shall be provided to protect the external surfaces the underground Vessel as specified.

Unless otherwise stated in the data sheets, the following parameters shall be used for design of permanent cathodic protection system:

5.1	Protection Current Density Range	:	10-30 mA/m2 (at 25 ^{0}C operating temperature)
5.2	If operating temperatures of Bullet exceed 25 deg. C, protective current density shall be corrected @ 0.5mA/ m2/ deg. C.		
5.3	Sand resistivity	:	200 Ohm-m
5.4	Vessel natural potential	:	(-) 0.45 V (w.r.t. Cu/CuSO4 ref. cell)
5.5	Anode	:	MMO wire anode
5.6	Current capacity of anode	:	30 mA/m
5.7	Design life of CP system	:	30 years, unless specified elsewhere

5.8 Anode ground bed loop resistance including anode to ground resistance, anode and cathode cable resistances : 1 Ohm (max.)

5.9 Scheme for Cathodic Protection System of a Vessel

5.9.1 Each Vessel's CP system shall be independent and exclusive. The scheme defined below shall be applicable.

5.9.2 Impressed Current Cathodic Protection (CP) System shall be provided for sand side corrosion prevention of Vessel external surface.

5.9.3 Anodes employed for CP System of vessels shall be mixed metal oxide coated on titanium wire anode, piggyback connected with anode lead cable, factory pre-packed with coke breeze.

5.9.4 The anode strings shall be located around the Vessel. Specific installation requirements of String Anode shall be as follows:

- Anode strings shall be distributed in loops and shall be installed in the sand cushion surrounding the Vessel at a separation distance of 1000mm from the Vessel surface.
- Separation distance between consecutive String anode loops (vertical separation) shall be uniform and shall be limited to maximum 1000 mm.
- Two consecutive anode loops shall be connected to different AJBs located opposite-along the Vessel centreline.
- The above anode distribution is based on the assumption that temperature of the sand in pit at 1000mm distance from Vessel surface shall be below 75 deg.C

5.9.5 Highest of number/length of anodes calculated as per design parameters defined under clause 5.1 to 5.8 and that worked out as per clause 5.9.4 shall be provided.

5.9.6 Free ends of each string anode shall be terminated to AJB through loop connection.

5.9.7 Cathodic Protection Transformer-Rectifier unit (CPTR Unit) of suitable rating (25V/25A or 50V/50A or 75V/75A) shall be installed to energize the anode strings for Vessels.

5.9.8 CPTR Unit shall have two outgoing positive header cables, which shall be terminated to 2 nos. AJBs to be installed on opposite sides of the Vessel along its Centerline (TL-TL).

5.9.9 CPTR Unit shall have one out going negative header cable, which shall be connected to cathode junction box (CJB) located near Vessel for the drainage connection and potential measurement.

5.9.10 Two drainage cables and two measurement cables from each vessel shall be terminated to its CJB.

5.9.11 Minimum 5 no.s Cu/$CuSO_4$ Permanent Reference cells shall be provided for each vessel which shall be able to measure the complete potential profile of the Vessel.

5.9.12 Power supply for the CPTR Unit shall be drawn from the nearest Substation.

5.9.13 The reference cell cables and the measurement cables from each Vessel shall be routed through the respective Monitoring Junction Box (MJB).

5.9.14 If required, a MJB may be integrated with CJB and a single/composite Cathode junction box cum Reference cell junction box (CRJB) may be provided.

5.9.15 The CPTR unit shall preferably have the built-in RMU module. In case RMU is not integral part of CPTR unit, then a separate RMU panel may be provided and both the equipments (CPTR Unit and RMU) shall be connected with communication cables for status monitoring and control purpose.

5.9.16 For monitoring of Vessel to sand potentials, monitoring cables of reference cells shall be laid between MJB and CPTR unit & RMU. For CPTR unit at least three reference cells shall be connected and for RMU all the Reference cell cables shall be connected.

5.9.17 All Cable laying shall be done on existing cable route which shall be overhead cable trays/ cable trenches wherever possible. Underground Cable laying in paved/ unpaved areas shall be done through RCC trench/directly buried trenches respectively, wherever overhead cable trays/ cable trenches are not available.

5.9.18 Connection of drainage cables and measurement cables to the Vessel shall be done by Thermit welding.

5.9.19 Minimum 3 no's of perforated HDPE pipes surrounding the Vessel shall be installed for measuring potential using portable reference cells. The HDPE pipe shall be covered with geotextile cloth and shall be of 75mm diameter, slotted of 50 mm (2 inch) in length 0.15 mm width, 4 kg/cm^2 pressure rating, sealed at one end.

6.0 CATHODIC PROTECTION DESIGN CRITERIA

Cathodic protection system shall be designed to meet the following criteria:

6.1 The Vessel to sand potential (VSP) measurements shall be between (-) 0.85V (OFF) and (-) 1.20V (OFF) with respect to a Cu/CuSO4 reference electrode.

6.2 A minimum polarization shift of (-) 100 millivolts can be accepted as an adequate level of cathodic protection for the Vessel with the approval of Owner in exceptional cases. Discretion to use any of the criteria shall solely rest with owner/owner's representative.

6.3 A positive potential swing of 50 millivolts or more shall be considered sufficient to indicate the presence of an interaction/ interference situation requiring investigation and incorporation of mitigation measures.

7.0 CATHODIC PROTECTION EQUIPMENTS

7.1 The system shall include the following major equipment/ sub-systems unless otherwise specified in project specifications:

- Power Distribution Board
- CPTR units.
- Remote monitoring unit
- MMO Anodes
- Anode junction box
- Cathode junction box
- Measurement Junction box
- Permanent reference cells
- Cables

7.2 All equipment shall be new and procured from EIL approved manufacturers. Equipment offered shall be field proven. Equipment requiring specialized maintenance or operation shall be avoided as far as possible. Prototype equipment shall not be accepted.

7.3 All equipment/ materials shall conform to the relevant specifications included in the tender document.

7.4 The CPTR unit and RMU etc. shall be located in safe non-hazardous areas. However all junction boxes shall be flame proof, Temperature class T3 (min.) & suitable for Gas Group specified in datasheet.

7.5 The electrical and electronic equipments installed in hazardous area shall be flame proof type and shall meet the requirements as per IS/ IEC: 60079 and shall be weather proof IP-65 as per IS/IEC:60529.

7.6 Hazardous area certificate from CIMFR or equivalent test house of country of origin, applicable PESO approval certificate, BIS license and original drawings referred in type test certificate shall be shown to the Inspection agency during inspection. The Certificate and BIS license must be valid at the time of dispatch.

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Power Distribution board (PDB) shall be provided incase multiple CPTR units are envisaged. PDB shall be fed through 1 no. 415V±10%, 50Hz±3% TPN feeder from Owner's substation and shall have required no. of outgoing feeder rated for 240V, SPN or 415V, TPN feeders.

7.8 CP Transformer Rectifier Unit

The Cathodic Protection Transformer Rectifier Unit (CPTR unit) shall confirm to the requirements mentioned in datasheet and shall be installed in non-hazardous area as specified in data sheets.

7.9 Anode Beds/ Loops

Anodes shall be supplied complete with tail cables, which shall be long enough for termination on their associated anode lead junction boxes without intermediate joints. Exact lengths and termination details shall be indicated in construction drawings.

Potential gradient around the anodes shall be within safety requirements with regard to interference on foreign structures and its effective boundary shall be defined.

7.10 MMO Anodes

Anodes shall be mixed metal oxide coated titanium wire anodes. The MMO wire anodes shall be piggyback connected with anode lead cable, factory pre-packed with coke breeze. The detail specification shall be as mentioned in data sheet.

7.11 Anode Junction Box

All cable tails from individual anodes shall be terminated onto the respective anode junction boxes, which shall be further connected to the positive cable coming from CP power source. Each anode circuit in junction shall have provision for measurement and control of individual circuit/anode current through variable resistors, shunts and links of suitable ratings.

7.12 Cathode Junction Box

Cathode junction box shall be provided near the Vessel for connection of the negative drainage cables to the Vessel. The negative of the CP power source shall be connected to the incoming circuit of the cathode junction box.

The incoming circuit and each out going circuits shall have provision for measurement and control of current through variable resistors, shunts and links of suitable ratings.

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All the reference cells provided around the Vessel shall be connected to monitoring junction boxes. Measurement and control cables from monitoring junction box shall be connected to CPTR unit and RMU unit.

7.14 Permanent Reference Cells

Unless otherwise agreed, High purity copper/ copper sulphate reference cells with proven high reliability shall be provided for stable Vessel to sand potential measurement.

7.15 Cables

7.15.1. All the Power Cables i.e. Cables from Power feeder to PDB, PDB to CPTR Unit, PDB to RMU unit, and Positive/ Negative Header cables shall be with annealed high conductivity stranded copper conductor, PVC insulated, 650/1100 V grade, armoured, PVC sheathed conforming to IS 1554 part-I.

7.15.2. Anode lead cable shall be of 1CX16 mm^2 stranded copper conductor, 7 strands, insulated (Refer Sr. no. 1 or Sr. no. 2 of Table-1), unarmoured, with a double insulation system. The primary insulation shall be 0.04 inch thick irradiated cross-linked polyvinylidene floride (PVDF) or Ethylene Chlorotrifloroethylene (ECTFE) 1100 Volt grade. The secondary insulation shall be 0.065 inch thick HMWPE (Refer Sr. no. 3 of Table-1) sheathing jacket over the primary insulation.

Table-1

Sr no.	Insulation type	Insulation Specification*	
1.	polyvinylidene floride (PVDF) Irradiation cross linked	Tensile Break Strength	4500 PSI (min)
		Break Elongation	50%
		Flexural Strength	8600 PSI (min)
		Resistivity	$2X10^{14}$ (min)
		Dielectric Constant	8 (min) at 100Hz
2.	Ethylene Chlorotrifloroethylene (ECTFE)	Tensile Break Strength	6500 PSI (min)
		Break Elongation	100%
		Resistivity	$1X10^{15}$ (min)
		Dielectric Constant	2.5 (min) at 1MHz
3.	High Density Molecular Weight Polyethylene (HMWPE)	Color	Black
		Density	0.941 gm/cm^3
		ASTM D1248, Type 3, Class C, Category 5 or IEC 60502-1	
		Temperature rating	90°C

* Standard Test Method ASTM D638 shall be used to determine the tensile strength, Flexural Strength and Break Elongation. For the resistivity and dielectric constant tests, standard test methods ASTM D257and ASTM D150 shall be utilized.

7.15.3. The cables for reference cells, potential measurements shall be of copper conductor, HMWPE insulated, Aluminium backed by mylar/ polyester tape shielded, HMWPE sheathed, armoured, HMWPE over all sheathed type.

टैंकों के लिये कैथोडिक प्रतिरक्षण प्रणाली हेतु स्थापना, प्री-कमिशनिंग, परीक्षण और कमिशनिंग के लिए विनिर्देश

SPECIFICATION FOR INSTALLATION, PRE-COMMISSIONING, TESTING AND COMMISSIONING OF CATHODIC PROTECTION SYSTEM FOR TANKS

Rev.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	26 02 20	ISSUED AS STANDARD SPECIFICATION	AKD	NSB	SA	RKT

Abbreviations:

AJB	:	Anode Junction Box
CJB	:	Cathode Junction Box
CP	:	Cathodic Protection
CPTR	:	Cathodic Protection Transformer Rectifier
DC	:	Direct Current
EIL	:	Engineers India Limited
ICCP	:	Impressed Current cathodic Protection
IS	:	Indian Standards
MMO	:	Mixed Metal Oxide
NACE	:	National Association of Corrosion Engineers
OISD	:	Oil Industry Safety Directorate
PDB	:	Power Distribution Box
TRU	:	Transformer Rectifier Unit

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Ms. ANP Singh
Ms. N.S. Bhattacharya
Mr. Amrit Kumar Dey
Mr. Raj Kishore (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 OBJECTIVE

This procedure defines the methodology, requirements, responsibilities and equipment required for the Impressed Current Cathodic Protection System Installation, Pre-commissioning and Commissioning of the tank bottom plate to ensure CP contractor conform to the specifications and other applicable codes and standards

2.0 SCOPE

The scope of this document is to describe the procedures for typical requirement for wire anode installation, Pre-commissioning and Commissioning of an Impressed Current Protection System works for Tank bottom plates and provide adequate Quality Assurance / Control of workmanship and inspection at site. Pre-commissioning inspection and testing will be carried out to conform satisfactory installation works as per the project specification design and drawings.

The contractor shall have all necessary construction equipment, tools and tackle and testing instruments to carry out the erection works and to commission the system as specified. These equipment shall be brought to site by contractor before start of work.

3.0 REFERENCES

i) Project Specification for CP system for Crude Tanks
ii) CP System Design & Detail Calculation Document for Tank Bottom Plates.
iii) Overall CP Equipment and Cable Route Layout.
iv) NACE : RP-0193 : External Cathodic Protection of on-grade carbon steel storage tank bottom
v) IS/ IEC : 60529 : Classification of Degree of Protection Provided by Enclosures
vi) OISD-GDN-180 : Lightning Protection

4.0 INSTALLATION

4.1 Prior to start of installation, contractor shall verify that equipment and complete materials have been received. Handling, shifting to required site location, installation, pre-commissioning, testing and commissioning shall be done by contractor with utmost care. Manufacturer's instructions and the requirements given in their technical manual shall be strictly adhered. The substation/control room wherein the equipment to be installed shall be clean, dry and free from all debris. Care shall be taken to observe the correct lifting arrangements and to make sure that the slings are attached to the manufacturer's designated lifting points, where applicable. No parts shall be subjected to undue strains or sudden stresses which could cause damage to the equipment.

The lifting position mark indicated on packing casing shall be adhered to strictly for keeping it in required vertical position.

Contractor shall check and report to the Engineer-in-charge about any damaged item and/ or missing component and shall replace the same as per specifications. During installation, all accessories and loose items shall also be inspected by the contractor before their assembly/mounting.

Manufacturer checklist, manual for erection, installation and any specific requirement for equipment handling, installation and commissioning shall be strictly adhered to.

4.2 Following activities shall be done by contractor during various stages of installation

4.2.1 STAGE-I:

i) Making the cable trench for pre-packed Mixed Metal Oxide (MMO) wire anodes considering the number of Strings as per design calculation.

ii) Check continuity of anode and cable before installation in tank pad to ensure healthiness.

iii) Laying of pre-packed Mixed Metal Oxide wire Anodes in Tank sand pad, one by one at its full length.

iv) Jointing of Pre-packed Mixed Metal Oxide wire Anodes end with connecting lead cable by using Inline splice kits at front side of Tank as per Inline splice Kit jointing procedure.

v) Provide anode identification marks on anode lead cable of each loops coming out from tanks

4.2.2 STAGE-II

i) Making box type pocket for Reference Cell, position as per requirement

ii) Checking healthiness of Permanent Reference Cell before installation with respect to calibrated Master Reference Cell.

iii) Check continuity of reference cell cable before installation in tank pad to ensure healthiness.

iv) Installation of Reference Cell ($Cu-CuSO_4$) inside pocket and sand filling with layer by layer compaction with wooden pallet.

v) Jointing of Reference Cell end with connecting reference lead cable by using jointing ferrule and sealing compound kit.

vi) Provide reference cell identification mark on cable of each cell coming out from tanks.

vii) Insert perforated pipe as per approved design and drawing

4.2.3 STAGE-III

Activities which are to be performed outside the Tank sand pad foundation:

i) Installation of all junction boxes on a mounting frame in front of the Tank as per approved design and drawing.

ii) Termination & connection of all the cables in the junction boxes.

iii) Installation of grounding cell (DC Decoupler) in enclosure & connecting the cables from Tank to grounding cells.

iv) Connection of the outgoing cable from Grounding cell to the earthing grid.

v) Installation of TRU panels.

vi) TR-Unit connection of all incoming & outgoing cables & termination

vii) Generation of installation report in standard format.

5.0 PRE-COMMISSIONING AND TESTING

i) After the equipment is installed properly in accordance with specifications, design documents, drawings and contractor shall carry out all pre-commissioning checks and tests as per EIL format in the presence of Engineer-in-charge and test readings shall be recorded and furnished to EIL in triplicate.

ii) It is anticipated that various installation checks have been previously accomplished and accepted during installation of CP equipment and facilities or otherwise to be carried out in conjunction with the commissioning activities.

iii) The pre-commissioning inspection among other requirements shall include visual inspection, checking the workmanship of the installation, the rating of equipment, safety clearances, sizes of cables installed, wiring properly dressed and labeled, sealing of unused cable entries, checking of all safety interlocks, control/interface functions as per requirement etc.

iv) The contractor shall bring to site all required tools, tackles and testing instruments for carrying out field testing. Contractor shall use only calibrated measuring and test instruments and shall maintain valid calibration record.

v) The inspection/test data sheets associated with pre-commissioning and commissioning of cathodic protection system shall be provided by vendor.

5.1 General Inspection

Prior to commissioning of the CP system and before energizing the transformer rectifier unit, the following activities shall be performed.

i) Ensure that minimum 50% of product level is maintained in the structure to have proper contact with soil.

ii) Review all test and inspection data sheets that have been previously accomplished during CP installation. All installation data results to be verified to ensure that inspection and testing have been carried out successfully.

iii) Review all CP design drawings, deviations if any shall be noted and incorporated in the as-built drawings.

iv) Visual inspections to be performed to ensure that all above ground (exposed) CP components and facilities are not physically damaged during or after CP installation works. Any discrepancies to be noted and necessary corrective actions shall be taken prior to commissioning.

v) All CP cables to be checked for proper termination and identification as per schematic drawings.

5.2 Pre-Commissioning Check List

5.2.1 Transformer Rectifier

5.2.1.1 The following information to be obtained and recorded as a minimum

i) TR unit ID
ii) TR unit Manufacturer
iii) TR type/ model/ Sl. No.
iv) Sun Shade
v) TR Input and Output Rating
vi) Date of Inspection
vii) Name of Inspector

5.2.1.2 **Inspection**

The following inspections and checks shall be performed and recorded when the TR unit is in switched off condition.

i) Visual inspection of each TR (transformer rectifier) unit to be performed to ensure correct installation and that the unit has not been physically damaged prior to operation. Any discrepancies will be noted and rectified.

ii) All panel connections and terminals to be checked for tightness. Any loose connection shall be tightened.

iii) The polarity of the DC output cable to be verified to ensure that the positive output cables are connected to the anode terminals and the negative terminals are connected to the tank.

iv) Verify that the power supply to the Transformer Rectifier (TR) corresponds to the required rating. Measure and record the AC supply voltage at the input terminals of the transformer rectifier circuit breaker.

v) Verify and ensure that the Transformer Rectifier is properly grounded to the earthing system.

vi) Ensure that all fuses are of proper current and voltage ratings. Check the continuity of all fuses and spares by an ohmmeter.

vii) Measure the insulation resistance between Transformer & TR body and earthing resistance between TR and earth.

viii) Check whether the output knobs are in minimum position.

ix) Check the colour of silica gel.

x) Ensure that TR (oil cooled) has at least minimum level of oil, if necessary add more.

5.2.1.3 **Total Circuit Resistance Test**

i) After proper polarity of the DC output cables have been confirmed and the cables have been labelled with permanent tags, disconnect the anode and the cathode cables from the DC output terminal of the Transformer Rectifier.

ii) Using a four-pin resistance meter with P1/C1 and P2/C2 terminal shorted, connect the test leads of the instruments across the DC cables and measure the resistance.

iii) This testing will be done to measure the overall circuit resistance of the CP system and to ensure that no short circuit exist between the anode (positive) and cathode (negative).

iv) The result will be recorded in the pre-commissioning data sheet.

5.2.2 **Anode Inspection**

i) Verify that the anode have been properly checked and accepted for compliance with the drawings and design during the installation works.

ii) Based on the above, check the power feed connections and verify that the cable is properly terminated and identified at the Anode Junction Box (AJB). Any discrepancies shall be rectified.

iii) The tests shall be performed at the AJB between the anode feeders. Continuity test to be carried out between all anode feeders lead cable to ensure electrical continuity of all anodes.

iv) The result will be recorded in the AJB pre-commissioning data sheet.

5.2.3 **Junction Boxes & PDB**

5.2.3.1 The following information shall be obtained and recorded as minimum:

i) Junction Box & PDB ID
ii) Number of Circuits
iii) Resistor Rating if present
iv) Shunt Rating if present
v) Date of Inspection and Name of the Inspector

5.2.3.2 The following inspections shall be performed at each junction box.

i) A visual inspection of the junction box & PDB will be performed to ensure correct installation in accordance with the drawings and that the junction boxes & PDB have not been physically damaged prior to operation. Any discrepancies will be noted.
ii) All cable connections and terminals shall be checked for tightness. Any loose connections shall be tightened.
iii) All cables are to be checked for proper tagging and to ensure it is as per design/drawing.
iv) The result will be recorded in the pre-commissioning format.

5.2.4 **Natural Potential measurement**

Before energizing the transformer rectifier, the natural potential of tank (partially filled with product) base plate should be measured and recorded using permanent reference electrodes as well as using portable reference electrode.

5.2.4.1 Potential Measurement using Permanent Reference Electrodes

i) The tank to soil potential measurement is obtained using high impedance multimeter (min. 10 Mega ohms).

ii) Attach the test lead from the positive terminal of the meter to the tank at the junction box.

iii) Attach the test lead from the negative terminal of the meter to the permanent reference electrode point at the junction box.

iv) The tank potential in millivolts is read directly from the meter.

v) Natural potential measurement using permanent reference electrode to be carried out at all reference electrode locations.

vi) Record the millivolts reading with polarity on the corresponding data sheet.

NOTE:

When product level is low, tank bottom may not have a good contact with the electrolyte thus affecting the tank to soil potentials. This error can be minimized by ensuring that there is sufficient level of the product in the tank during commissioning.

6.0 COMMISSIONING

After successful pre-commissioning of the cathodic protection equipment, the CP system is ready for testing, start up and commissioning. The contractor shall carry out complete testing and commissioning of material and equipment as per Inspection and test plans (ITP).

6.1 Before switching "ON" the transformer rectifiers, the following condition should be met.

i) All CP cables inside junctions and TR are to be checked and corrected for any discrepancies.

ii) Natural potential of all structures involved in cathodic protection system has been measured and recorded.

iii) Tanks are to be full or minimum half-filled with electrolyte.

iv) A close visual inspection of electrical equipment in hazardous area shall be made to ensure that equipment is suitable for the classified zone and gas group and correctly installed, with all covers, bolts, nuts and hardwares intact and there is no physical damage mark seen on the enclosure.

6.2 Commissioning Steps

The steps described below should be followed systematically during execution of final commissioning.

i) The transformer rectifier has been previously checked and tested during the pre-commissioning stages and the results are recorded in the data sheet. Read and study the transformer rectifier data sheet & operation manual to familiarize the system and result of the pre-commissioning test.

ii) Set the transformer rectifiers output control to 0% range and switch "on " the transformer rectifier.

iii) Gradually adjust the transformer rectifier's output power in manual mode.

iv) Measure and record the tank to soil potential.

6.2.1 The following procedures should be followed when measuring the tank to soil potential:-

i) For tanks with permanent reference electrodes, at each reference cell box, connect the negative lead of the meter on the reference cell and positive on the tank. Record each reference electrode reading with respect to negative.

ii) Increase the transformer rectifier output in manual mode until the tank bottom potential reaches the value as per specification [-850 to -1100 mV (typical)]. The "On" potential is not a true representation of the tank protected potential. The instant "off" potential will be measured for final reading & conclusion. Before taking instant off potentials, the transformer rectifier should be kept energized until adequate polarisation is achieved (typically 24 to 48 hrs).

iii) Instant "Off" potential measurement is required to determine the IR drop free potential of the tank.

iv) Final tank to soil potential (instant off and on) will be measured by switching the rectifier output using current interrupter. Current interrupter shall be hooked-up to the transformer rectifier and programmed to switch in 1:4 ration (1 second off and 4 second on or any other cycle in the same ratio). Instant Off potential measurement is required to determine the IR drop free potential of the tank.

v) Instant Off potential can be measured by the following procedures:

a) Switch off the transformer rectifiers.
b) Disconnect the positive header cable connected in the positive terminal of the transformer rectifier.
c) Install the Current interrupter in series with the positive header cable and positive terminal of the transformer rectifier.
d) Set the current interrupter in 1:4 ration i.e. 1 second off and 4 seconds on cycle or any other cycle in the same ratio.
e) Record the instant "off" and instant "on" potential in the commissioning data sheet. After recording, disconnect the current interrupter and return the transformer rectifier to its original connection.

vi) Check and record individual powers feed current in the junction box and record the results. Current shall be measured using digital clamp meter or digital multi meter.

vii) Check and record the output voltage and current in the transformer rectifier.

a) Check and record the output voltage and current in the transformer rectifier, when the instant 'OFF' potential value at all the reference electrode is in the range specified in the Specification (-0.850 to -1.1 V typical) after 48 hrs of polarization.

b) AVCC MODE: After recording the TR output DC voltage and current in Manual Mode at which all the reference electrodes show -0.850V to -1.1V in instant 'OFF' (typical figure) condition as described above, changeover the operation to constant

voltage in AVCC mode and set the DC output voltage at the predetermined voltage recorded during Manual Mode of operation at which all the reference electrodes having potential in the range specified in the specification (typically -0.850V to -1.1V voltage) if necessary to ensure optimal protection potential at all the reference electrodes. Record the corresponding DC output current for the set voltage. This will be the final setting at which the unit will be left for operation and handed over to client. Individual current output of all the anode loops to be measured and recorded in AVCC mode voltage setting.

The results will be recorded in the commissioning data sheet.

7.0 RECORDS

i) Contractor shall keep up-to-date records of all activities carried out and test results. Field inspection / test / commissioning reports shall be submitted to EIL/Owner by contractor in bound volumes (triplicate copies)

ii) All equipment layout drawings shall be marked by the contractor for "AS BUILT STATUS" and two sets of hard copies shall be submitted to EIL.

8.0 HEALTH, SAFETY & ENVIRONMENT

i) Necessary PPE shall be utilized.
ii) Only trained / experienced personnel shall be deployed for this activity.

9.0 PRECAUTION

i) Care shall be taken for the proper connection of cables including Positive Header cable from Anode Junction Box to Positive (+ve) Terminal of TR Unit & Negative Header Cable from Structure to Negative (-ve) Terminal of the TR unit and interconnection cables

iii) Before the systems facilities are put into operation, necessary tests shall be carried out to establish that equipment's, devices and wiring connection have been correctly set up and connected in good condition for projected operation.

iv) Proper PPE shall be used.

v) Trained personnel to be deployed for Commissioning.

vi) Care should be taken while using MCB, AC/DC cable operation.

10.0 EQUIPMENT AND TOOLS

i) Portable Reference Electrodes ($Cu/CuSO_4$)
ii) Digital Multimeter
iii) Clamp-on meter
iv) Megger
v) CP / Electrical Tool Box
vi) Crimping tool

11.0 REPORTS

All the parameters recorded during the Testing & Commissioning at site will be recorded in inspection format as per approved QAP.

12.0 FORMATS (TYPICAL)

12.1 Pre-Commissioning Inspection and Test Plat Format

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Check Sheet			
Sl. No.	Activity	Contractor	EIL/Owner
1	Approval of Pre-Commissioning Check Procedure	P	A
2	Pre Commissioning Checks For Cu/$CuSO_4$ Reference Electrode and Anode using Anode Tail Cable	P	RM / W
3	ICCP System Cable Termination and Tagging	P	RM / W
4	ICCP unit Working Condition (No Load Condition)	P	W
5	Pre-Commissioning Checks of Earthing, Termination & Tagging for TR Unit and Junction Boxes	P	RM / W
Legends: A-Approval, RM-Random Check, W-Witness all, P- Perform			
Remarks:			

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

12.2 Quality Assurance Plan (QAP)

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Check Sheet					
Sl. No.	**Activity**	**CP Vendor**	**EPC Contractor**	**EIL/Owner**	**Remarks**
1	Approval of Procedure for Testing & Commissioning	S	R	A&R	
2	Checking of Parameters as Per Procedure	P	W	R&W	
3	Measuring of Natural Potential	P	W	R&W	
4	Measuring IR value of TR unit	P	W	R&W	
5	Measuring of TR Unit Input & Output	P	W	R&W	
6	Check Circuit Resistance	P	W	R&W	
7	Measuring Of Structure To Electrolyte Polarized Potential With Portable/ Permanent Cu/$CuSO_4$ Reference Cell.	P	W	R&W	
8	Measuring of Individual Anode Loop Current	P	W	R&W	
9	Measuring On - Instant Off Readings	P	W	R&W	
10	Running TR Unit in Auto mode (AVCC mode)	P	W	R&W	
11	Central Monitoring System (CMS)	P	W	R&W	
Legends: A-Approval, R- Review of Records, W-Witness All, P-Perform, S-Submitted By					

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

12.3 Pre-Commissioning Check Format

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Pre-commissioning- Check Sheet

Item-1	Ref. Cell No.	Native Potential Reading (Volt)	Remarks
1.1	RE-1		
1.2	RE-2		
1.3	RE-3		
....	....		
1.n	RE-N		
Item-2	**Anode String No.**	**Continuity test**	
2.1	A-1	OK/ Not OK	
2.2	A-2	OK/Not OK	
2.3	A-3	OK/Not OK	
...	....	OK/ Not OK	
2.n	A-N	OK/ Not OK	
Item-3	**TRU (no load test in manual mode)**	**Reading**	
3.1	AC input voltage	Volt	
3.2	AC input current	Amp.	
3.3	DC output voltage	Volt	
3.4	DC output current	Amp.	
Remarks (overall):			

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

12.4 Commissioning Check Format

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Check Sheet (potential measurement using permanent $Cu/CuSO_4$ electrode)				
Item-1	**TRU**	**Reading**	**Remarks**	
1.1	AC input voltage	Volt		
1.2	AC input current	Amp.		
1.3	DC output voltage	Volt		
1.4	DC output current	Amp.		
Item-2	**Permanent Ref. Cell No.**	**Initial Reading (Volt)**	**Reading after 24 hrs (Volt)**	**48 hrs (Volt)**
2.1	RE-1			
2.2	RE-2			
2.3	RE-3			
....	....			
2.n	RE-N			
Item-3	**Activity**	**Reading**	**Remarks**	
3.1	Natural PSP			
3.2	Energised PSP			
3.3	ON PSP			
3.4	Instant Off PSP			
3.5	100 mV Shift			
Remarks (overall):				

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

वेसल्स के लिए कैथोडिक प्रतिरक्षण प्रणाली हेतु स्थापना, प्री-कमीशनिंग, परीक्षण और कमिशनिंग के लिए विनिर्देश

SPECIFICATION FOR INSTALLATION, PRE-COMMISSIONING, TESTING AND COMMISSIONING OF CATHODIC PROTECTION SYSTEM FOR VESSELS

Rev.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	26 02 20	ISSUED AS STANDARD SPECIFICATION	AKD	NSB	SA	RKT

Abbreviations:

AJB	:	Anode Junction Box
CJB	:	Cathode Junction Box
CP	:	Cathodic Protection
CPTR	:	Cathodic Protection Transformer Rectifier
DC	:	Direct Current
EIL	:	Engineers India Limited
ICCP	:	Impressed Current Cathodic Protection
IS	:	Indian Standards
MMO	:	Mixed Metal Oxide
NACE	:	National Association of Corrosion Engineers
OISD	:	Oil Industry Safety Directorate
PDB	:	Power Distribution Box
TRU	:	Transformer Rectifier Unit

Electrical Standards Committee

Convenor: Ms. Sumita Anand

Members:
Mr. Parag Gupta
Mr. M K Sahu
Ms. ANP Singh
Ms. N.S. Bhattacharya
Mr. Amrit Kumar Dey
Mr. Raj Kishore (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 OBJECTIVE

This procedure defines the methodology, requirements, responsibilities and equipment required for the Impressed Current Cathodic Protection System Installation, Pre-commissioning and Commissioning of the vessel (external) to ensure CP contractor conform to the specifications and other applicable codes and standards

2.0 SCOPE

The scope of this document is to describe the procedures for typical requirement for wire anode installation, Pre-commissioning and Commissioning of an Impressed Current Cathodic Protection System works for vessel (external) and provide adequate Quality Assurance / Control of workmanship and inspection at site. Pre-commissioning inspection and testing will be carried out to conform satisfactory installation works as per the project specification design and drawings.

The contractor shall have all necessary construction equipment, tools and tackle and testing instruments to carry out the erection works and to commission the system as specified. These equipment shall be brought to site by contractor before start of work.

3.0 REFERENCES

i) Project Specification for CP system for vessels

ii) CP System Design & Detail Calculation Document for vessels (external).

iii) Overall CP Equipment and Cable Route Layout.

iv) NACE : SP-0285 : Corrosion control of underground storage tank systems by Cathodic Protection

v) IS/ IEC: 60529 : Classification of Degree of Protection Provided by Enclosures

vi) OISD-GDN-180 : Lightning Protection

4.0 INSTALLATION

4.1 Prior to start of installation, contractor shall verify that equipment and complete materials have been received. Handling, shifting to required site location, installation, pre-commissioning, testing and commissioning shall be done by contractor with utmost care. Manufacturer's instructions and the requirements given in their technical manual shall be strictly adhered. The substation/control room wherein the equipment to be installed shall be clean, dry and free from all debris. Care shall be taken to observe the correct lifting arrangements and to make sure that the slings are attached to the manufacturer's designated lifting points, where applicable. No parts shall be subjected to undue strains or sudden stresses which could cause damage to the equipment.

The lifting position mark indicated on packing casing shall be adhered to strictly for keeping it in required vertical position.

Contractor shall check and report to the Engineer-in-charge about any damaged item and/ or missing component and shall replace the same as per specifications. During installation, all accessories and loose items shall also be inspected by the contractor before their assembly/mounting.

Manufacturer checklist, manual for erection, installation and any specific requirement for equipment handling, installation and commissioning shall be strictly adhered to.

4.2 Following activities shall be done by contractor during various stages of installation

4.2.1 STAGE-I

When the sand bed reaches at the bottom level of vessel shell, the activities involved are as given below:

i) Making of slot in sand pad for Pre-packed MMO Wire Anode cable as per applicable drawing at surrounding of vessel sand layer.

ii) Check continuity of anode and cable before installation in sand pad to ensure healthiness. This shall be followed at each stage of anode installation.

iii) Provide anode identification marks on anode lead cable of each loops coming out from vessels. This shall be followed at each stage of anode installation.

iv) Laying of Pre-packed MMO Wire Anode at bottom sand layer of vessel as per drawing.

v) Making of pocket in sand pad for Ref. Cell as per applicable drawing at surrounding of vessel sand layer.

vi) Checking healthiness of Permanent Reference Cell before installation at different stages with respect to calibrated Master Reference Cell.

vii) Check continuity of reference cell cable before installation at different stages in sand pad to ensure healthiness.

viii) Laying of Ref. Cell inside the pocket & sand fill with proper compaction by using wooden pallet.

4.2.2 STAGE-II

When the sand bed reaches up to middle Level of the vessel shell, the activities involved are as given below.

i) Making of slot in sand pad for Pre-packed MMO Wire Anode cable as per applicable drawing at surrounding of vessel sand layer.

ii) Laying of Pre-packed MMO Wire Anode at Middle sand layer of vessel as per drawing.

4.2.3 STAGE-III

When the sand bed reaches the Top level of the vessel shell, the activities involved are as given below.

i) Making of slot in sand pad for Pre-packed MMO Wire Anode cable as per applicable drawing at surrounding of vessel sand layer.

ii) Laying of Pre-packed MMO Wire Anode at bottom sand layer of vessel as per drawing.

iii) Jointing of Pre-packed MMO Wire Anode strings end with anode lead cable by using In-line splice kits.

iv) Laying of Cathode cleat cable and its termination at CJB.

v) Laying of Measurement cleat cable and its termination at CJB.

vi) Connecting Cathode cable with cleat by Thermit welding on the Vessel.

vii) Connecting Measurement cable with cleat by Thermit welding on the Vessel.

viii) Making of pocket in sand pad for Ref. Cell as per applicable drawing at surrounding of vessel.

ix) Laying of Ref. Cell inside the pocket & sand fill with proper compaction by using wooden pallet.

4.2.4 STAGE-IV

The Activities which are to be performed outside the Mound area, the activities involved are as given below.

i) Installation of junction boxes (AJB, CJB) with mounting frame.

ii) Termination & connection of all the cables in the junction boxes (AJB, CJB etc.)

iii) Installation of Transformer rectifier unit.

iv) TR-unit connection of all incoming & outgoing cables & termination.

5.0 PRE-COMMISSIONING AND TESTING

i) After the equipment is installed properly in accordance with specifications, design documents, drawings and contractor shall carry out all pre-commissioning checks and tests as per EIL format in the presence of Engineer-in-charge and test readings shall be recorded and furnished to EIL in triplicate.

ii) It is anticipated that various installation checks have been previously accomplished and accepted during installation of CP equipment and facilities or otherwise to be carried out in conjunction with the commissioning activities.

iii) The pre-commissioning inspection among other requirements shall include visual inspection, checking the workmanship of the installation, the rating of equipment, safety clearances, sizes of cables installed, wiring properly dressed and labeled, sealing of unused cable entries, checking of all safety interlocks, control/interface functions as per requirement etc.

iv) The contractor shall bring to site all required tools, tackles and testing instruments for carrying out field testing. Contractor shall use only calibrated measuring and test instruments and shall maintain valid calibration record.

v) The inspection/test data sheets associated with pre-commissioning and commissioning of cathodic protection system shall be provided by vendor.

5.1 General Inspection

Prior to commissioning of the CP system and before energizing the transformer rectifier unit, the following activities shall be performed.

i) Review all test and inspection data sheets that have been previously accomplished during CP installation. All installation data results to be verified to ensure that inspection and testing have been carried out successfully.

ii) Review all CP design drawings, deviations if any shall be noted and incorporated in the as-built drawings.

iii) Visual inspections to be performed to ensure that all above ground (exposed) CP components and facilities are not physically damaged during or after CP installation works. Any discrepancies to be noted and necessary corrective actions shall be taken prior to commissioning.

iv) All CP cables to be checked for proper termination and identification as per schematic drawings.

5.2 Pre-Commissioning Check List

5.2.1 Transformer Rectifier

5.2.1.1 The following information to be obtained and recorded as a minimum

i) TR unit ID
ii) TR unit Manufacturer
iii) TR type/ model/ Sl. No.
iv) Sun Shed
v) TR Input and Output Rating
vi) Date of Inspection
vii) Name of Inspector

5.2.1.2 **Inspection**

The following inspections and checks shall be performed and recorded when the TR unit is in switched off condition.

i) Visual inspection of each TR (transformer rectifier) unit to be performed to ensure correct installation and that the unit has not been physically damaged prior to operation. Any discrepancies will be noted and rectified.

ii) All panel connections and terminals to be checked for tightness. Any loose connection shall be tightened.

iii) The polarity of the DC output cable to be verified to ensure that the positive output cables are connected to the anode terminals and the negative terminals are connected to the vessel.

iv) Verify that the power supply to the Transformer Rectifier (TR) corresponds to the required rating. Measure and record the AC supply voltage at the input terminals of the transformer rectifier circuit breaker.

v) Verify and ensure that the Transformer Rectifier is properly grounded to the earthing system.

vi) Ensure that all fuses are of proper current and voltage ratings. Check the continuity of all fuses and spares by an ohmmeter.

vii) Measure the insulation resistance between Transformer & TR body and earthing resistance between TR and earth.

viii) Check whether the output knobs are in minimum position.

ix) Check the colour of silica gel.

x) Ensure that TR (oil cooled) has at least minimum level of oil, if necessary, add more.

5.2.1.3 **Total Circuit Resistance Test**

i) After proper polarity of the DC output cables have been confirmed and the cables have been labelled with permanent tags, disconnect the anode and the cathode cables from the DC output terminal of the Transformer Rectifier.

ii) Using a four-pin resistance meter with P1/C1 and P2/C2 terminal shorted, connect the test leads of the instruments across the DC cables and measure the resistance.

iii) This testing will be done to measure the overall circuit resistance of the CP system and to ensure that no short circuit exist between the anode (positive) and cathode (negative).

iv) The result will be recorded in the AJB pre-commissioning data sheet.

5.2.2 **Anode Inspection**

i) Verify that the anode have been properly checked and accepted for compliance with the drawings and design during the installation works.

ii) Based on the above, check the power feed connections and verify that the cable is properly terminated and identified at the Anode Junction Box (AJB). Any discrepancies shall be rectified.

iii) The tests shall be performed at the AJB between the anode feeders. Continuity test to be carried out between all anode feeders lead cable to ensure electrical continuity of all anodes.

iv) The result will be recorded in the AJB pre-commissioning data sheet.

5.2.3 **Junction Boxes & PDB**

5.2.3.1 The following information shall be obtained and recorded as minimum:

i) Junction Box & PDB ID
ii) Number of Circuits
iii) Resistor Rating if present
iv) Shunt Rating, if present
v) Date of Inspection and Name of the Inspector

5.2.3.2 The following inspections shall be performed at each junction box.

i) A visual inspection of the junction box & PDB will be performed to ensure correct installation in accordance with the drawings and that the junction boxes & PDB have not been physically damaged prior to operation. Any discrepancies will be noted.

ii) All cable connections and terminals shall be checked for tightness. Any loose connections shall be tightened.
iii) All cables are to be checked for proper tagging and to ensure it is as per design /drawing.
iv) The result will be recorded in the pre-commissioning format.

5.2.4 **Natural Potential measurement**

Before energizing the transformer rectifier, the natural potential of vessel (partially filled with product) should be measured and recorded using permanent reference electrodes as well as using portable reference electrode.

5.2.4.1 **Potential Measurement using Permanent Reference Electrodes**

i) The vessel to soil potential measurement is obtained using high impedance multimeter (min. 10 Mega ohms).

ii) Attach the test lead from the positive terminal of the meter to the vessel at the junction box.

iii) Attach the test lead from the negative terminal of the meter to the permanent reference electrode point at the junction box.

iv) The vessel potential in millivolts is read directly from the meter.

v) Natural potential measurement using permanent reference electrode to be carried out at all reference electrode locations.

vi) Record the millivolts reading with polarity on the corresponding data sheet.

6.0 COMMISSIONING

After successful pre-commissioning of the cathodic protection equipment, the CP system is ready for testing, start up and commissioning. The contractor shall carry out complete testing and commissioning of material and equipment as per Inspection and test plans (ITP).

6.1 Before switching "ON" the transformer rectifiers the following condition should be met.

i) All CP cables inside junctions and TR are to be checked and corrected for any discrepancies.

ii) Natural potential of all structures involved in cathodic protection system has been measured and recorded.

iii) A close visual inspection of electrical equipment in hazardous area shall be made to ensure that equipment is suitable for the classified zone and gas group and correctly installed, with all covers, bolts, nuts and hardwares intact and there is no physical damage mark seen on the enclosure.

6.2 Commissioning Steps

The steps described below should be followed systematically during execution of final commissioning.

i) The transformer rectifier has been previously checked and tested during the pre-commissioning stages and the results are recorded in the data sheet. Read and study the transformer rectifier data sheet & operation manual to familiarize the system and result of the pre-commissioning test.

ii) Set the transformer rectifiers output control to 0% range and switch "on " the transformer rectifier.

iii) Gradually adjust the transformer rectifier's output power in manual mode.

iv) Measure and record the vessel to soil potential.

6.2.1 The following procedures should be followed when measuring the vessel to soil potential:-

i) For vessels with permanent reference electrodes, at each reference cell box, connect the negative lead of the meter on the reference cell and positive on the vessel. Record each reference electrode reading with respect to negative.

ii) Increase the transformer rectifier output in manual mode until the vessel bottom potential reaches the value as per specification [-850 to -1100 mV (typical)]. The "On" potential is not a true representation of the vessel protected potential. The instant "off" potential will be measured for final reading & conclusion. Before taking instant off potentials, the transformer rectifier should be kept energized until adequate polarisation is achieved (typically 24 to 48 hrs).

iii) Instant "Off" potential measurement is required to determine the IR drop free potential of the vessel.

iv) Final vessel to soil potential (instant off and on) will be measured by switching the rectifier output using current interrupter. Current interrupter shall be hooked-up to the transformer rectifier and programmed to switch in 1:4 ratio (1 second OFF and 4 second ON or any other cycle in the same ratio). Instant Off potential measurement is required to determine the IR drop free potential of the vessel.

v) Instant Off potential can be measured by the following procedures:

a) Switch off the transformer rectifiers.
b) Disconnect the positive header cable connected in the positive terminal of the transformer rectifier.
c) Install the Current interrupter in series with the positive header cable and positive terminal of the transformer rectifier.
d) Set the current interrupter in 1:4 ratio i.e. 1 second off and 4 seconds on or any other cycle in the same ratio.
e) Record the instant "off" and instant "on" potential in the commissioning data sheet. After recording, disconnect the current interrupter and return the transformer rectifier to its original connection.

vi) Check and record individual powers feed current in the junction box and record the results. Current shall be measured using digital clamp meter or digital multi meter.

vii) Check and record the output voltage and current in the transformer rectifier.

a) Check and record the output voltage and current in the transformer rectifier, when the instant 'OFF' potential value at all the reference electrode is in the range specified in the Specification (-0.850 to -1.1 V typical) after 48 hrs of polarization.

b) AVCC MODE: After recording the TR output DC voltage and current in Manual Mode at which all the reference electrodes show -0.85V to -1.1V in instant 'OFF' (typical figure) condition as described above, changeover the operation to constant voltage in AVCC mode and set the DC output voltage at the predetermined voltage recorded during Manual Mode of operation at which all the reference electrodes having potential in the range specified in the specification (typically -0.850V to -1.1V voltage) if necessary to ensure optimal protection potential at all the reference electrodes. Record the corresponding DC output current for the set voltage. This will be the final setting at which the unit will be left for operation and handed over to client. Individual current output of all the anode loops to be measured and recorded in AVCC mode voltage setting.

The results will be recorded in the commissioning data sheet.

7.0 RECORDS

i) Contractor shall keep up-to-date records of all activities carried out and test results. Field inspection/test/commissioning reports shall be submitted to EIL/Owner by contractor in bound volumes (triplicate copies)

ii) All equipment layout drawings shall be marked by the contractor for "AS BUILT STATUS" and two sets of hard copies shall be submitted to EIL.

8.0 HEALTH, SAFETY & ENVIRONMENT

i) Necessary PPE shall be utilized.

ii) Only trained / experienced personnel shall be deployed for this activity.

9.0 PRECAUTION

i) Care shall be taken for the proper connection of cables including Positive Header cable from Anode Junction Box to Positive (+ve) Terminal of TR Unit & Negative Header Cable from Structure to Negative (-ve) Terminal of the TR unit and interconnection cables

ii) Before the systems facilities are put into operation, necessary tests shall be carried out to establish that equipment's, devices and wiring connection have been correctly set up and connected in good condition for projected operation.

iii) Proper PPE shall be used.

iv) Trained personnel to be deployed for Commissioning.

v) Care should be taken while using MCB, AC/DC cable operation.

10.0 EQUIPMENT AND TOOLS

i) Portable Reference Electrodes ($Cu/CuSO_4$)

ii) Digital Multimeter

iii) Clamp-on meter

iv) Megger

v) CP / Electrical Tool Box

vi) Crimping tool

11.0 REPORTS

All the parameters recorded during the Testing & Commissioning at site will be recorded in inspection format as per approved QAP.

12.0 FORMATS (TYPICAL)

12.1 Pre-Commissioning Inspection and Test Plat Format

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Check Sheet			
Sl. No.	**Activity**	**Contractor**	**EIL/Owner**
1	Approval of Pre-Commissioning Check Procedure	P	A
2	Pre Commissioning Checks For Cu/$CuSO_4$ Reference Electrode and Anode using Anode Tail Cable	P	RM / W
3	ICCP System Cable Termination and Tagging	P	RM / W
4	ICCP unit Working Condition (No Load Condition)	P	W
5	Pre-Commissioning Checks of Earthing, Termination & Tagging for TR Unit and Junction Boxes	P	RM / W
Legends: A-Approval, RM-Random Check, W-Witness all, P- Perform			
Remarks:			

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

12.2 Quality Assurance Plan (QAP)

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Check Sheet

Sl. No.	Activity	CP Vendor	EPC Contractor	EIL/Owner	Remarks
1	Approval of Procedure for Testing & Commissioning	S	R	A&R	
2	Checking of Parameters as Per Procedure	P	W	R&W	
3	Measuring of Natural Potential	P	W	R&W	
4	Measuring of TR Unit Input & Output	P	W	R&W	
5	Measuring IR (insulation resistance) value of TR unit	P	W	R&W	
6	Check Circuit Resistance	P	W	R&W	
7	Measuring of Structure To Electrolyte Polarized Potential With Portable/ Permanent Cu/$CuSO_4$ Reference Cell.	P	W	R&W	
8	Measuring of Individual Anode Loop Current	P	W	R&W	
9	Measuring On - Instant Off Readings	P	W	R&W	
10	Running TR Unit in Auto mode (AVCC mode)	P	W	R&W	
11	Central Monitoring System (CMS)	P	W	R&W	

Legends: A-Approval, R- Review of Records, W-Witness All, P-Perform, S-Submitted By

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

12.3 Pre-Commissioning Check Format

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Pre-commissioning- Check Sheet			
Item-1	**Ref. Cell No.**	**Native Potential Reading (Volt)**	**Remarks**
1.1	RE-1		
1.2	RE-2		
1.3	RE-3		
....	....		
1.n	RE-N		
Item-2	**Anode String No.**	**Continuity test**	
2.1	A-1	OK/ Not OK	
2.2	A-2	OK/Not OK	
2.3	A-3	OK/Not OK	
...	....	OK/ Not OK	
2.n	A-N	OK/ Not OK	
Item-3	**TRU (no load test in manual mode)**	**Reading**	
3.1	AC input voltage	Volt	
3.2	AC input current	Amp.	
3.3	DC output voltage	Volt	
3.4	DC output current	Amp.	
Remarks (overall):			

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

12.4 Commissioning Check Format

Project	
Client/Owner	
Consultant	
Main Contractor	
CP Contractor	
Ref. Document	
Report No.	

Check Sheet (potential measurement using permanent Cu/$CuSO_4$ electrode)			
Item-1	**TRU**	**Reading**	**Remarks**
1.1	AC input voltage	Volt	
1.2	AC input current	Amp.	
1.3	DC output voltage	Volt	
1.4	DC output current	Amp.	
Item-2	**Permanent Ref. Cell No.**	**Initial Reading (Volt)**	**Reading after 24 hrs(Volt) 48 hrs (Volt)**
1.1	RE-1		
1.2	RE-2		
1.3	RE-3		
....	....		
1.n	RE-N		
Item-3	**Activity**	**Reading**	**Remarks**
3.1	Natural PSP		
3.2	Energised PSP		
3.3	ON PSP		
3.4	Instant Off PSP		
3.5	100 mV Shift		
Remarks (overall):			

For CP Vendor		For Main/EPC Contractor		Client/EIL	
Name		Name		Name	
Sign		Sign		Sign	
Date		Date		Date	

ई.ओ.टी. क्रेन
के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR E.O.T. CRANE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
8	28/03/24	REVISED AND REISSUED	VMG	PD	NK	MN
7	14/01/20	REVISED AND REISSUED	VMG	RRS	PPP	RKT
6	25/09/14	REVISED AND REISSUED	Anand	RRS	PB	SC
5	28/06/13	REVISED AND REISSUED	DS	SPC	PB	DM
4	07/07/10	REVISED AND REISSUED	SPC	PB	MK/DM	ND

Abbreviations:

BHN	:	Brinell Hardness Number
CT	:	Cross Travel
GA	:	General Arrangement
HTB	:	High Tensile Brass
IRS	:	Indian Railway Standard specification
IS	:	Indian Standard
LT	:	Long Travel
MOC	:	Material of Construction
MT	:	Metric Tonnes
QA	:	Quality Assurance
SS	:	Stainless Steel
SWL	:	Safe Working Load

Packaged Equipment Standards Committee

Convenor: Mr. Nalin Kumar

Members: Mr. Shishupal Choudhary
Mr. R.R Shrivastava (Coordinator)
Mr. Manos Biswas
Mr. K.C Paikar
Mr. A. Natarajan
Mr. Plaban Dan
Mr. Mayank Sharma
Mr. Deepak Kumar
Mr. Venkitesh M G
Mr. Aasheesh Handa (Projects)

Contents

1.0 GENERAL

1.1 This specification outlines the minimum requirements for design, engineering, manufacture and assembly at shop, painting, inspection, testing, supply and performance testing at site of Electric Overhead Travelling (EOT) Crane(s), complete with all accessories.

2.0 CODES AND STANDARDS

2.1 This standard is based on the following Indian Standards, and the standards referred therein, which shall be deemed to be part of this standard:

IS-3177	:	Code of practice for Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Work Cranes.
IS-807	:	Design, Erection and Testing (Structural Portion) of Cranes and Hoists – Code of practice
IS- 15560	:	Point hooks with shank up to 160 Tonne-Specification
IS-5749	:	Specification for Forged Ramshorn Hooks
IS- 3443	:	Specification for Crane Rail Sections
IS-2266	:	Steel Wire Ropes for General Engineering Purposes-Specification
IS-304	:	Specification for High Tensile Brass Ingots and Castings
IS-305	:	Specification for Aluminium Bronze Ingots and Castings
EIL Std.- 7-76-0103	:	Instructions to Vendor for Site Performance guarantee Requirements for Package units.

Latest revision of the above-mentioned standards as on the date of enquiry shall be applicable.

2.2 Other international standards may also be acceptable subject to their being equivalent or superior with prior approval of purchaser.

2.3 For provisions not covered by the above codes & standards, applicable good engineering practices and norms of the industry shall be applicable.

2.4 National laws and statutory provisions, together with any Local by-laws for the state wherein crane is required to be installed shall be complied with.

3.0 TECHNICAL REQUIREMENTS

Technical requirements of EOT Crane shall be as per Codes and Standards referred in clause 2.1 above, subject to the following additions, deletions and modifications:

3.1 Addition / Deletion / Modifications to IS-3177: 2020

i) Clause no. 1.4 (Addition): For EOT cranes in hazardous area application, the requirements of IS 3177 including the additions, deletions, modification covered in this standard specification shall be complied along with the Special requirements for hazardous area cranes covered in section 3.2 of this standard specification.

ii) Clause no. 7.4.5.8.2 (Modification): For double girder EOT crane, a full-length platform of minimum 750mm width shall be provided on drive side girder. Two short

platforms, each of minimum 750mm width and 900mm length shall be provided on non-drive side girder at both ends. In case the panels are to be mounted on the full-length platform, minimum clear width of 500 mm shall be ensured in front of the panels, on the platform.

iii) Clause no. 8.1 (Modification): Unless otherwise specified, for crane capacity of less than 50MT, lifting hooks shall comply with IS 15560 and for crane capacity of 50MT and above, lifting hook shall be Ramshorn type and shall comply with IS 5749. Laminated hooks are not acceptable.

iv) Clause no. 8.6 (Modification): Hook latch shall be provided on all hooks.

v) Clause no. 9.1 (Modification): Galvanized wire ropes with steel core, having tensile designation of '1960' and of either 6x36 or 6x37 construction shall be provided.

vi) Clause no. 9.9 (Modification): The drum shall be flanged on both ends.

vii) Clause no. 9.11 (Modification): Cast iron drum shall not be acceptable.

viii) Clause no. 12.1 (Modification): The wheel shall be made of forged steel. MOC of wheel shall be grade C55Mn75 of IS 1570 (Part 1 and Part 2/Sec 2), 42CrMo4 or superior.

ix) Clause no. 12.2 (Modification): Wheel hardness value specified is not applicable for HTB/ Aluminium bronze solid wheels/tyres.

x) Clause no. 12.3 (Addition): In case the wheels are with HTB / Aluminium Bronze tyres, the value of P_L (limiting pressure of wheel) shall be considered as the minimum value indicated in Table 6 (i.e. P_L =5), irrespective of the ultimate tensile strength of the steel (hub) portion of the wheel.

xi) Clause no. 12.7 (Addition): The width of wheel tread shall be at least 35 mm and 15mm more than the rail head, for Long travel and Cross travel wheels respectively, unless specified otherwise.

xii) Clause no. 13 (Addition): Limit switches for LT and CT motions shall be provided in such a way that drive motors are switched off before the buffers are pressed.

xiii) Clause no. 13.1 (Modification): Only Spring type buffers shall be used. Resilient Plastic / Hydraulic buffers are not acceptable.

xiv) Clause no. 16.1 (Addition): All bearings shall be anti-friction type with dust proof seals.

xv) Clause no. 20 (Addition): Unless otherwise specified, grouped grease lubrication shall be provided for each mechanism (CT, LT, Hoist/s) for double girder EOT Cranes. All grease piping shall be securely fixed. For LT motion, two groups (one at each end) shall be provided.

xvi) Clause no. 23 (Addition): Operator cabin shall be provided if the same is specified in the scope of work/Job specification forming part of the tender/requisition.

xvii) Clause no 35 (Addition): Bare conductors are not acceptable.

xviii) Clause no 35.2 (Addition): Repair cages shall be provided below the end carriage for maintenance of DSL (shrouded conductor system) and current collectors. The approach to repair cage will be provided from bridge platform by a ladder.

xix) Clause no. 35.2.2 (Modification): Unless otherwise specified, current conductor system or DSL system shall be provided by Crane supplier.

xx) Clause no. 53.5 (Addition): Unless otherwise specified, Radio Remote Control (RRC) along with the following additional features shall be provided:

a) There shall be common push button for siren and START and a separate push button for under bridge lights. Crane shall start with time delay after the siren is blown.

b) The working range of radio control shall be limited to 40 – 50 m from the transmitter.

c) EOT crane shall be supplied with Two (2) complete sets (1 working + 1 spare) Radio Remote control. Each set of Radio Remote Control shall consist of Transmitter suitable for respective electrical area classification, batteries and battery charger.

d) Necessary operating license/ permission, if required, for the RRC system on the Crane shall be arranged by the Vendor from the statutory bodies. License fee, if any, should be borne by the Vendor for the first time on behalf of Owner/EIL.

xxi) Clause no. 56 (Addition): Electro-hydraulic thruster type brakes are also acceptable for Hoisting motions and the same shall be provided with anti-drop circuitry to arrest dropping of load while brake is applied.

xxii) Clause no. 56.1.5 (Modification): Braking torque of the selected brakes shall not be less than 125 % of computed full load torque (as per the referred clause).

xxiii) Clause 35 to 63 – Section-3 (Modification): In case of any conflict between Electrical Specifications of Material Requisition/Tender and electrical requirements specified in the above referred sections of IS 3177, the former shall prevail.

xxiv) General (Addition):

a) Crane shall be designed for Mechanism Class "M5" as minimum unless otherwise specified in datasheet.

b) Unless otherwise specified, LT, CT & Hoist motion shall also be provided with creep speed. Creep speed shall be 10% of respective main LT, CT & Hoist speed.

c) The end carriage and CT crab shall be fitted with safety stops to prevent crane/crab from falling more than 25 mm in the event of breakage of a track wheel or axle.

d) End carriage/ crab shall be designed so as to enable the track wheels to be withdrawn readily. Jacking pads shall be provided for jacking up the crane for changing crane wheels.

e) For EOT crane capacity up to 50 MT, LT rail size shall be minimum IRS 52 and for EOT crane capacity above 50 MT, LT rail section shall be as per design calculation. However, for EOT crane capacity up to 5 MT, square bar (billet) section of minimum 50 mm X 50 mm may also be considered.

3.2 Special Requirements for Hazardous Area Cranes

i) MOC of wheel shall be solid construction in High Tensile Brass / Aluminium Bronze / SS or all Wheels shall be provided with High Tensile Brass/Aluminium bronze /SS tyres on core wheel of forged C55Mn75 as per IS 1570 (Part 1 and Part 2/Sec 2), 42CrMo4 or superior MOC. The minimum thickness of tyres shall be 30mm at the tread.

The minimum core diameter of the wheel on which the HTB / Aluminium bronze / SS tyre is shrunk, shall be calculated as per the formula given in Clause. no. 12.3 of IS-3177.

ii) Wheel hardness value as specified in Clause. no. 12.2 of IS-3177 is not applicable for Cranes having tyres / solid wheels of HTB / Aluminium bronze / SS.

iii) Main hoisting hook and Auxiliary hoisting hook material shall be of forged stainless steel / bronze coated forged steel.

iv) The buffer striking surface shall be lined with HTB/Aluminium bronze/Rubber/Polyurethane liner.

v) Any mechanism where two non-lubricated parts mate, one of them shall be of non-ferrous material like HTB or Aluminium Bronze.

vi) Coupling guards shall be non-ferrous/non-metallic type.

vii) All electrical components/equipment shall meet the requirements of respective area classification.

3.3 Noise level shall not exceed 85 dB (A) at one (1) meter distance from the source of noise.

4.0 INSPECTION AND TESTING

4.1 Equipment shall be subjected to stage-wise expediting, inspection and testing at vendor's/sub-vendor's works by purchaser/its authorised inspection agency. Vendor shall submit Quality Assurance (QA) plan before commencement of fabrication. Approved QA plan shall form the basis for equipment inspection.

4.2 Testing at Works

4.2.1 Vendor shall perform tests and inspection necessary to ensure that the material and workmanship conform to the requirement of Clauses 64 and 65 of IS-3177. Load and over load tests shall also be carried out at vendor's works.

4.2.2 Any or all the tests, at purchaser's option, shall be witnessed by purchaser/its authorised inspection agency. However, such inspection shall be regarded as check-up and shall in no way absolve the vendor of his responsibility.

4.3 Performance Testing and Guarantees

4.3.1 A field performance test shall be conducted by the vendor to demonstrate the performance of the equipment after commissioning in accordance with PG test procedure prepared as per EIL Standard 7-76-0103.

The procedure of performance testing shall be submitted for Purchaser's review and shall be mutually agreed between the purchaser and the vendor.

4.3.2 A field performance test shall be conducted by the vendor to demonstrate the performance of the Crane after commissioning as per clause 66 of IS-3177. Following parameters shall be guaranteed.

i) SWL of Main and Auxiliary Hoists

ii) LT, CT and Hoisting Speeds.

iii) Deflection of bridge girder (deflection shall be within the limits specified under clause 20 of IS-807).

4.3.3 All parts of the crane shall operate satisfactorily with no undue friction, noise or display of any other unfavourable characteristics during the performance test.

4.3.4 All equipment and component parts shall be guaranteed by the vendor against defective material and design for a period as specified in Purchaser's general purchase conditions.

4.3.5 If any defect occurs during the guaranteed period the Vendor shall make all necessary alterations, repairs and replacement at their own cost.

4.3.6 Necessary instruments for the performance testing shall be arranged by the vendor, and shall be tested and calibrated before undertaking the performance test. Only test load shall be provided by purchaser near test site.

5.0 PROTECTION AND PAINTING

5.1 Surface preparation and painting shall be done as per Specification for Surface preparation and protective coating attached elsewhere with the enquiry/purchase document.

5.2 Surface preparation and paintings for all bought out components shall be as per respective sub-vendor's standards suitable for industrial corrosive environment.

5.3 The colour of Crane shall be golden yellow, unless otherwise specified.

5.4 All machined and bearing surfaces shall be protected against rust with a thick coat of grease.

6.0 PACKAGING AND IDENTIFICATION

6.1 All packaging shall be done in such a manner as to reduce the volume. The equipment shall be dismantled into major components, suitable for shipment and shall be properly packed to provide adequate protection during shipment. All assemblies shall be properly match marked for site erection.

6.2 Attachments, spare parts of the equipment and small items shall be packed separately in wooden-cases. Each item shall be appropriately tagged with identification of main equipment, item denomination and reference number of the respective assembly drawing.

6.3 Detailed packing list in water-proof envelope shall be inserted in the package together with equipment.

6.4 Each equipment shall have an identification plate giving salient equipment data, make, year of manufacture, equipment number, name of manufacturer etc.

6.5 Vendor shall furnish procedure for prolonged storage of supplied equipment/ material at site.

7.0 SPARE PARTS

7.1 Vendor shall submit list of spare parts with recommended quantities and itemised prices for first two years of operation of the equipment. Proper coding and referencing of spare parts shall be done so that later identification with appropriate equipment is facilitated.

7.2 Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor's service facilities around the proposed location of equipment.

7.3 Vendor shall supply adequate quantity of commissioning spares. The commissioning spares shall be sufficient for trouble free commissioning of the system at site. Any commissioning spares required during commissioning, over and above, the commissioning spares supplied, shall be made available by the vendor without any cost and time implication to purchaser. If for any reason, during commissioning, vendor needs to utilise spares from 2 years' operation spares (if already available at site), the same shall be replenished by vendor within a reasonable time without any cost implication to purchaser. Any unused commissioning spares shall be handed over to owner.

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STANDARD SPECIFICATION FOR H.O.T. CRANE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	25.02.22	REVISED AND REISSUED	DS	PD	NK	SM
4	01.04.16	REVISED AND REISSUED	MS	SPC	PB/RKT	RN
3	13/08/10	REVISED AND REISSUED	SPC	PB	MK/DM	ND
2	31/07/06	REVISED AND REISSUED	PPP	AK	SMA	VJN
1	05/08/99	REVISED AND REISSUED	AK	SMA	NN	AS
0	28/12/94	ISSUED AS STANDARD SPECIFICATION	AK	SSC	DKD	AS

Abbreviations:

CI	:	Cast Iron
CS	:	Cast Steel
CT	:	Cross Travel
HTB	:	High Tensile Brass
IS	:	Indian Standard
LT	:	Long Travel
QA	:	Quality Assurance
SS	:	Stainless Steel
SWL	:	Safe Working Load

Packaged Equipment Standards Committee

Convenor : Mr. Nalin Kumar

Members: : Mr. Shishupal Choudhary (Coordinator)
Mr. R.R. Shrivastava
Mr. K.C. Paikar
Mr. A. Natarajan
Mr. Plaban Dan
Mr. Deepak Kumar
Mr. Venkitesh M.G.
Mr. Ayush Mathur (Projects)

CONTENTS

1.0 GENERAL

This specification outlines the minimum requirements for design, engineering, manufacturing and assembly at shop, painting, inspection, testing, supply and performance testing at site of Hand Operated Overhead Travelling (H.O.T) crane, complete with all accessories.

2.0 CODES AND STANDARDS

2.1 This standard is based on the following Indian Standard, and the standards referred therein, which shall be deemed to be part of this standard:

IS 28	:	Phosphor Bronze Ingots and Castings
IS-210	:	Grey Iron Castings-Specification
IS 304	:	High Tensile Ingots and Castings
IS 305	:	Aluminium Bronze Ingots and Castings
IS:807	:	Code of Practice for Design, manufacture, erection and testing (structural portion) of cranes and hoists.
IS:1570	:	Schedule for Wrought Steels
IS:2429	:	Specification for Round Steel Short Link Chains (Electric Butt Welded), Grade I.(3)
IS:3177	:	Code of Practice for Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Work Cranes. (As applicable)
IS:3443	:	Crane Rail Sections.
IS:3832	:	Hand-operated Chain Pulley Block-Specification.
IS: 15560	:	Specification for Point hooks with shank up to 160 Tonne.
EIL Std.-7-76-0103	:	Instructions to vendor for site performance guarantee requirements for packaged units.
EIL Spec.-6-81-0136		Inspection and Test Plan for H.O.T crane

Latest revision of the above-mentioned standards as on the date of enquiry shall be applicable. For hazardous area application, following additional standards shall also govern.

2.2 Other international standards may also be acceptable subject to their being equivalent or superior with prior approval of purchaser.

2.3 For provisions not covered by the above codes & standards, applicable good engineering practices and norms of the industry shall be applicable.

2.4 National Laws and statutory provisions together with any local bylaws for the state wherein package is required to be installed shall be complied with.

3.0 TECHNICAL REQUIREMENT

Technical requirements of H.O.T Crane shall be as per Indian Standards referred in clause2.1 above, subject to the following additions, deletions and modifications:

3.1 Addition / Deletion / Modifications to IS-3177: 1999 (Reaffirmed 2015)

i) Clause no..4.2.b (Deletion): Clause deleted.

ii) Clause no..4.2.f (Deletion): The part "such as motors" from sentence deleted.

iii) Clause no. 7.4.8 (Deletion): Clause deleted.

iv) Clause no. 8.1.2 (Modification): Hook latch shall be provided on all hooks.

v) Clause no. 8.3 (Deletion): Clause deleted.

vi) Clause no. 8.4 (Deletion): Clause deleted.

vii) Clause no. 8.5 (Deletion): Clause deleted.

viii) Clause no. 8.6.1 (Addition): Wheels for Crane shall be double flanged when the crane /hoist are top running type and shall be single flanged when the crane/ hoist is underslung type. The tread and flange of wheels shall be machined accurately to size and flanges shall be tapered and radiused. The wheels shall be of single piece type. However for cranes working in hazardous area, wheels with tyre of non-ferrous metallurgy as specified in cl. no. 3.6 below shall be provided.

ix) Clause no. 8.6.3 (Modification): Wheel hardness shall not be applicable for hazardous area Cranes having HTB/Aluminium bronze tyred wheels.

x) Clause no. 8.6.4 (Modification): For Cranes working in hazardous areas, wheels shall be provided with HTB/Aluminium bronze tyres. The minimum thickness of tyres shall be 30mm at the tread.

xi) Clause no. 8.6.6 (Addition): For wheels with HTB/Aluminium bronze tyres, the minimum tread diameter of the wheel on which the HTB/Aluminium bronze tyre is shrunk, shall be calculated as per the formula given in IS-3177.

xii) Clause no. 8.6.11(Addition): The width of wheel tread shall be at least 35mm and 15 mm greater than the rail head, for Long travel and Cross travel wheels respectively, unless specified otherwise.

xiii) Clause no. 8.7.1 (Modification): Only anti-friction bearings shall be used. Bearing enclosure shall be dust tight. Bearing caps/nipples shall be provided with fittings for lubrication.

xiv) Clause 8.7.3 (Deletion): Clause deleted.

xv) Clause 8.8.3 (Deletion): Clause deleted.

xvi) Clause 8.11.2 (Modification): Buffers shall be made from resilient plastic, rubber or polyurethane.

xvii) Clause 8.12 (Deletion): Clause deleted.

xviii) Clause 9.1 (Deletion): From second paragraph the sentence "suitable guards shall be provided on the down shop lead side to prevent accidental contact between wire ropes or hook block or lifting attachments and live conductors" shall be deleted.

xix) Clause 9.2 (Deletion): The term "electrical" deleted.

xx) Clause 9.3 (Deletion): The term "electrical" deleted.

xxi) Clause 11.2.b (Deletion): Clause deleted.

xxii) Clause 11.4.f (Deletion): Clause deleted.

xxiii) Clause12 to 25 (Section 3)(Deletion):Clause deleted.

xxiv) Clause 26.2 (Deletion): The term "electrical" deleted.

xxv) Clause 26.3.10 to 26.3.17 (Deletion): Clause deleted.

xxvi) Clause 28.1 &2(Deletion): Clause deleted.

xxvii) Clause 28.3(Modification): Load test shall be carried out to the extent applicable for H.O.T crane.

3.2 Addition / Deletion / Modification to IS 807: 2006 (Reaffirmed 2020)

i) Clause no. 24.1 (Addition): End carriage shall be made from rolled steel sections welded together to form a box. The design shall be such that the load is uniformly distributed. For the attachment of end carriages to the main girders, gusset plates or diagonal bracings shall be employed to provide lateral strength.

End carriages shall be designed so as to enable the track wheels to be withdrawn readily. Jacking pads shall be provided for jacking up the crane for changing crane wheels.

ii) Clause no. 24.2 (Addition): Square bar type rail may be provided for LT motion, if specified in data sheet.

3.3 Addition / Deletion / Modification to IS 3832: 2005 (Reaffirmed 2020)

i) Clause no. 4.2.1 (Modification): Mechanism class 2 shall be considered for design of chain pulley Block unless otherwise specified in the data sheet.

ii) Clause no.5.1(Addition): The frame shall be built from steel plates with bolted/welded construction.

iii) Clause no. 5.2 (Addition): All gears shall be machine cut.

iv) Clause no. 5.5 (Addition): Only anti friction bearing shall be used.

v) Clause no. 5.6 (Modification): The block shall be provided with adequate facilities for lubrication and same shall be clearly indicated in the maintenance manual.

vi) Clause no. 5.7.1 (Addition): Hooks (both top and bottom) shall be provided with safety latches to prevent accidental unhooking unless otherwise stated.

vii) Clause no. 5.7.1.2 (Modification): First line to be modified as "Bottom hook shall be provided with thrust bearing to enable it to rotate freely under load so as to prevent twisting of the load chain."

viii) Clause no. 5.10.3 (Modification): The length of hand chain shall be such that the lowest point of the suspended loop shall be 400 mm (maximum) above operating level.

ix) Clause no. 5.11 (Addition): The trolley for the chain pulley block shall be geared type, fabricated construction, 4 wheeled, driven by hand chain and shall have provision for mounting the chain pulley block. Trolley shall be designed to suit the suitable joist size and the hoisting capacity.

x) Clause no. 11.1 (Addition): Following shall also be marked on Chain Pulley Block:

a) "Non Sparking Type" on chain Pulley Block suitable for hazardous area.

xi) Clause no. 11.2 (Modification): The chain pulley block shall carry ISI (BIS) stamp for safe area application.

3.4 Additional requirements

i) The Crane may be under slung type if specifically asked in data sheet. For under slung cranes, geared type four wheeled trolley shall be provided. The wheels/runner shall be suitable for the flange of the I sections used for the girders.

ii) The bridge drive assembly shall consist of reduction gear assemblies with shaft extensions and couplings to connect the bridge cross shaft extensions to truck wheels. The travelling motion shall be communicated by endless hand chain wheel to a steel cross shaft, positively driving one travelling wheel in each end carriage. The cross shaft shall be suitably supported. The wheels and cross shaft shall have roller/ball bearings.

iii) Cross traversing motion shall be transmitted through suitable gearing by an endless hand chain and chain wheel.

3.5 The following material shall be used for construction of various parts of the crane. However, equivalent or superior metallurgy is also acceptable subject to review and approval by Client /Consultant.

Sl. No.	Name of Part	Material
1.	Girder	CS weldable quality as per IS 2062 (100% Radiography to be taken on all Butt welded joints)
2.	End carriage	CS weldable quality as per IS 2062
3.	Hand chain wheel for trolley	CI grade 25 of IS 210, or fabricated steel or pressed steel metal.
4.	Hand chain for LT and Trolley	Grade I.3 as per IS 2429
5.	CT trolley	CS weldable quality as per IS:2062
6.	Rails for LT	Crane rails as per IS:3443 or Square Bar as per IS: 2062, as applicable.
7.	Wheels for LT	55C8 (Old designation:C55Mn75) as per IS:1570 (part 2/sec 1)
8.	Gears	45C8 (Old designation:C45)as per IS:1570 (part 2/sec 1)
9.	Pinions	50C4 (Old designation:C50) as per IS:1570 (part 2/sec 1)
10.	Shafts	30C8 (Old designation:C30) as per IS:1570 (part 2/sec 1)
11.	Axles	45C8 (Old designation:C45) as per IS:1570 (part 2/sec 1)
12.	Couplings	Forged steel as per IS:1570
13.	Suspension pin in the trolley	50C4 (Old designation:C50) as per IS:1570 (part 2/sec 1)

All materials shall be of tested quality and shall conform to the standards as mentioned above.

3.6 Special Requirements for Hazardous Area Cranes

3.6.1 For H.O.T. Crane to be located in hazardous area, non-sparking type design features shall be incorporated. Basic approach for such application calls for use of non-ferrous material for one out of two mating parts for a non-lubricated mating/striking pair.

3.6.2 The suggested materials for such components are as follows

	Part/Component	Material of Construction
A	**Lifting Mechanism**	
	Ratchet wheel, chain guides	Solid construction in Aluminium Bronze/ High Tensile Brass /Stainless Steel
	Hand chain wheel	Solid construction of Aluminium Bronze/ Phosphor Bronze/ High Tensile Brass /Stainless Steel
	Load chain wheel	Solid construction in Aluminium Bronze/ High Tensile Brass/Stainless Steel

	Hook (Top & bottom)	Bronze coated forged steel/Bronze coated forged alloy steel/Forged Stainless Steel
B	**Trolley Mechanism**	
	Hand chain wheel guides	Solid construction in Aluminium Bronze/ Phosphor Bronze/ High Tensile Brass /Stainless Steel
	Hand chain wheel	Solid construction of Aluminium Bronze/ Phosphor Bronze/ High Tensile Brass /Stainless Steel
	Ungeared and geared wheels	Solid construction in Aluminium Bronze/ High Tensile Brass/Stainless Steel or Tyre of Aluminium Bronze/ High Tensile Brass /Stainless Steel shrunk fitted on core wheel of C55Mn 75 or equivalent/superior MOC.
C	**LT Mechanism**	
	LT wheels	Solid construction in Aluminium Bronze/ High Tensile Brass /Stainless Steel or Tyre of Aluminium Bronze/ High Tensile Brass /Stainless Steel shrunk fitted on core wheel of C55Mn 75 or equivalent/superior MOC.

3.6.3 Phosphor Bronze, High Tensile Brass and Aluminium Bronze shall conform to IS 28, IS 304 and IS 305 respectively.

3.6.4 The minimum thickness of tyres shall be 30mm at the tread.

4.0 INSPECTION AND TESTING

4.1 Equipment shall be subjected to stage wise inspection and testing at vendor's/sub-vendor's works by purchaser/its authorised inspection agency. Vendor shall list out all items in the H.O.T Crane for inspection categorization. Subsequently, detailed Quality Assurance Plan (QAP) shall be submitted for review / approval. Approved Quality Assurance (QA) plan shall form the basis for equipment inspection.

4.2 Testing at Works

4.2.1 Vendor shall perform tests and inspection necessary to ensure that the material and workmanship confirm to the requirement of this specification.

4.2.2 Vendor shall submit to the purchaser, for his review and comments, detailed procedures for all running tests and all specified optional tests, including acceptance criteria for all monitored parameters. Inspection and Test Plan (ITP) for H.O.T crane is attached with the requisition. The same shall form basis of Inspection and Testing of the package. For the items for which no ITP has been attached with requisition, vendor shall furnish their job specific ITP during detail engineering which shall be subject to review/ approval by purchaser/its authorised inspection agency.

4.2.3 Testing at vendors works shall be carried out in accordance with IS:3177 and 3832 and shall include following tests as minimum:

- Full load and 125% overload test for hoist & cross travel motions at works (chain pulley block shall be separately tested for operational proof as per cl. No. 9.2 of IS 3832).
- Deflection Test at Works.

4.2.4 Any or all the tests, at purchaser's option, shall be witnessed by purchaser/its authorised inspection agency.

The shop tests besides being witnessed by Purchaser's/Consultant's Inspector may also be witnessed by Owner's/Consultant's equipment specialists. Vendor shall inform the purchaser about the scheduled test dates six (6) weeks in advance and reconfirm the firm date of testing one (1) week in advance

4.2.5 Acceptance of shop tests shall not constitute a waiver of requirements to meet field tests or performance guarantee under the specified operating conditions, nor such inspection & testing shall absolve the Vendor of his responsibilities in any way whatsoever.

However, such inspection shall be regarded as check-up and in no way absolve the vendor of his responsibility.

4.3 Performance Testing and Guarantees at Site

4.3.1 A field performance test shall be conducted by the vendor to demonstrate the performance of the equipment after commissioning in accordance with test procedure prepared as per EIL Standard 7-76-0103.

4.3.2 Testing at site shall be carried out in accordance with IS: 3177.Following parameters shall be guaranteed and demonstrated during the performance testing.

i) SWL of Hoist

ii) Deflection of bridge girder (deflection shall be within limits specified in IS-807)

4.3.3 All parts of the crane shall operate satisfactorily with no undue friction, noise or display of any other unfavourable characteristics during the performance test.

4.3.4 All equipment and component parts shall be guaranteed by the vendor against defective material and design for a period as specified in Purchaser's general purchase conditions.

4.3.5 If any defect occurs during the guaranteed period the Vendor shall make all necessary alterations, repairs and replacement at their own cost.

4.3.6 Necessary instruments for the performance testing shall be arranged by the vendor, and shall be tested and calibrated before undertaking the performance test. Only test load shall be provided by purchaser near test site.

5.0 PROTECTION AND PAINTING

5.1 Unless otherwise specified in job specification, surface preparation and painting system for fabricated items shall be as below:

Surface preparation	Primer	Finish Paint
SSPC-SP-10 (SA-2 ½)	• One (1) coat of P-9 (Inorganic zinc silicate coating) @ 65-75 µm DFT/coat. • One (1) coat of P-6 (Epoxy zinc phosphate primer) @ 40 µm DFT/coat.	• Two (2) coats of F-6B (polyamide cured epoxy resin medium suitably pigmented) @ 100 µm DFT/coat • One (1) coat of F-2 (Acrylic-Polyurethane finish paint) @ 40µm DFT/coat. Total DFT of Primer + finish shall be 345 (minimum).

Refer Table Nos. 5.1, 5.2 and 5.3 attached at the end of this specification for the properties of different paints (primer/finish paint) as mentioned above.

5.2 Stainless steel surfaces, both inside and outside, shall be pickled and passivated.

5.3 Machined and bearing surfaces shall be protected with thick coat of grease.

5.4 Surface preparation and paintings for all bought out components shall be as per respective sub-vendor's standards suitable for industrial corrosive environment.

5.5 The colour of Crane shall be golden yellow (RAL 1004), unless otherwise specified.

6.0 PACKAGING AND IDENTIFICATION

6.1 All packaging shall be done in such a manner as to reduce the volume. The equipment shall be dismantled into major components, suitable for shipment and shall be properly packed to provide adequate protection during shipment. All assemblies shall be properly match marked for site erection.

6.2 Attachments, spare parts of the equipment and small items shall be packed separately in wooden-cases. Each item shall be appropriately tagged with identification of main equipment, item denomination and reference number of the respective assembly drawing.

6.3 Detailed packing list in water-proof envelope shall be inserted in the package together with equipment.

6.4 Each equipment shall have an identification plate giving salient equipment data, make, year of manufacture, equipment number, name of manufacturer etc.

6.5 Vendor shall furnish procedure for prolonged storage of supplied equipment/ material at site.

7.0 SPARE PARTS

7.1 Vendor shall submit list of spare parts with recommended quantities and itemised prices for first two years of operation of the equipment. Proper coding and referencing of spare parts shall be done so that later identification with appropriate equipment is facilitated.

7.2 Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor's service facilities around the proposed location of equipment.

7.3 Vendor shall supply adequate quantity of commissioning spares. The commissioning spares shall be sufficient for trouble free commissioning of the system at site. Any commissioning spares required during commissioning, over and above, the commissioning spares supplied, shall be made available by the vendor without any cost and time implication to purchaser. If for any reason, during commissioning, vendor needs to utilise spares from 2 years' operation spares (if already available at site), the same shall be replenished by vendor within a reasonable time without any cost implication to purchaser. Any unused commissioning spares shall be handed over to owner.

TABLE No. 5.1 PRIMERS

SL No.	DESCRIPTION	P-2	P-4	P-6	P-7
1	Technical name	Chlorinated rubber Zinc Phosphate primer.	Etch primer/wash primer	Epoxy zinc phosphate primer	ZINGA, LOCKTITE or ZRC cold galvanizing
2	Type and composition	Single pack, air drying chlorinated rubber based medium plasticised with unsaponifiable plasticizer, pigmented with zinc phosphate.	Two pack polyvinyl butyral resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate.	Two component polyamine cured epoxy resin medium, pigmented with zinc phosphate.	One pack Synthetic Resin based zinc galvanizing containing min 92% of electrolytic zinc dust of 99.95% purity.
3	Volume Solids %	40 ±3	10±1	50±1	37%
4	DFT (Dry Film thickness) per coat in microns	40-45	8-10	40-50	40-50µ
5	Theoritical covering capacity in M^2/coat/ litre	8-10	8-10	8-10	4m²/kg
6	Weight per litre in kgs/litre	1.3±0.05	1.2±0.05	1.4±0.05	2.67 kg at 15°C
7	Touch dry at 30°C (minimum)	30 minutes	2 hrs.	After 30 min.	10 minutes
8	Hard dry at 30°C (maximum.)	8 hrs.	24 hrs.	8 hrs	24 hrs.
9	Overcoating interval	Min.: 8 hrs	Min: 4-6 hrs.	Min.:8hrs.	Min.:4 hrs
10	Pot life at 30°C for two component paints	Not Applicable	Not applicable	6 - 8 hrs.	Unlimited
11	Temperature (Resistance (minimum)	60 °C Dry service	NA Dry service	80°C Dry service	50°C Dry service

TABLE No. 5.2FINISII PAINTS

Sl No	DESCRIPTION	F-2	F-3	F-6A/B	F-6C	F-7
1	Technical name	Acrylic Polyurethane finish paint	Chlorinated rubber based finish paint	Epoxy-High Build coating	Solvent less epoxy coating	High build coal tar 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.	F-6A Two-pack Aromatic amine cured epoxy resin medium suitably pigmented. F-6B: polyamide cured epoxy resin medium suitably pigmented	Two pack, cured with Amine Adduct; catalyzed epoxy resin suitably pigmented	Two pack polyamide cured epoxy resin blended with coaltar medium, suitably pigmented
3	Volume Solids %	40 ± 3	38±2	60±3	99±1	65±3
4	DFT (Dry Film thickness) per coat in microns	30-40µ	30-40	100-125µ	200-500	100-125µ
5	Theoritical covering capacity in M^2/coat/litre	11-15	11-15	5-6	2-3	5.2-6.5
6	Weight per liter in kgs/litre	1.15±0.03	1.15±0.03	1.42±0.03	1.40±0.03	1.40±0.03
7	Touch dry at 30°C	30 minutes	30 minutes	3 hrs.	3 hrs.	4 hrs.
8	Hard dry at 30°C (max) Full cure at 30°C (for immersion/ high temperature service)	8 hrs	8 hrs	16 hrs 5 days	16 hrs	48 hrs 5 days
9	Over-coating interval at 30 °C	Min. 12 hrs.	Min.: Overnight	Min.: Overnight Max.: 5 days	Min.: 8 hrs. Max.: 48 hrs.	Min.: 24 hrs Max.: 5 days.
10	Pot life (approx.) at 30°C for two component paints	6-8 hrs.	Not applicable	4-6 hrs	30 minutes	4-6 hrs.
11	Temperature Resistance (minimum)	80 °C Dry service min	60 °C Immersion service	80°C Dry service	120°C(Dry service), 50°C (Immersion service)	125°C Immersion service

TABLE No. 5.3FINISH PAINTS

Sl. 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 silicate coating	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C dry temp.	Heat resistant silicone Aluminium paint suitable upto 500°C dry temp.
2	Type & composition.	Two pack epoxy resin based suitable 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 with minimum 80% zinc content on dry film. The final cure of the dry film shall pass the MEK rub test.	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C.	Single pack silicone resin based medium with Aluminium flakes.
3	Volume Solids %	78±3	60±3	38±0.03	20±2
4	DFT (Dry Film thickness) per coat in microns	100-125	65-75µ	15-20µ	15-20µ
5	Theoritical covering capacity in M^2/coat/ litre	6.0-7.2	8-9	10-12	8-10
6	Weight per liter in kgs/litre	1.41±0.03	2.3±0.03	0.95±0.03	1.00±0.03
7	Touch dry at 30°C (maximum)	3 hrs.	30 minutes.	3 hrs.	30 minutes.
8	Hard dry at 30°C (maximum) Full cure 30°C (for immersion /high temperature service)	24 hrs 5days	12 NA	12 hrs NA	24 hrs NA
9	Over-coating interval	Min.: 10 hrs	Min.: 12 hrs.at 20°C & 50 % RH	Min. 24 hrs	Min.: 24 hrs
10	Pot life at 30°C for two component paints	90 minutes.	4-6 hrs.	Not applicable	Not applicable
11	Temperature Resistance (minimum)	80 °C Dry service	400 °C Dry service	250°C Dry service	500°C Dry service

NOTES (for tables 5.1 to 5.3):

1. Covering capacity and DFT depends on method of application. Covering capacity specified above are theoretical. Allowing the losses during application, min 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 instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship should be ensured. In case of conflict between this specification and manufacturer's recommendation, the same shall be clarified through EIL SMMS department.

उच्च वोल्टेज स्विचबोर्डों के लिए मानक विनिर्देश

SPECIFICATION FOR MEDIUM VOLTAGE SWITCHBOARDS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
8.	20.11.2024	REVISED & ISSUED AS STANDARD SPECIFICATION	VB/MKM	RKS	HK	MN
7.	10.01.2019	REVISED & ISSUED AS STANDARD SPECIFICATION	VB	HK	BRB	RKT
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Abbreviations:

A	Ampere
AC	Alternating Current
BIS	Bureau of Indian Standards
BS	British Standard
CNT	Close-Neutral-Trip
CEA	Central Electricity Authority
CPRI	Central Power Research Institute
CRCA	Cold Rolled Cold Annealed
CT	Current Transformer
DC	Direct Current
EPDM	Ethylene Propylene Diene Monomer
FBT	Fast Bus Transfer
FRP	Fiber Reinforced Polyester
MV	Medium Voltage
Hz	Hertz
IAC	Internal Arc Classification
IEC	International Electro-Technical Commission
IEEE	Institute of Electrical & Electronics Engineer
IP	Ingress Protection
kV	Kilo Volt
kW	Kilo Watt
kWH	Kilo Watt Hour
LED	Light Emitting Diode
LOTO	Lock-Out Tag-Out
LSC	Loss of Service Continuity
MCB	Miniature Circuit Breaker
MCC	Motor Control Center
MCCB	Moulded Case Circuit Breaker
NEMA	National Electrical Manufacturers Association
NO	Normally Open Contact
NC	Normally Close Contact
OTMS	Online Temperature Monitoring System
PO	Purchase Order
PT	Potential Transformer
PU	Polyurethane
p.u.	Per unit
PVC	Poly Vinyl Chloride
RAL	Reichs-Ausschuss fur Lieferbedingungen
SF_6	Sulphur Hexafluoride
SWG	Standard Wire Gauge
VCB	Vacuum Circuit Breaker
VDE	Verband Deutscher Elektrotechniker
VFD	Variable Frequency Drive
VT	Voltage Transformer
XLPE	Cross linked Poly Ethylene

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CONTENTS

1.0 SCOPE

This specification covers the design, manufacture, testing, packing and supply of indoor, drawout type Medium Voltage Switchboards >1 kV up to and including 33 kV, incorporating Vacuum or SF_6 circuit breakers.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS: 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2071	High Voltage Test Technique
IS: 2544	Porcelain post-insulators for systems with nominal voltage greater than1000V
IS: 2705-1	Current transformers specification: Part 1 General Requirements
IS: 3618	Specification for phosphate treatment of iron and steel for protection against corrosion
IS: 5082	Wrought aluminium and aluminium alloy bars, rods, tubes, sections, plates and sheets for electrical applications
IS: 5578	Guide for marking of insulated conductors
IS: 6005	Code of practice for phosphating of iron and steel
IS: 16227	Instrument transformers
IS: 11353/ IEC 60445	Basic and safety principles for man-machine interface marking and identification - identification of equipment terminals conductor terminations and conductors
IS: 13703-4	Specification for low - voltage fuses for voltages not exceeding 1000V AC or 1500V DC : supplementary requirements for fuse links for the protection of semiconductor devices
IEC 60282-1	High voltage fuses – Current Limiting fuses
IS/IEC 60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000'V
IS/ IEC 60529	Degree of Protection provided by Enclosure
IS/IEC 62271 (Part 1, 100, 102, 103, 105, 106, 200, 201, 301)	High Voltage Switchgear and Controlgear
IEC 62271	High Voltage Switchgear and Controlgear

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, most stringent requirement shall govern and decision of Owner/ EIL in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven track record of the manufacturer of similar product. No equipment without mandatory type test shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The switchboards shall be suitable for installation and satisfactory operation in an air conditioned/ pressurised sub-station or in a substation with restricted natural air ventilation or in a covered shed/ enclosed electrical room (e-room) in a tropical, humid and corrosive atmosphere.

4.2 The switchboards shall be designed to operate under site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000 metres above mean sea level shall be considered.

4.3 All equipments described in this specification are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIEMENTS

5.1 Enclosure and Protection

5.1.1 The Medium Voltage Switchboard shall be metal-enclosed and shall comprise of standard pre-fabricated, cold-rolled, sheet steel units, assembled to form a rigid, freestanding, dead-front structure. As a minimum, 2mm (14 SWG) CRCA sheet steel shall be used for all front and rear doors and covers, and 1.6mm (16 SWG) CRCA sheet steel for inter-panel partitions. Wherever required, stiffeners shall be provided to increase stiffness of large size doors and covers.

As an alternative to CRCA, Aluzinc/pre-galvanised sheet steel can also be provided for internal inter-panel partitions only. However, all external surface shall be of CRCA with specified paint shade.

5.1.2 Vertical panels shall be assembled to form a continuous line-up of uniform height both for HV chamber as well as control chamber. Rear extension panels shall also be of full height. However, HV chamber height can be different from control chamber height.

5.1.3 The switchboards shall be totally enclosed and vermin-proof. If necessary, openings for natural ventilation shall be provided. These shall be louvered and provided with wire mesh having opening less than 1mm. Design of louvers/ opening shall be such that the arc does not come out in case of internal arc. The same shall be type tested for internal arc, as specified. The enclosure shall have complete protection against approach to live parts or contact with internal moving parts (IP-4X) as per IS/IEC: 60529.

5.1.4 All openings, covers and doors shall be provided with suitable Neoprene/ XLPE/ EPDM gaskets around the perimeter to make the switchboard dust and vermin proof.

5.1.5 Each unit of the switchgear shall have necessary internal sheet metal barriers to form separate compartments for circuit breaker, busbars, instruments and relays, cable connections etc. Compartments for cable connections shall allow cable termination and connection work with the switchgear energised. Suitable interlock shall be provided such that cable compartment can be opened only when earth switch is ON or Earthing truck is inserted.

5.1.6 The panel shall be internal arc tested as per IS/IEC 62271-200 requirements for full short circuit current and for a duration of 0.5 second (minimum) unless specified otherwise in job specification/ datasheet and shall be qualified to comply with all the 5 criteria as per IS/IEC 62271-200. Independent pressure relief devices shall be provided for all HV compartments, i.e. bus bar, cable and breaker compartments and each compartment shall have type test certificate for internal arc classification (IAC) as per IS/IEC 62271-200 for the short circuit current and duration as specified. IAC test shall be conducted on the offered panel variants such as smallest width panel, panel with louvers, panel with thermography window and any other variants (as applicable) as per job requirements. The panel shall also be AFLR tested as per IS/IEC 62271-200 requirements.

For panels having busduct entry in place of cable entry, busduct interface with panel shall be such that it does not interfere with the IAC type tested design of panel. Separate rear extension panel shall be provided for the Busduct entry. Wall through bushings shall be provided at interface point between busduct and panel.

In case vendor has considered pressure relief/ gas duct above switchboard for release of gases due to internal arc; vendor shall preferably provide suitable absorbers in the switchboard to prevent the release of harmful gases in the switchgear hall. Alternatively, duct including all accessories/supporting arrangement/sealing material/bends/installation material etc. shall be provided for evacuating harmful gases. The offered arrangement of pressure relief/ gas duct shall be as per type tested design.

5.1.7 All identical equipment and corresponding parts shall be fully interchangeable.

5.1.8 Safety barriers / shutters shall be provided to permit personnel to work safely within an empty compartment with the bus bars energised. Loss of Service Continuity (LSC) category of the switchgear shall be LSC2B as per IS/IEC-62271-200.

5.1.9 It shall be possible to extend the switchgear in either direction at a later date. Ends of bus bars shall be suitably drilled for this purpose. Panels at extreme ends shall have openings, which shall be covered with plates screwed to the panel. Details of drilled holes in bus bar and openings in the panels, provided for future extension shall be clearly shown in the vendor drawings.

5.1.10 The drawout carriage on the switchboard shall have three positions: "Service", "Test" and "Drawout" viz:

- "Full in" or "Service" position - In this position both power and control circuits shall be connected. This shall be the normal operating position of the circuit breaker.
- "Test" position - The power contacts shall be disconnected in this position but the control connections shall not be disturbed, it shall be possible to close and trip the breakers in this position.
- "Draw out" Position - both power and control circuits shall be disconnected in this position. Alternatively, "Test Position" with the secondary control circuit disconnected may be provided in lieu of "Draw out Position"

Circuit breaker operation shall be possible only in "Service" and "Test" positions. The circuit breaker shall be lockable in "Test" / "Draw-out" positions. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the carriage is drawn out.

There shall be a distinct overall door for the breaker compartment, which can be closed with the carriage in drawout position and it shall be lockable type.

5.1.11 All circuit breaker modules of the same rating shall be inter-changeable. Suitable interlocks shall be provided to prevent the following operations:

- "Plugging in" or "drawing out" of a closed breaker.
- "Plugging in" a breaker with the earthing isolator closed.
- "Closing" of the earthing isolator with the breaker "plugged in".
- Pulling out the auxiliary circuit plug with the breaker in the service position. Pushing in the breaker to the service position, with the auxiliary circuit plug not in position.

Additionally, the following shall also be provided:

- All operations such as breaker rack-in, breaker rack-out, breaker On/Off, spring charging, earth switch On/Off etc. shall be possible only with panel door closed.
- Pad locking arrangement shall be provided for rack in operation of breaker as well as for the panel door meeting LOTO requirements.

LOTO arrangement shall include provision for the following:

a) Provision for hooking lockout devices by multiple lock arrangement to prevent opening of panel door and racking-in of circuit breaker.

b) Provision for attaching tag-out device for warning against energisation and to provide information regarding date of isolation, agency working on the equipment, etc.

c) Provision for Hasp such that the same shall be put-in and closed in the locking arrangement of the breaker/switch and panel door.

5.1.12 All hardware shall be corrosion-resistant. All joints and connections of the panel members shall be made by zinc-passivated high-quality Grade 8.8 or superior steel bolts, nuts and washers, secured against loosening.

5.1.13 Suitable eyebolts/ lifting clamps shall be provided for the lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panels.

5.1.14 If specified in job specifications/datasheet/Tender, light/ arc/ pressure based sensors with controller shall be provided to quickly detect internal arc and immediately initiate tripping action.

5.1.15 Thermography window for infrared electrical inspection shall be provided if specified in job specifications/datasheet/Tender . The switchgear with thermo-graphy window shall be type tested and certified for internal arc faults as per IS/IEC 62271-200 requirements. In case IAC test report with thermography window is not available, IAC test report to be submitted for the panel along with internal arc withstand capability report for the material used for thermography window.

5.1.16 MV Switchgear shall be provided with online wireless temperature monitoring facility if specified in job specifications/datasheet/Tender. The passive sensor shall be wireless, battery less, dielectrically safe, robust to high voltage, high electromagnetic field, and harsh environment. It shall take direct measurement of temperature from critical points. This facility shall be interfaced with Substation Automation System/ ECS.

In case online temperature monitoring system (OTMS) for real time monitoring of temperature is being provided for MV switchboards, thermography window is not required.

5.2 Accessibility

5.2.1 All relays, metering, and control components shall be mounted on the panel front only. However, auxiliary contact multiplier relays with auto reset can be mounted inside the panel.

5.2.2 The switchgear shall be considered to be accessible to authorized personnel having access all around and shall be tested for following type of accessibility as per IS/IEC 62271-200:

Type of accessibility where	:	AFLR
Accessibility type A	:	Restricted to authorised personnel only
F	:	for front side
L	:	for lateral side
R	:	for rear side

5.2.3 Checking and removal of components shall be possible without disturbing adjacent equipment. All equipment shall be easily accessible. It shall be possible to set all measuring relays and instruments in-situ without de-energising the switchboard. All mounted equipment shall have identification tags of self-sticking PVC tapes at the rear also. In addition, permanent identification details shall be provided on the panel. Mounting of relays for a particular breaker feeder panel shall be limited to that particular feeder only.

5.2.4 All terminals shall be shrouded with plastic covers to prevent accidental contact.

5.3 Bus Bar

5.3.1 The switchboard shall comprise of 3-phase bus bars which shall extend through all units of the switchgear line-up. The main bus bars shall have uniform cross-section throughout their length and shall be sized to carry continuously the rated current specified in the data sheet.

5.3.2 Bus bars shall be of high conductivity electrolytic aluminium or copper supported on insulators made of non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in Indian standards. Self supporting busbars can also be accepted provided the same is type tested design.

5.3.3 Bus bars shall be housed in a separate chamber and shall be accessible for inspection. Wire guards /cover shall be provided inside the enclosure to avoid accidental contact when the cover is removed.

5.3.4 Both bus bars and the supports shall be adequately sized and braced to withstand the specified short-circuit current for 1 second. Dynamic stresses shall be calculated on the basis of the specified peak short-circuit current. All bus bars supports shall be of non-carbonising material, resistant to acids and alkalies.

5.3.5 Bus bars shall be insulated by using heat-shrinkable sleeves or glass fibre tubes suitable for withstanding heat under worst operating condition as per type tested design. The sleeves/ tubes shall be rated to withstand the system line-to-line voltage for 1 minute. This shall be verified by a type test in which the line voltage will be applied between the sleeved/ tubed main bus bar and an aluminium foil wrapped closely around the insulation over a length of at least 500mm.

5.3.6 All bus bar joints and all tap-off connections from the main horizontal bus bars shall be provided with removable FRP/PU/PVC/EPDM/Nylon shrouds. The material of the shrouds shall be flame retardant (FR).

5.3.7 Bus bars shall be prominently marked with Red, Yellow and Blue colour rings/ stickers for easy phase identification at regular interval and at every power tap off point.

5.3.8 The thermal design of the bus bars shall be based on installation of the switchgear in poorly ventilated conditions. The cooling air volume shall take into account only the bus bar enclosure.

5.3.9 The hot spot temperature of busbars, including joints, at design ambient temperature shall not exceed 100^0C under normal operating conditions while for silver plated joints, the allowable maximum temperature shall be 115^0C in line with IS/IEC-62271-1.

5.3.10 Only zinc passivated high tensile strength high-quality Grade 8.8 or superior steel bolts, nuts and washers shall be used for all busbar joints and supports. Also, instruction label for torque tightening of busbar coupling shall be provided on switchboard.

5.3.11 The current rating as defined for switchboard and components in data sheet/job specification are for design ambient temperature at site conditions and for being inside the cubicle at fully loaded condition. The vendor shall suitably derate the nominal rating to suit the above condition.

5.4 HV Power Connections

5.4.1 The incoming power connection shall be through XLPE cables / busduct and outgoing power connection shall be through XLPE cables/ busduct, as indicated in the data sheet. Ample space for connection of these cables shall be provided at the rear of the switchboards. In order to avoid accidental contact in the cable compartment while carrying out inspection by opening the rear cover, a removable expanded metal barrier/ wire mesh shall be provided in the cable compartment. In order to facilitate infra-red electrical inspection through thermography window, metal barrier/ wire mesh may not be provided. Non-magnetic cable gland plates shall be provided for feeders wherever single core cables are used.

5.4.2 The switchboard shall be supplied complete with supports for clamping outgoing and incoming cables. The head-room available between cable gland plate and terminal lugs shall not be less than 600 mm for switchgear up to 11 kV, and 900 mm for 22 and 33 kV cables.

5.4.3 In case, the standard panel depth cannot accommodate the specified number of cables, a rear extension panel of full height shall be provided. An earth strip shall also be brought to this extension panel.

5.4.4 Unless otherwise specified, all power cables shall enter the switchboard from the bottom.

5.5 Auxiliary Wiring and Terminals

5.5.1 Inside the cubicles, the wiring for control, signalling, protection and instrument circuits shall be done with BIS approved, PVC/XLPE insulated, flame retardant low smoke (FRLS) type, copper conductor wire. The insulation grade shall be 660 V. FRLS shall be embossed on the inter-panel wires.

The wiring shall preferably be enclosed in FRLS plastic channels or neatly bunched together. Wiring between HV breakers or cable compartments to relay and metering compartments shall be routed through FRLS flexible conduits. FRLS shall also be embossed on the plastic channels/ flexible conduits. However, as an alternative to FRLS embossing, manufacturer compliance for FRLS plastic channels/ flexible conduits in form of certification can also be accepted.

5.5.2 A minimum of 10% spare terminals shall be provided on each terminal block. Conductors shall be terminated with adequately sized compression-type lugs for connection to equipment terminals and strips. Stranded conductors shall be soldered at the ends/ crimped with suitable lugs before connections are made to the terminals. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal. Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spare contacts of auxiliary relays, timers, etc shall be wired up to the terminals.

5.5.3 Each wire shall be identified at both ends by correctly sized PVC ferrules. Shorting links shall be provided for all CT terminals.

5.5.4 XLPE/ PVC insulated copper conductor of cross section 1.5 mm^2 may normally be used provided the control fuse rating is 10A or less. For 16A control fuse circuit 2.5 mm^2 copper conductors shall be used. Each wire shall be terminated at a separate terminal. CT Circuit wiring shall be done with 2.5 mm^2 copper conductors. Shorting links / suitable shorting arrangement for shorting CT secondary shall be provided.

5.5.5 Unless otherwise specified, all control cables shall enter the switchboard from the bottom.

5.5.6 Supporting facilities shall be provided for clamping the control cables.

5.5.7 All inter-panel control wiring within each shipping section shall be by switchgear vendor. The inter-panel wiring shall be taken through PVC sleeves or suitable grommets. For inter-panel wiring between the shipping sections, wires in rolls of the required length, connected at one point, shall be supplied with the panel for connection at site.

5.6 Control and Indication

5.6.1 Breaker tripping, closing and spring charging devices shall be fed with DC control power supply. The rated DC voltage shall be as specified in the data sheet. The power supply for breaker opening, closing and indication devices shall be arranged as follows:

a. One DC feeder shall be provided for each bus section. The bus coupler panel may be fed from any of the two supplies.

b. One separate, single-phase power supply shall be provided for each bus section for feeding space heaters, etc. Supply voltage shall be 240 V AC, unless otherwise specified.

Provision to receive DC and AC control supply shall preferably be provided in bus-coupler panel / bus PT panel.

5.6.2 Breaker positions (CLOSE, OPEN, spring-charged, test position, service position) shall be indicated mechanically. Test & service position viewed through viewing window is also acceptable. Electrical indications, with colours as given below, shall also be provided:

Breaker 'CLOSED'	:	Red lamp
Breaker 'OPEN'	:	Green lamp
Breaker 'Auto-trip'	:	Amber lamp
Trip circuit healthy	:	White lamp
Spring charging	:	Blue lamp

5.6.3 A common DC control supply fail indication shall be provided for each bus section with a blue coloured lamp.

5.7 Earthing Connections

All cubicles shall be connected to an earth bus bar running throughout the length of the switchboard. The minimum earth bus bar size shall be 30 x 6 mm^2 copper up to short-circuit withstand capacity of 31.5 kA and 50 x 6 mm^2 copper for a short-circuit withstand capacity above 31.5 kA and upto 40 kA. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing bus bar to the plant earthing grid at two ends. All non current-carrying metallic parts of the equipment and components shall be earthed. The earth bus shall be brought back to the cable compartment, and earthing bolts shall be provided to ground cable armour. The mating surfaces of all bolted parts shall be zinc passivated to ensure continuity between them.

5.8 Space Heaters

The panels shall be provided with space heaters to prevent moisture condensation, and maintain cubicle temperature 5°C above the ambient. The space heaters shall be located at the bottom of the panel, and shall be controlled through a double pole MCB and a thermostat with an adjustable setting range of 30 to 70°C. The thermostat shall preferably be located in the metering or relay chamber. Space heaters shall be supplied from 240V AC auxiliary bus for space heater.

5.9 Panel Supporting Frame

The panels shall be suitable for installation on panel supporting frame, to be supplied by others. The panels shall be suitable for tack welding, directly to this frame.

5.10 Nameplates

5.10.1 The switchgear shall be provided with durable and clearly legible nameplate in accordance with Table-1 of IS/IEC 62271-200 requirements.

5.10.2 A nameplate with the switchboard designation shall be fixed at the top of the central panel. A separate nameplate giving details for each feeder compartment of all panels shall be provided. Danger plate (Red) shall be provided at the front and rear for each panel.

5.10.3 The nameplates for feeder compartments shall be in two parts. One part shall have necessary details pertaining to the compartment's number of vertical panel of the switchboards. The other parts shall be removable and shall contain all details regarding the feeder number for drives/equipment controlled by the particular module as per approved single line diagram.

5.10.4 Blank nameplates shall be provided for all spare and vacant modules.

5.10.5 Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the switchboard. Special warning plates shall be provided on removable covers or doors giving access to cable terminals and bus bars.

5.10.6 Special warning labels shall be provided inside the switchboards also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.

5.10.7 Engraved nameplates shall preferably be of 3- ply (Black-White-Black) lamicoid sheets or anodised aluminium. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

5.11 Painting

5.11.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. Alternately, supplier's standard paint procedure as per their ISO standard is also acceptable. The under surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.2 After preparation of the under surface, the switchboard shall be spray painted with two coats of epoxy based final paint or shall be powder coated.

5.11.3 Colour shade of final paint shall be as RAL 7032 unless specified otherwise.

5.11.4 The finished panels shall be dried in stoving ovens in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint etc. Vendor shall supply final paint (1 litre per switchboard) in non-returnable container for final touch up at site.

5.11.5 All unpainted steel parts shall be Zinc passivated or suitably treated to prevent rust formation. If these parts are moving elements then they shall be greased. Aluzinc/ pre-galvanised sheet, wherever provided, need not be painted.

6.0 SWITCHBOARD COMPONENTS

6.1 Circuit Breakers

6.1.1 Vacuum or SF_6 circuit breakers shall be used in the switchboard. The exact type and rating of breakers shall be as indicated in the data sheet. Breaker transport trolleys required for cassette-mounted breakers shall be provided for each switchboard. Number of trolleys to be provided shall be as per data sheet.

6.1.2 Vacuum circuit breakers shall be designed to have low switching-over voltage levels and with a long switching life. The interrupter shall be leak-free. The VCB shall be type tested with the offered make & model of vacuum interrupter.

6.1.3 In case of SF_6 circuit breaker, each pole shall be provided with a pressure switch to monitor the gas pressure with local indication / lockout, and remote annunciation in the event of SF_6 gas leakage.

6.1.4 The breakers shall have at least 6 normally open (NO) and 6 normally closed (NC) spare auxiliary contacts for purchaser's use. If these are not available, auxiliary relays shall be used to multiply the auxiliary contacts of the breakers.

6.1.5 The breakers shall have a motor-operated, spring-charging mechanism. It shall also be possible to charge the springs manually. The closing spring shall get re-charged (for subsequent closing) soon after a closing shot and prior to breaker tripping. In case the limit switch fails to cut out the spring-charging motor with the springs fully charged, the motor shall be automatically de-coupled or else positive isolation (at both ends) of power supply to spring charging motor shall be ensured. The control circuit shall be suitable for local as well as remote control. Breakers shall be trip-free and shall have an anti-pumping device. The breaker operating duty shall be O-3min.-CO-3min.-CO, unless otherwise agreed.

6.1.6 Operating Mechanism

a) Electric power operating mechanism shall be motor wound spring charged stored energy type. However, manual-operating mechanism may be of the spring charging stored energy type or spring assisted type. For circuit breakers with electrical power operating mechanism, provision shall also be made for manual spring charging. Closing time of circuit breakers with manual operating mechanism shall be independent of the speed of the operating handle.

b) All stored energy operating mechanisms shall be equipped with the following features:

i) Failure of springs, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation.

ii) Closing of circuit breakers shall be prevented unless the spring is fully charged.

c) All electrical power operating mechanisms shall be suitable for remote operation and shall be equipped with following features:

i) Provided with motors operable on AC or DC control supplies as specified.

ii) Provided with emergency manual charging facility. The motor shall be automatically, decoupled (mechanically) once the manual-charging handle is inserted.

iii) Closing operation of circuit breaker shall automatically initiate charging of the spring for the next closing operation without waiting for tripping of circuit breaker.

iv) Closing operation shall be completed once the closing impulse is given and the first device in the control scheme has responded even though the control switch / Push Button is released, provided no counter trip impulse is present.

6.1.7 Circuit breaker trip and closing coils, in case of electrically operated breakers, and trip coil in case of mechanically operated breakers and circuit breaker indication shall be suitable for satisfactory operation on a control supply system indicated in data sheets/job specification. Additional second shunt trip coil (operating on different control voltage supply) shall also be provided if specified in job specifications/datasheet/Tender.

6.1.8 All circuit breakers shall be provided with mechanically operated emergency trip device. This device shall be available on the front of the panel. Mechanically operated 'closing' device shall be provided for all breakers. However mechanical closing shall be inhibited for all circuit breakers in service position.

6.1.9 The breakers shall be provided with anti pumping & trip free feature. Each breaker shall be also provided with an operation counter.

6.1.10 For all HV VFD outgoing feeders, breaker shall be provided with one no. shunt trip coil and with undervoltage release. As an alternative, two shunt trip coils can be also provided. One shunt trip coil shall be suitable for switchgear DC control supply while second shunt trip coil shall be suitable for external AC control supply. The control supply voltage level shall be as specified in data sheet.

6.1.11 Metal Oxide surge suppressors shall be provided on all outgoing vacuum circuit breakers to limit the over voltage to a maximum of 2.2 p.u. rated peak line to earth voltage. Sizing calculations for surge suppressor shall be provided post order.

6.1.12 Line PT shall be mounted in a separate drawout carriage having separate arrangement for rack-in/rack-out which will be independent of breaker. For cassette type breaker, line PT can be housed in the same vertical panel housing breaker. In case of truck mounted breaker, line PT

shall be provided in a separate panel. Further, bus PT and line PT shall not be mounted in the same vertical panel.

6.1.13 The complete breaker assembly should have inter-changeability with breakers of identical ratings.

6.1.14 The switchgear shall be supplied in single tier arrangement i.e. one circuit breaker in one vertical panel. For switchgears specified with double tier circuit breaker arrangement, the outgoing feeder breakers shall have double tier arrangement and incomer breakers with Line/bus PT shall be housed in one vertical panel. In double tier arrangement, sheet steel partitions shall be provided for each compartment. Compartmentalization shall be such that maintenance of one breaker is possible without disturbing the adjacent breaker compartment. Suitable trolley(s) shall be supplied for drawing out the breakers in upper tier. The maximum height of the operating handle/switches/reset knobs/pushbuttons shall not exceed 1900 mm and minimum height shall not be below 300 mm.

6.1.15 An integral earthing system, or a separate earthing carriage/truck, shall be provided. In case of a separate earthing carriage, the necessary trolleys for bus-side and cable-side earthing shall be supplied. After withdrawing the circuit breaker, this can be inserted to facilitate earthing of cables and bus bars. Earthing truck shall be complete with the PT and voltmeter giving audio-visual indication and solenoid interlock to prevent closing of bus side earthing truck on live busbars. In case voltmeter cannot be provided suitable voltage detecting system shall be provided. Suitable interlock shall also be provided for Earthing switch. Earthing truck/ earthing switch operation shall be only with door closed.

Integral earthing switch shall be suitable for short time withstand current and peak withstand current rating equal to the corresponding breaker withstand rating.

6.1.16 Number and type of earthing trucks shall be as specified elsewhere.

6.1.17 Circuit breaker electrical endurance shall be class E2 and mechanical endurance shall be class M2 as per IS/IEC-62271-100. Probability of restrike during capacitive current breaking shall be of class C1 as per IS/IEC-62271-100 except for capacitor feeders which shall be of class C2 as per IS/IEC-62271-100.

6.2 Fuse Contactor Units

For outgoing feeders requiring fuse contactor (as specified in job specification/ datasheet), following shall be complied with:

Fuse contactors shall be fully drawable type.

Contactors shall comply with IS/IEC-60470 and shall be suitable for intermittent duty class 0.1 as well as for uninterrupted duties.
The minimum short circuit breaking capacity of the contactor shall be at least 6 kA at rated voltage.

Anti-pumping device (APD) shall be included to prevent "pumping actions" of mechanisms.

Overvoltage surge diverters shall be installed if required to keep high over-voltages during operating conditions within acceptable values.

Contactors for motor starters and capacitor Bank feeders shall be of the latched type. The tripping supply shall be obtained from the DC tripping and closing supply. Motor contactor panels shall be provided with restarting facilities as specified in job specification/ datasheet.

Fuse links shall be in accordance with IEC 60282-1 and shall have high rupturing capacity. They shall be short circuit current limiting type. Fuses shall be provided with striker pin arrangement tripping the contactor.

Fuses for motor starters shall have a time-current characteristic suitable for the method of starting.

Correct discrimination shall be established between fuse characteristics and contactor breaking capacities. This shall ensure that overload and fault currents are safely interrupted by the appropriate devices avoiding any risk of welding or other damage to the contactor.

6.3 Instrument Transformers

Current and voltage transformers shall be cast-resin insulated. The primary and secondary terminals shall be marked indelibly and easily approachable for termination and testing etc.

6.3.1 Current transformer

i) Current transformers shall conform to IS: 2705 Part-1 and IS:16227 Part-1 & 2. The short-time current rating shall be equal to that of the switchboard. They shall be mounted on the stationary part of the switchboard. The CT ratings shall be as shown in the data sheet. Protective CTs shall have an accuracy class of 5P and an accuracy limit factor greater than 10. CTs for instruments shall have an accuracy class of 1.0 and an accuracy limit factor less than 5.0. For numerical relays having protection and metering functions, dual rated CT shall be provided suitable for protection class and metering class. One leg of the CTs shall be earthed. Separate CTs shall be provided for each of Differential protections such as transformer, line, bus, motor, Restricted Earth fault protection, etc. However, common CT having separate cores for any differential and Restricted Earth fault protection is acceptable.

ii) All CTs shall be star connected. Interposing CT (ICT) shall be provided (if required) for differential protection of transformers having star-delta connection.

iii) Proper access to each set of CTs shall be provided for repair / maintenance.

iv) Core Balance Current Transformer shall be provided in motor feeders for sensitive earth fault protection, if specified in job specifications/datasheet/Tender.

6.3.2 Potential transformer

i) The potential transformers shall conform to IS: 16227-1 & 16227-3. The potential transformers shall be of drawout-type, and shall be provided with 4 pole miniature circuit breakers with auxiliary contacts on the secondary side.

ii) The drawout mechanism shall disconnect the PT from the busbars. The primary connection shall be disconnected before the PT becomes accessible. Neutral point of the star connected PTs both on the primary and secondary sides shall be earthed.

iii) The PTs shall have an over-voltage factor of 1.2 continuous and 1.9 for 30 seconds, and an accuracy class of 1.0 from 10% to 120% of normal voltage. PT selected shall be compatible with system grounding. Also precaution shall be provided to mitigate the problem of ferroresonance.

iv) The primary rated voltage shall be equal to the rated voltage V of the system, or $V/\sqrt{3}$, if the PT is connected between phase and neutral.

v) If not otherwise specified, the secondary voltage shall be 110 V, or $110/\sqrt{3}$ V. The burden and class of accuracy shall be as specified in data sheets. For directional relays, either a 3-phase 5-limb PT, or 3 single-phase PTs with secondary windings connected in open delta shall be provided.

6.4 Measuring Instruments

All analogue instruments shall be of square pattern, 96 x 96 mm, flush-mounted type. Measuring instruments shall be provided, as specified in the data sheet. All required auxiliary equipment such as shunts, transducers, CTs, PTs, etc, shall be included in the scope of the switchboard supplier. The accuracy class for all instruments shall be 1.0 as per IS: 1248.

Digital instruments shall also be acceptable, provided specific approval of EIL/Owner for make and model is obtained.

6.4.1 **Ammeters and voltmeters**

Analogue meters shall be of moving-iron type. The range shall be as indicated on the drawings. Ammeters for motor feeders shall have a non-linear compressed scale above rated current to indicate motor starting current.

6.4.2 **kW / kWh meters**

The kW / kWh meters shall be suitable to measure unbalanced loads on a 3-phase, 3-wire system. The kW meters shall operate on a PT secondary voltage of 110 V.

6.4.3 **Frequency meters**

These shall be of direct-reading or digital type and shall operate on a PT secondary voltage of 110V. The standard range shall be 45-50-55 Hz.

6.4.4 **Power factor meters**

Power factor meters shall operate on a PT secondary voltage of 110 V. The CT secondary current shall be as shown on the relevant drawings. The standard range shall be 0.5 lead-1.0-0.5 lag.

6.4.5 Digital meters shall be provided, if specified in job specifications/datasheet/Tender. All digital meters shall be highly reliable, accurate & compact. Digital meter data shall be retained & retrievable even in case of power failure. Field programming from front of the meter shall be possible and shall have RS232/485 port in case specified in the job specification/data sheet.

6.5 Relays

6.5.1 Type of relay i.e. electromechanical, static or numerical shall be as defined in data sheet / job specification.

6.5.2 All electromechanical protective relays shall be back-connected, of drawout type, suitable for flush mounting, and fitted with dust-tight covers. Alternatively, "plug-in" type relays will also be acceptable. Auxiliary relays are acceptable in fixed execution.

6.5.3 The protective relay cases shall have a provision for insertion of a test plug at the front for testing and calibration using an external power supply without disconnecting the permanent wiring. The insertions of the test plug shall automatically short circuit the CTs and permit extension of external power supply to the relay.

6.5.4 All protective relays shall have hand reset facility and clear operating indication, e.g. flags for electro-mechanical type relays or light emitting diodes for static/numerical type relays. It shall be possible to reset the flag without opening the relay case.

6.5.5 All tripping relays (electrical fault trip) shall be of lockout type with hand-reset contacts, and shall be suitable to operate on the specified voltage. These relays shall have self coil cut off contacts, and shall be provided with hand-reset operation indicators. However, for process trip, the lock out relay shall be self reset type Tripping relays will be acceptable in non-drawout cases.

6.5.6 The tripping relay shall be suitable for satisfactory operation from 50% to 110% of the specified control supply voltage.

6.5.7 Motor protection relay provided shall have terminals for CBCT input and feature for detecting sensitive earth fault, if CBCT is provided as specified in datasheet.

6.5.8 Fast Bus Transfer (FBT) relay shall be provided, if specified in job specifications/datasheet/Tender.

6.6 Auxiliary Equipment

6.6.1 Auxiliary relays and contactors:

Auxiliary relays and contactors shall generally be used for inter-locking and multiplying contacts. Auxiliary contacts shall be capable of carrying the maximum anticipated current.

6.6.2 Control Switches:

i) All control switches shall be rotary type, having a cam-operated contact mechanism otherwise stated. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles and shall be lockable.

ii) Ammeter selector switches shall have a make-before-break feature on its contacts. The selector switch shall generally have four positions, three positions for reading 3-phase currents and the fourth position for OFF. The voltmeter selector switch shall also have four positions, three positions shall be used to measure phase-to-phase voltages and the fourth position shall be for OFF.

6.6.3 Timers:

For re-acceleration duty, timers unless otherwise stated, shall be pneumatic type and shall have adjustable time setting of 0-60 seconds. Alternatively static timer may be considered. The time settings, where specified, shall be accurately set before despatch of the switchboard. Timer provided for control of capacitor feeder shall have minimum setting of 0-5 minutes. Timer as part of numerical relay is also acceptable.

6.6.4 Indicating Lamps:

Clustered LED type indicating light with minimum 8mm diameter size shall be provided for indications. The LED shall have a low glow voltage protection and shall not glow on voltage leakage.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the switchboard shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

7.2 For testing requirements refer Inspection & Test Plan No. 6-81-1001.

8.0 PACKING AND DESPATCH

The switchboard shall be divided into several shipping sections for protection and ease of handling during transportation. All outgoing feeders shall be packed as separate shipping sections. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO number.' etc., shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should also be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed.

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SPECIFICATION FOR FLAMEPROOF CONTROL STATIONS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	29.9.20	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/ RKS	ANPS	SA	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	24.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CT	Current Transformer
DC	Direct Current
FRLS	Flame Retardant Low Smoke
FRP	Fibre Reinforced Plastic
GI	Galvanised Iron
IEC	International Electro-technical Commission
IP	Ingress Protection
IS	Indian Standards
LED	Light Emitting Diodes
LV	Low Voltage
MR	Material Requisition
NABL	National Accreditation Board for Testing and Calibration Laboratories
PB	Push Button
PESO	Petroleum and Explosives Safety Organisation
PVC	Poly Vinyl Chloride
SMD	Surface Mounted Device
SWG	Standard Wire Gauge
XLPE	Cross Linked Poly Ethylene

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Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of flameproof control stations and accessories suitable for installation in locations handling flammable liquids and gases/ vapors.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	: Colours for ready mixed paints and enamels.
IS-1248	: Direct acting indicating analogue measuring instruments and their accessories.
IS / IEC 60079-0	: Electrical apparatus for explosive gas atmospheres (General Requirements).
IS / IEC 60079-1	: Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d").
IS / IEC 60529	: Degree of protection provided by enclosures (IP Code).
IS / IEC 60947	: LV switchgear and control gear.

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also confirm to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 CERTIFICATION

The equipment shall have test certificates issued by NABL-approved/ Central Government labs in India/ IECEx-approved/ equivalent labs). All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location and marking as per IS/ IEC 60079 or IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license.

6.0 TECHNICAL REQUIREMENTS

6.1 Construction

6.1.1 The enclosures of the control stations shall be made of cast light metal alloy, unless otherwise specified. The enclosures of the control stations intended for use in units handling sulphuric acid/ other corrosive materials shall be made of stainless steel grade SS-316L, if specified in MR/ tender.

6.1.2 The control stations shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. They shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanised sheet steel/ FRP/ stainless steel minimum SS-304 (as specified in purchase specifications). The canopy shall be suitable for providing protection against rain from top, back and two sides.

6.1.3 The control station enclosure shall be provided with gaskets for IP, if required by equipment certification. Gaskets, wherever provided, shall be made of non-inflammable and self-extinguishing material.

6.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flame proof (Gas group IIA/ IIB) : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flame proof (Gas group IIC) : Light yellow shade 355 of IS-5/ RAL 1012

All unpainted parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving then these shall be greased. Grease, which does not solidify, shall be applied to flamepath. However, in case of Stainless Steel control stations, finish shall be Electropolish/ Buffed/ equivalent finish.

6.1.5 Equipment shall be marked as per IS/IEC 60079.

6.1.6 All accessories like nuts, bolts, washers etc. and operating shaft of push buttons, switches etc. shall be made of stainless steel SS-304. Alternatively, Nickel-plated brass material may be used for the operating shafts of push buttons, switches etc.

6.1.7 The control stations shall be provided with two earthing studs (minimum M10 bolt, nut with spring and plain washer) with lugs on the external surface of the enclosures suitable for termination of 8 SWG GI wire. No screw type fixing arrangement shall be allowed.

6.1.8 The control station shall be provided with two cable entries at bottom, and one entry to be blocked with flameproof nickel plated brass sealing plug, unless otherwise specified. Required number of flameproof double compression nickel plated brass cable glands shall be provided. The cable termination chamber of the control station shall be large enough to provide a minimum space of 100mm between top of the cable gland and bottom of the terminal block.

6.1.9 The control stations shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

6.1.10 A tag plate indicating Tag Number shall be provided on each control station. A nameplate shall be provided to indicate the Name of Manufacturer, test certificate number, serial number, BIS license number, applicable gas group etc. as per IS/IEC 60079 and any additional marking required by statutory authority like approval no. etc. The nameplates shall be engraved type or laser-marked and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate. All

tag plates shall be engraved, 3 ply laminate fixed with screws and name plate shall be Al anodized or SS-304 engraved or laser-marked and fixed with rivets.

6.1.11 All flameproof control stations shall be suitable for 240V AC as well as 110V/ 220V DC control supply.

6.2 Component Specification

6.2.1 Push buttons for START/ OPEN and STOP/ CLOSE shall be of GREEN and RED colour respectively. The STOP push button shall be mushroom type with stay put feature and lockable in pressed position. Refer Sketch 1 for wiring and other details for various types of local control stations.

6.2.2 All selector switches shall have minimum two poles for each position. Each position of switch shall be indelibly marked on the control station. Exact configuration of selector switch (e.g. LOCAL-OFF-REMOTE) shall be as per datasheet/ MR requirement.

6.2.3 All ammeters shall be of moving iron type having an accuracy class of 1.5 and suitable for 1 Ampere CT secondary. Minimum size of ammeter shall be either 72mm x 72 mm or 65 mm diameter. 80% of the scale length shall cover 100% of the CT primary current uniformly and the balance 20% of the scale shall cover 100-800% of the CT primary. A red mark corresponding to the full load current of the motor shall be provided on the ammeter dial. The ammeter front glass shall be toughened.

6.2.4 Indicating lamp(s) wherever provided shall be clustered LED type or SMD chip type LED with colour lens of minimum 25mm diameter.

6.3 Terminals & Wiring

6.3.1 The control stations shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. Each terminal for external cable connection shall be suitable for termination of 2.5 mm^2 (unless otherwise specified) stranded copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.

6.3.2 All internal wiring shall employ 1.5 mm^2, 660V/ 1100V grade, FRLS type, XLPE/ PVC insulated copper conductor wires. All termination shall be with suitable lugs.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorized by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/acceptance tests shall be carried out at manufacturer's works under his care & expense.

7.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.

7.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1006.

7.4 All equipments shall be subjected to various routine / acceptance tests as per Inspection and Test Plan no. 6-81-1006.

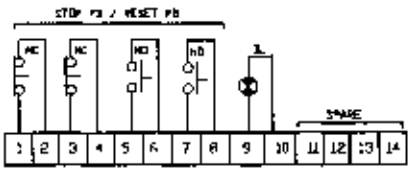
8.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

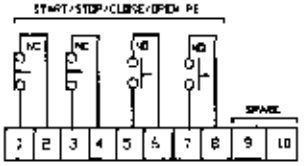
The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

SKETCH-1

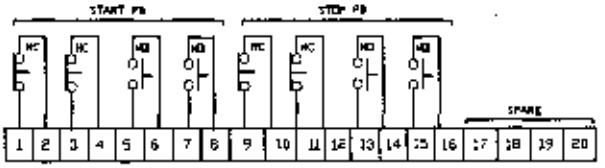
WIRING DETAILS OF LOCAL CONTROL STATIONS



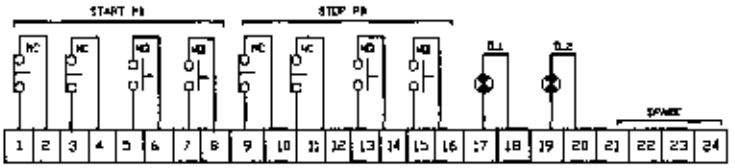
TYPE-A1 (STOP P.B. WITH LAMP)
OR
(RESET P.B. WITH LAMP)
(CABLE SIZE : 4Px2.5 Sq.mm)



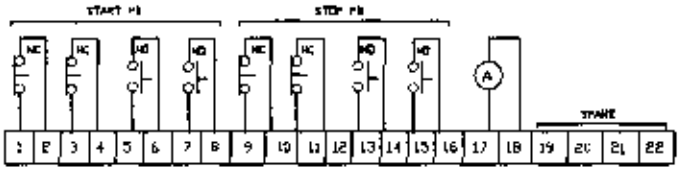
TYPE-A2
(START PB) OR (STOP PB) OR (CLOSE PB) OR (OPEN PB)
(CABLE SIZE : 2Px2.5 Sq.mm)



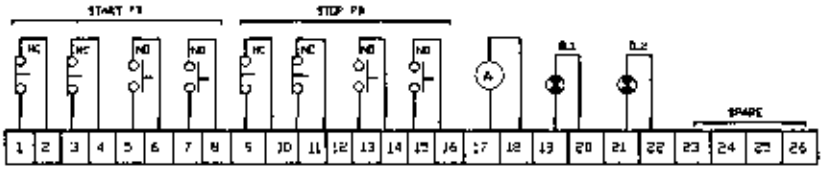
TYPE-B1 (WITH START & STOP PBs) OR (WITH CLOSE & OPEN PBs)
(CABLE SIZE : 4Px2.5 Sq.mm)



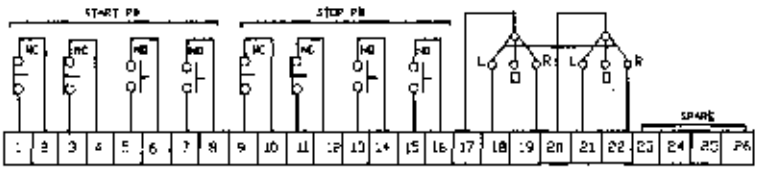
TYPE-B2 (WITH START & STOP PBs & INDICATION LAMPS)
OR
(WITH CLOSE & OPEN PBs & INDICATION LAMPS)
(CABLE SIZE : 6Px2.5 Sq.mm)



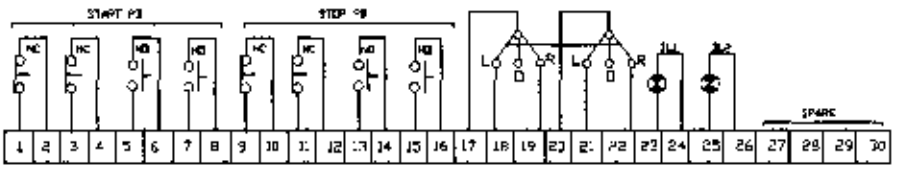
TYPE-C1 (WITH START & STOP PBs & AMMETER)
(CABLE SIZE : 4Px2.5 Sq.mm)



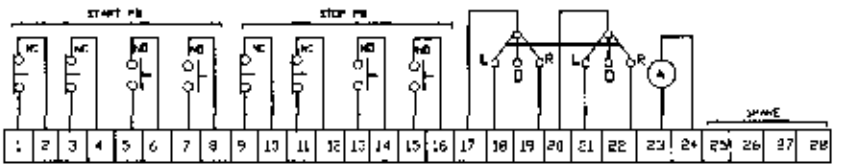
TYPE-C2 (WITH START & STOP PBs, AMMETER & INDICATION LAMPS)
(CABLE SIZE : 6Px2.5 Sq.mm)



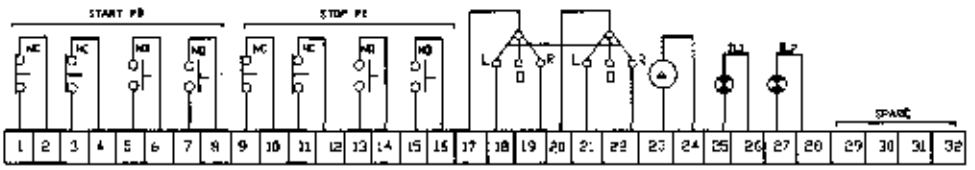
TYPE-D1 (WITH START & STOP PBs & L-O-R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm) (REFER NOTE-11)



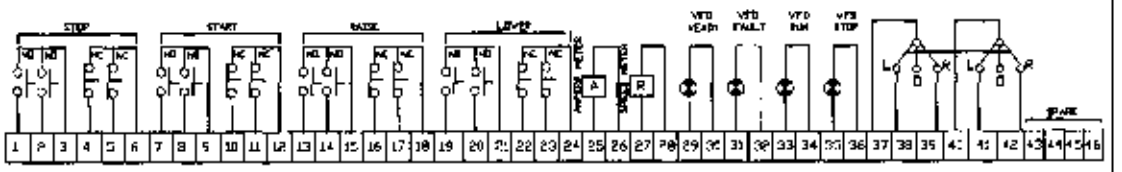
TYPE-D2 (WITH START & STOP PBs, L-O-R SELECTOR SWITCH & INDICATION LAMPS)
(CABLE SIZE : 12Px2.5 Sq.mm) (REFER NOTE-11)



TYPE-E1 (WITH START & STOP PBs, AMMETER & L-O-R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm) (REFER NOTE-11)

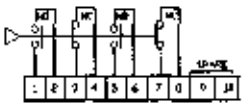


TYPE-E2 (WITH START & STOP PBs, AMMETER, L-O-R SELECTOR SWITCH & INDICATION LAMPS)
(CABLE SIZE : 12Px2.5 Sq.mm) (REFER NOTE-11)

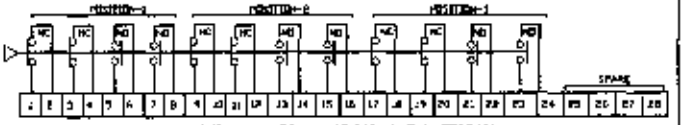


TYPE-F (WITH START & STOP PBs, RAISE & LOWER PBs, L-O-R SWITCH, AMPERE METER, SPEED METER & INDICATING LAMPS) (REFER NOTE-5,6,7)

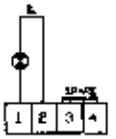
(CABLE SIZE : 12Px2.5 Sq.mm)



TYPE-11
SEL SWITCH (2POSITION)



TYPE-12 SEL SWITCH (3POSITION)



TYPE-13
(LAMP STATION)

GENERAL NOTES:

1. SHORTING LINKS SHALL BE PROVIDED BY VENDOR. REQUIREMENT SHALL BE INFORMED DURING VENDOR DRAWING REVIEW.
2. WIRING DETAILS SHALL BE READ IN CONJUNCTION WITH MR/TENDER.
3. CABLE SIZES AS INDICATED ABOVE ARE TENTATIVE AND MINIMUM. EXACT CABLE SIZES SHALL BE INFORMED DURING VENDOR DRAWING REVIEW. VENDOR TO PROVIDE REQUIRED SIZE OF CABLE TERMINATION CHAMBER WITH SUITABLE TERMINALS, CABLE ENTRIES, CABLE GLANDS AND LUGS. CROSS SECTIONAL AREA SHALL BE 2.5 SQ MM, UNLESS OTHERWISE SPECIFIED
4. AMMETER WHEREVER PROVIDED, SHALL BE ANALOGUE OR 4-20mA TYPE AS DEFINED IN MR/TENDER.
5. FOR VFD LCS, LAMP SUPPLY VOLTAGE SHALL BE SAME AS VFD CONTROL SUPPLY VOLTAGE.
6. FOR VFD LCS, IF EXTERNAL SUPPLY IS REQUIRED FOR METERS, THEN SAME SHALL BE AS VFD CONTROL SUPPLY VOLTAGE.
7. METERS IN VFD LCS SHALL BE SUITABLE FOR 4-20mA TRANSDUCER OUTPUTS AND SHALL BE CALIBRATED FOR THE ACTUAL MOTOR CURRENT. FOR DRIVERS WITH BYPASS FACILITY, METERS SHALL BE CAPABLE OF READING BYPASS MODE FULL LOAD AND STARTING CURRENTS AS WELL AS VFD MODE DRIVE CURRENT.
8. NUMBER AND COLOUR OF INDICATING LAMPS SHALL BE AS PER THE JOB SPECIFICATION/TENDER.
9. LCS TYPE 'I' ARE TYPICALLY FOR INSTRUMENTATION USE.
10. ALL PUSH BUTTON AND CONTROL SWITCH CONTACTS SHALL BE RATED FOR MINIMUM 6A AT 240V(AC-15) AND 1A AT 110V(DC-13) DUTY CONTACT RATINGS FOR LCS FOR INSTRUMENTATION USE SHALL BE AS PER INSTRUMENTATION REQUIREMENT.
11. SECOND CONTACT OF L-O-R SWITCH REQUIRED ONLY WHERE DCS INTERFACE IS REQUIRED BY INSTRUMENTATION
12. THE EXACT DESCRIPTION OF PB'S WHETHER START/STOP OR OPEN/CLOSE SHALL BE INFORMED DURING VENDOR DRAWING REVIEW
13. ALL L-O-R SELECTOR SWITCHES SHALL BE LOCKABLE IN OFF POSITION.

अग्निरोधक विद्युत वितरण बोर्ड के लिए विनिर्देश

SPECIFICATION FOR FLAMEPROOF POWER DISTRIBUTION BOARDS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	31.03.22	ISSUED AS STANDARD SPECIFICATION	SAC/RKS	ANPS	MKS	SM

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CT	Current Transformer
DGMS	Directorate General of Mines Safety
EIL	Engineers India Limited
FRLS	Flame Retardant Low Smoke
GI	Galvanised Iron
IEC	International Electro-technical Commission
IP	Ingress Protection
IS	Indian Standards
kW	Kilo Watt
kWH	Kilo Watt Hour
MR	Material Requisition
MV	Medium Voltage
MCB	Miniature Circuit Breaker
MCCB	Moulded case circuit breaker
NABL	National Accreditation Board for Testing and Calibration Laboratories
PDB	Power Distribution Board
PESO	Petroleum and Explosives Safety Organisation
PO	Purchase Order
PVC	Poly Vinyl Chloride
SPN	Single Phase and Neutral
SWG	Standard Wire Gauge
SS	Stainless Steel
TPN	Three Phases and Neutral
XLPE	Cross Linked Poly Ethylene

Electrical Standards Committee

Convenor: Mr. Manjit Kumar Sahu

Members:
Mr. Harish Kumar
Ms. Arvind NP Singh
Ms. Shalini Verma
Mr. Raman Sood
Mr. Bishan Dass
Mr. Rajiv Kumar Saha
Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Ms. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of free standing flameproof Power Distribution Board (PDB) for field power distribution to MOVs, soot blowers, auxiliary motors, electric heat tracing, high masts etc. suitable for installation in hazardous locations handling flammable liquids and gases/ vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS : 5	:	Colours for ready mixed paints and enamels.
IS : 1248	:	Direct acting indicating analogue measuring instruments and their accessories
IS : 2824	:	Method for determining the proof and the comparative tracking indices of solid insulating materials
IS : 5082	:	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes
IS : 5578	:	Guide for marking of insulated conductor
IS : 11353	:	Guide for uniform system marking and identification of conductors and apparatus terminals
IS : 12640	:	Residual current operated circuit breakers
IS : 13703	:	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC
IS : 16227/ IEC 61869	:	Instrument transformers (Current transformers & Voltage transformers)
IS/IEC 60255		Measuring Relays & Protection Equipment
IS/IEC 60269	:	Low voltage fuses
IS/IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General requirements).
IS/IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d").
IS/IEC 60529	:	Degree of protection provided by enclosures (IP Code).
IS/IEC 60898	:	Electrical Accessories circuit breakers for over protection for household and similar installations
IS/IEC 60947	:	LV switchgear and control gear.
IS/IEC 61439	:	Low voltage switchgear and control gear assemblies

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The Equipment shall also confirm to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

4.1 The equipment shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants, which are classified as hazardous. The power distribution boards shall be designed to operate under site conditions as specified in the data sheet. If not specifically mentioned therein, a design ambient temperature of 40° C and an altitude not exceeding 1000m above mean sea level shall be considered.

4.2 All the equipments described in this specification are intended for continuous duty with the specified rating under the specified ambient conditions unless indicated otherwise.

5.0 POWER SUPPLY

5.1 PDB shall be suitable for 415V, 50Hz, TPN incoming supply.

5.2 The outgoing of PDB shall be 415V TP/TPN power supply circuits and/or 240V SPN circuits as specified in the data sheet/ job specification.

6.0 CERTIFICATION

The equipment shall have test certificates issued by NABL accredited/ Central Government labs in India/ IECEx-approved/ equivalent labs. All equipment (indigenous & imported) shall also have valid statutory approvals, as applicable, for the specified location, and marking as per IS/IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license. All flameproof equipment shall have PESO approval.

7.0 TECHNICAL REQUIREMENTS

7.1 Construction

7.1.1 The Flameproof PDB shall be designed for service at project ambient temperature and shall be suitable for continuous operation without harmful effect with voltage and frequency variations as specified in the data sheets. The flameproof PDB shall have rated current and fault level rating as specified in the datasheet/ job specification.

7.1.2 The Flameproof PDB shall be free standing on a self-supporting pedestal mounting steel framework of angles and channel section, suitable for installation on concrete base with front access for operation and maintenance. The Flameproof PDB shall be fixed type, in single front execution, assembled in single line up with multiple flameproof cubicles housing feeders, cable terminations and bus bar. The arrangement shall provide adequate spacing between enclosures for direct vertical installation of power and control cables, entering enclosures from bottom/ top as specified in data sheet/ job specification. Adequate spacing and clearances shall be provided both on the top and at the bottom for maintenance works.

7.1.3 The devices and components mounted inside the cubicles shall have adequate clearances. The quantity and type/rating of components inside each cubicle shall be in accordance with the statutory test certificate details.

7.1.4 The enclosure of the flameproof PDB shall be made of cast light metal alloy. The enclosure of the flameproof PDB intended for use in units handling sulphuric acid/ other corrosive materials shall be made of stainless steel grade SS-316L, if specified in MR/Tender.

7.1.5 The flameproof PDB shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. It shall preferably be provided with integral canopy.

However, where the enclosure has been certified without integral canopy, a separate canopy shall be accepted for installation over the PDB. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanized sheet steel/stainless steel minimum SS-304. The canopy shall be suitable for providing protection against rain from top two sides and front.

7.1.6 The flameproof PDB shall be provided with gaskets made of non-inflammable and self-extinguishing material.

7.1.7 All metal surfaces shall undergo manufacturer's standard cleaning/ painting / powder coating cycle. After preparation of under surface, the panels shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flameproof Ex'd' (Gas group IIA/IIB) : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flameproof Ex'd' (Gas group IIC) : Light yellow shade 355 of IS-5 / RAL 1012.

All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then these shall be greased with non-solidifying grease. However, in case of stainless steel flameproof power distribution boards, finish shall be Electropolish/ Buffed/ equivalent finish.

7.1.8 A warning inscription "DO NOT OPEN WHEN ENERGIZED" 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.

7.1.9 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304, as minimum.

7.1.10 Main bus bars shall be of high conductivity electrolytic aluminium having uniform current rating, for specified fault level throughout their length. The bus bars shall be sized depending upon the maximum expected current and to limit the specified maximum operating temperature at specified design ambient temperature. Bus bars shall be supported by non-hygroscopic insulators. Bus bars shall be colour coded for identification of phases and neutral.

7.1.11 Copper earth bus of suitable size for specified fault level shall be provided throughout the length of the PDB. The earth bus shall be provided with alternate bands of yellow and green. All earth connection wires shall be suitably colour coded. All the non-current carrying metallic parts of the board shall be inherently bonded together. Each flameproof PDB shall be provided with two earthing studs with lugs on the exterior of the board suitable for termination of earth bus bar.

7.1.12 Neutral and earth bars shall be suitable for connecting the neutral and earth conductors of the circuits. The earth bars shall be drilled and tapped unnumbered brass link bars with stud bolts and screws. The neutral and earth terminals shall 10% more than the number of circuit breakers.

7.1.13 Provision shall be made for the bonding of earth conductor, cable glands and cable armouring at cable termination point.

7.1.14 Each cubicle shall be provided with space heater rated for 240V AC supply, provided with a switch, fuse or double pole MCB and thermostat having variable setting range of 30-70 °C, to prevent moisture condensation.

7.1.15 The PDB shall be provided with suitable sized cable entries as mentioned in datasheet/ job specification for incoming and outgoing cables. Unless otherwise specified, the PDB shall be suitable for bottom cable entry. Top cable entry shall be provided if specified in data sheet/ job specification.

All connections to incoming and outgoing cables shall terminate in terminal block, which shall be adequately sized for termination of the cables as specified in MR/ Tender. Sufficient space shall be provided inside the PDB for easy connection of Purchaser's cable. Suitable terminal blocks/ terminal studs, adequately rated, shall be provided for cable termination of each of the

feeders. Adequate number of terminals shall be provided for terminating incoming and outgoing cable entries. Board shall be supplied complete with double compression type nickel plated brass flameproof cable glands and Tinned copper lugs for incoming and outgoing cables. Flameproof nickel plated brass sealing plugs shall be supplied, for plugging the unused cable entries. The quantity of sealing plugs shall be equal to 20% of the total number of outgoing cable entries.

7.1.16 Inside the PDB, the wiring for power, control, signaling protection and instrument circuits shall be done with FRLS, PVC/ XLPE insulated copper conductor & BIS approved having 660/ 1100 V grade insulation. For modules rated above 100A, preferably copper strip connections shall be used. The control connections shall be done with 660V grade PVC/ XLPE insulated FRLS wires having stranded copper conductors. Minimum size of control wire shall be 1.5 mm^2 copper for circuits having fuse rating 10 A or less. For higher fuse rating control circuits, minimum 2.5 mm^2 copper conductor shall be used. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Cable sheath colours to be consistent with the phase/ neutral/ earth circuit to which they are connected. Only one conductor shall be connected to each terminal; additional linked terminals shall be provided where more connections are required. All terminals shall be shrouded. All wiring shall be clearly identified at both ends by individual non-ambiguous characters using barrel type ferrules/ marker tapes.

7.1.17 Clamp type terminals shall be acceptable for wires upto 10 mm^2 size. For conductors larger than 10mm^2, bolt type terminals with crimping lugs shall be provided. Each wire shall be terminated at a separate terminal. A minimum of 10% spare terminals shall be provided on each terminal block. Shorting links shall be provided for all CT terminals.

7.1.18 A Tag plate indicating Tag Number, engraved, 3 ply laminate fixed with screws shall be provided on each PDB. Nameplates shall also be provided for each incoming and outgoing feeder. A separate nameplate shall be provided to indicate the name of manufacturer, testing agency, test certificate number, serial number, BIS license number, applicable gas group as per IS/IEC 60079, statutory agency (PESO) approval number and any additional marking required by statutory authority. The nameplates shall be Al anodized or SS-304 engraved type or laser-marked and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate.

7.2 Equipment/ Component Specification

7.2.1 The Flameproof PDB shall be provided with incoming and out-going feeder with MCCBs/switches/ switch fuse unit/ MCBs as per data sheets/ job specification.

Unless otherwise specified, main incomers shall be suitable for 415V incoming TP/TPN power supply and provided with microprocessor based MCCB/ Switch along with CT, Ammeter, Voltmeter with selector switches and R,Y,B indicating lamps on line side.

7.2.2 The TPN outgoing feeders shall be with MCCB or switch fuse as specified in data sheet/ job specification. Further contactor, CT, ammeter, 3 pole ELCB with maximum sensitivity of 30 mA shall be provided for outgoing feeders as specified in MR/ Tender.

7.2.3 The SPN outgoing feeders, shall have 2 pole isolation, i.e. Phase and Neutral. Each outgoing circuit shall comprise of Miniature Circuit Breaker (MCB) with thermal over current and magnetic short circuit releases. 2 pole Earth Leakage Circuit Breaker (ELCB) (M9 Category) with maximum sensitivity of 30 mA & power contactor, CT, ammeter of required rating shall be provided if specified in data sheet/ job specification. MCB shall be double pole for single phase circuits. MCB rating shall be such that it shall not operate on starting current.

7.2.4 MCCBs shall be provided with spring assisted quick make/ break manually operated trip free mechanism with external operating handle mounted on the cubicle. MCCBs shall have provision for padlocking in OFF position. The ON and OFF position shall be clearly indicated.

7.2.5 Where specified, the MCCBs for feeder circuits such as those for Motor Operated Valve Actuators shall be suitable for motor duty. MCCBs as part of motor starter module shall be current limiting type and type tested for type-2 co-ordination as per IS/ IEC-60947 considering energy efficient motors of IE-3 type unless otherwise specified elsewhere.

7.2.6 MCB shall have minimum breaking capacity of 9kA unless otherwise specified. Positive ON/ OFF indication shall be provided.

7.2.7 All switches shall be load break, heavy duty/ motor duty, air break type with the operating handle. All switches other than rotary switches shall be lockable in OFF position. Rating of switches for starter module shall meet the requirements of AC-23 duty as per IS/ IEC 60947 and minimum rating shall be as specified in job specification/ data sheets.

7.2.8 All contactors shall be air break type, equipped with main contacts and provided with 1NO+1NC potential free spare auxiliary contacts wired to the terminal block for owner's use. The main contacts of contactor for motor starter module shall have AC-3 or AC-4 rating as per package requirements. Unless specified otherwise, the coil of the contactor shall be suitable for operation on 240 V, 1 Phase, AC supply.

7.2.9 All fuses shall be non-deteriorating HRC cartridge link type, BIS approved. Power fuses shall be pressure fitted type and shall preferably have ribs on the contact blades to ensure good line contact. It shall be possible to handle fuses during off load conditions with full voltage available on the terminals. Two nos. fuse pullers shall be provided. The fuse base shall be so located in the modules to permit insertion of fuse pullers and easy removal of fuse links without any problem.

7.2.10 Bimetal relays shall be provided for protecting the motor from thermal overload. Bimetal thermal overload relays shall be manually reset type with the reset push button provided on the cubical door. Bimetal relays shall be three elements, positive acting ambient temperature compensated type with adjustable setting range and built-in single phasing prevention feature, which operates even with 50% rated current at the time of single phasing.

7.2.11 All contactor controlled motor feeders for auxiliary motors etc. shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947 considering energy efficient motors of IE-3 type, unless otherwise specified elsewhere.

7.2.12 Current transformers for metering shall have an accuracy class 1.0 and instrument security factor not greater than 5. Protective current transformers shall have an accuracy class 5P and an accuracy limit factor greater than 10.

7.2.13 All measuring AC instruments shall be moving iron, flush mounting type for incomer and outgoing feeders. The accuracy class for all instruments shall be 1.0 as per IS-1248. Ammeters shall suitable for 1 Ampere CT secondary. Minimum size of ammeter shall be either 72mm x 72 mm or 65 mm diameter. For Ammeters of motor feeders 80% of the scale length shall cover 100% of the CT primary current uniformly and the balance 20% of the scale shall cover 100-800% of the CT primary. A red mark corresponding to the full load current of the motor shall be provided on the ammeter dial. The ammeter front glass shall be toughened. The kW/ kWH meters shall be suitable to measure unbalanced loads on 3 phases 4- wire system. Test terminal block shall be provided for kWH meters.

7.2.14 All control/ selector switches shall be rotary back-connected types having a cam operated contact mechanism with knob type handle. Ammeter selector switch shall have make before break feature on its contacts. The selector switch shall generally have 4 positions, three for reading 3 phase currents and the fourth position for OFF. The voltmeter selector switch shall also have 4 positions. Three positions shall be used to measure phase-to-phase voltage and fourth shall be OFF position.

7.2.15 Auxiliary relays/ contactors shall generally be used for interlocking and multiplying contacts.

7.2.16 All selector switches shall have minimum two poles for each position. Each position of switch shall be indelibly marked on the PDB. Exact configuration of selector switch (e.g. LOCAL-OFF-REMOTE etc.) shall be as per datasheet/ job specification.

7.2.17 Indicating lamps shall be cluster LED type or SMD chip type LED with colour lens of minimum 25mm diameter. The following indicating colours shall be used.

Closed/ ON	:	Red
Open/ OFF	:	Green
Fault trip	:	Amber

7.2.18 Push button colours shall be as follows:

Stop/open/emergency stop	:	Red
Start/close	:	Green
Reset	:	Black
Test	:	White

The 'Stop' push button shall be stayput type.

All motor starter feeders shall have Stop and Reset push buttons and ON and Trip indication lamps.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the equipment shall be subjected to inspection by Owner/ EIL or by an agency authorized by the Owner/ EIL, if specified/ agreed in Approved Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to Owner's/ EIL's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

8.2 Type test certificates from NABL accredited/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license and original drawings referred in type test certificates shall be shown to the inspection agency on demand during inspection. The test certificates, BIS license and PESO approval must be valid at the time of despatch.

8.3 Test certificates of bought out components shall be shown to the inspection agency on demand during inspection.

8.4 All equipments shall be subjected to various routine / acceptance tests as per Approved Inspection & Test plan.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

अग्निरोधक लाइटिंग और पावर पैनलों के लिए विनिर्देश

SPECIFICATION FOR FLAMEPROOF LIGHTING AND POWER PANELS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	22.03.21	REVISED AND ISSUED AS STANDARD SPECIFICATION	RKS	ANPS	PG	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	24.09.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
DGMS	Directorate General of Mines Safety
EIL	Engineers India Limited
ELCB	Earth Leakage Circuit Breaker
FRLS	Flame Retardant Low Smoke
GI	Galvanized Iron
IEC	International Electro-technical Commission
IP	Ingress Protection
IS	Indian Standards
LV	Low Voltage
MCB	Miniature Circuit Breaker
MR	Material Requisition
NABL	National Accreditation Board for Testing and Calibration Laboratories
PESO	Petroleum and Explosives Safety Organisation
PO	Purchase Order
PVC	Poly Vinyl Chloride
SPN	Single Phase and Neutral
SS	Stainless Steel
TPN	Three Phases and Neutral
XLPE	Cross Linked Poly Ethylene

Electrical Standards Committee

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Ms. Arvind N. P. Singh
Mr. Harish Kumar
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Mr. V. K. Jain
Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of flameproof Lighting and Power panels/ accessories suitable for installation in locations handling flammable liquids and gases / vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	:	Colours for ready mixed paints and enamels
IS-12640	:	Residual current operated circuit breakers
IS / IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General requirements)
IS / IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d")
IS / IEC 60529	:	Degree of protection provided by enclosures (IP Code)
IS / IEC 60898	:	Electrical Accessories - circuit breakers for over protection for household and similar installations
IS / IEC 60947	:	LV switchgear and control gear.

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also confirm to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. The lighting and power panels shall be designed to operate under site conditions as specified in the data sheet. If not specifically mentioned therein, a design ambient temperature of 40° C and an altitude not exceeding 1000m above mean sea level shall be considered.

5.0 POWER SUPPLY

5.1 Lighting and power panels shall be suitable for 415V, 50Hz, TPN incoming power supply and outgoing circuits for 240V, SPN power supply.

5.2 For projects falling under the jurisdiction of DGMS, the following additional requirements shall apply:

5.2.1 The phase-to-phase voltage shall not exceed 125V (where electric lighting is used in underground mine)/ 250V (where electric lighting is used in open cast mine or surface of a mine), with the neutral or the mid-point of the lighting system connected with earth.

5.2.2 The panels shall have three phase, 3-wire system, without neutral.

5.2.3 Outgoing circuits shall be controlled by 2-pole MCBs. Earth leakage protection shall be provided for all outgoing circuits, which shall isolate both poles.

6.0 CERTIFICATION

The equipment shall have test certificates issued by NABL-approved/ Central Government labs in India/ IECEx-approved/ equivalent labs. All equipment (indigenous & imported) shall also have valid statutory approvals, as applicable, for the specified location, and marking as per IS/IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license.

7.0 TECHNICAL REQUIREMENTS

7.1 Construction

7.1.1 The enclosures of the lighting and power panels shall be made of cast light metal alloy, unless otherwise specified. The enclosures of the lighting and power panels intended for use in units handling sulphuric acid/ other corrosive materials shall be made of stainless steel grade SS-316L, if specified in MR/ Tender.

7.1.2 The panels shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. They shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanized sheet steel/ stainless steel minimum SS-304 (as specified in MR/ Tender). The canopy shall be suitable for providing protection against rain from top, back and two sides.

7.1.3 The lighting and power panels shall be provided with gaskets made of non-inflammable and self-extinguishing material.

7.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the panels shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flame proof Exd (Gas group IIA/IIB): Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flame proof Exd (Gas group IIC): Light yellow shade 355 of IS-5/ RAL 1012.

All unpainted steel parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving elements, then these shall be greased with non-solidifying grease. However, in case of stainless steel lighting and power panels, finish shall be Electropolish/ Buffed/ equivalent finish.

7.1.5 A warning inscription "DO NOT OPEN WHEN ENERGIZED" 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.

7.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

7.1.7 All the non-current carrying metallic parts of the panel shall be inherently bonded together. Each lighting and power panel shall be provided with two earthing studs (bolt, nut with spring and plain washer) with lugs on the exterior of the panel enclosure suitable for termination of 10 mm dia GI wire rope. No screw type fixing arrangement shall be allowed.

7.1.8 Each outgoing feeder shall be provided with distinct terminals for phase, neutral and earth. The terminal block enclosures shall be adequately sized to properly terminate the cables by taking into account the required bending radii of cable cores and shall have the following minimum gland to terminal distances:

Conductor Size	Up to 2.5 mm^2	Above 2.5 mm^2 & Up to 10 mm^2	Above 10 mm^2 & Up to 35 mm^2	Above 35 mm^2 & Up to 95 mm^2
Gland to terminal distance	40 mm	60 mm	100 mm	150 mm

7.1.9 The panels shall be provided with suitably sized cable entries at the bottom/ sides, for incoming and outgoing cables. Panels shall be complete with double compression type nickel plated brass flameproof cable glands. Flameproof nickel plated brass sealing plugs shall be supplied, for plugging the unused cable entries. The quantity of sealing plugs shall be equal to 20% of the total number of outgoing cable entries.

7.1.10 The panels shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

7.1.11 A tag plate indicating Tag Number, engraved, 3 ply laminate fixed with screws, shall be provided on each lighting and power panel. Nameplates shall also be provided for each incoming and outgoing feeder. A separate nameplate shall be provided to indicate the name of manufacturer, testing agency, test certificate number, serial number, BIS license number, applicable gas group as per IS/IEC 60079, statutory agency (PESO) approval number and any additional marking required by statutory authority. The nameplates shall be Al anodized or SS-304 engraved type or laser-marked and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate.

7.2 Component Specification

7.2.1 Bus bars in the lighting and power panels shall be made of high conductivity copper, and shall be supported by non-hygroscopic insulators. Bus bars shall be colour coded for identification of phases and neutral.

7.2.2 The incomer shall have one no. 4 pole MCB isolator (without overload and short-circuit release) and one no. 4 pole ELCB (if specified in the MR/ Tender). ELCBs shall have a maximum sensitivity of 30mA.

7.2.3 The outgoing feeders shall be provided with double pole MCBs having overload and short-circuit releases. Further, separate 2 pole ELCBs with maximum sensitivity of 30mA shall be provided for outgoing feeders if specified in MR/ Tender.

7.2.4 All MCBs (except isolators) and ELCBs shall be with 10kA interrupting capacity.

7.2.5 The ELCB shall be hand reset type. Door mounted reset push button shall be provided for ELCB.

7.2.6 The operating knobs (ON/ OFF/ RESET) shall be provided with a suitable rack and pinion arrangement or cam type operating mechanism for operating them smoothly from outside.

7.3 Terminals & Wiring

7.3.1 The panels shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be

used. Tinned Copper lugs shall be provided for cable termination. Incoming and outgoing terminals shall be suitably segregated.

7.3.2 All internal wiring in lighting and power panels shall employ adequately sized, 660V/ 1100V grade, FRLS type, XLPE/ PVC insulated, Copper conductor wires, colour coded for phase, neutral and earth, with minimum conductor sizes as below:

Incomer	:	16 mm²
Outgoing	:	2.5 mm²

All terminations shall be with suitable lugs.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

8.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.

8.3 Test certificates of bought out components shall be submitted to the inspection agency, as per inspection and Test Plan no. 6-81-1008.

8.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test plan no. 6-81-1008.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

पैकेज उपस्कर के मध्यम वोल्टेज वाले फिक्स किस्म के स्वीचबोर्ड के लिए विनिर्देश

SPECIFICATION FOR MV SWITCHBOARDS FIXED TYPE FOR PACKAGE EQUIPMENT

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	10.02.2021	REVISED AND REISSUED AS STANDARD SPECIFICATION	CA/RKS	SA	PG	SM
4	01.04.2016	REVISED AND REISSUED AS STANDARD SPECIFICATION	CA/RKS	SA	BRB	RN
3	03.02.2011	REVISED AND REISSUED AS STANDARD SPECIFICATION	DA	SG	UAP	DM
2	07.03.2005	REVISED AND REISSUED AS STANDARD SPECIFICATION	SSM	RR	AAN	SKG
1	19.11.2001	REVISED AND ISSUED AS STANDARD SPECIFICATION	SSM	AAN	VPS	GRR

Abbreviations:

A	Ampere
AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CPRI	Central Power Research Institute
CRCA	Cold Rolled Cold Annealed
CT	Current Transformer
DC	Direct Current
DOL	Direct On Line
EIL	Engineers India Limited
EPDM	Ethylene Propylene Diene Monomer
FRLS	Flame Retardant Low Smoke
HDPE	High-Density Polyethylene
HRC	High Rupture Capacity
IEC	International Electrotechnical Commission
IP	Ingress Protection
IS	Indian Standard
kA	kilo Ampere
kW	kilo Watt
kWH	kilo Watt Hour
LED	Light Emitting Diode
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MV	Medium Voltage
NO	Normally Open
NC	Normally Closed
PVC	Poly Vinyl Chloride
V	Volt
XLPE	Cross-linked polyethylene

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Mr. Raman Sood
Mr. V.K. Jain
Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the requirement of design, fabrication, testing, packing and supply of Medium voltage fixed type switchboard in single front execution required for receipt, control and distribution of power to various medium voltage consumers of the package equipment such as Air conditioning plant, Pressurisation plant, etc.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS unless otherwise specified.

IS : 5	:	Colours for ready mixed paints and enamels
IS : 1248	:	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories
IS : 2824	:	Method for determining the proof and the comparative tracking indices of solid insulating materials.
IS : 5082	:	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes.
IS : 5578	:	Guide for marking of insulated conductor.
IS : 11353	:	Guide for uniform system marking and identification of conductors and apparatus terminals.
IS : 13703	:	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC.
IS : 16227/ IEC: 61869	:	Instrument transformers
IS/IEC: 60255	:	Measuring Relays and Protection Equipment.
IS/IEC: 60269	:	Low-Voltage Fuses
IS/IEC: 60529	:	Degree of protection provided by enclosures (IP Code).
IS/IEC: 60947	:	Low Voltage Switchgear and control gear.
IS/IEC: 61439	:	Low voltage switchgear and control gear assemblies.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner/EIL in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one-year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The switchboards shall be suitable for installation and satisfactory operation in a pressurised room or in room with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

4.2 The switchboards shall be designed to operate under specified site conditions. If not specifically mentioned, a design ambient temperature of 40° C and altitude not exceeding 1000 metres above mean sea level shall be considered.

4.3 All the equipments described in this specification are intended for continuous duty with the specified ratings under the specified ambient conditions unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 The switchboard shall be free standing, suitable for directly flush mounting with the wall, with complete front access for operation and maintenance. The switchboard shall be fixed type, in single front execution, assembled in single line up, metal enclosed, fully compartmentalised, totally segregated compartments for feeders, cables and bus bar, dust and vermin proof suitable for indoor installation with form of internal separation minimum"Form-3b" as per IS/IEC-61439, unless otherwise specified elsewhere.

5.2 The switchboard enclosure shall be dust and vermin proof and shall provide a degree of protection not less than IP-41.

5.3 The switchgear shall be assembled out of vertical panels of uniform height not exceeding 2450 mm in a single line up. The maximum height of the operating handle/switches shall not exceed 1900 mm and the minimum height not below 300 mm.

5.4 The switchboard shall be designed to ensure maximum safety during operation, inspection, and connection of cables, relocation of outgoing circuits and maintenance with the bus bar system energised and without taking any special precautions. The switchgear shall permit maximum interchangeability. All identical equipments and corresponding parts shall be fully interchangeable.

5.5 It shall be possible to extend the switchboard, in either direction at a later date. End of bus bars shall be suitably drilled for this purpose. Panels at extreme end shall have openings, which shall be covered with plates screwed to the panel.

5.6 Adequate means shall be provided to prevent shorting of power and / or control terminals due to accidental dropping of maintenance tools etc. inside the switchboard. Checking and removal of components shall be possible without disturbing adjacent equipment/modules/feeders.

5.7 The frame, of individual vertical panels shall be fabricated using pressed and cold rolled sheet steel. The sheet steel used for panel shall be of minimum 2mm (14SWG) CRCA except the doors and covers that may be made of 1.6mm (16SWG) CRCA. Wherever required, stiffeners shall be provided to increase mechanical strength of large size doors and covers.

As an alternative to CRCA, Aluzinc/pre-galvanised sheet steel can also be provided for internal inter-panel partitions only as per vendor's standard manufacturing practices. However, all external surfaces shall be of CRCA with specified paint shade.

5.8 The switchboard shall be provided with integral base frame for each vertical panel. The switchboard integral base frame shall be suitable for tack welding.

5.9 All hardware shall be corrosion resistant. All joints and connections of the panel members shall be made of galvanised or zinc passivated cadmium plated high quality steel bolts, nuts and washers, secured against loosening.

5.10 All openings, covers and doors shall be provided with gaskets of Neoprene/HDPE/EPDM or equivalent around the perimeter to make the switchboard dust and vermin proof.

5.11 Suitable removable type eyebolts/ lifting hooks shall be provided for lifting of the panel/shipping section. These eyebolts/ lifting hooks, when removed shall not leave any opening in the panels.

5.12 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL-7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.13 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

5.14 The switchboard shall be suitable for top or bottom cable entry as mentioned in datasheet, and shall be provided with removable gland plates. The gland plate thickness shall be minimum 3mm. Non-magnetic cable gland plates shall be provided for termination of single core cables. The switchboard shall have a separate cable alley for each vertical panel with cable tying arrangement. The cable alley width shall be sufficient to accommodate the required number of cables. However, in any case it shall not be less than 200mm width. The cable alley shall be provided with a suitable hinged door. Required number of single compression nickel plated brass cable glands and tinned copper compression type lugs (for bolted terminals) for all power and control cables shall be included in the vendor's scope of supply.

5.15 The switch board shall comprise of incoming load break switch panel or air circuit breaker panel, outgoing switch fuse, switch fuse contactor feeders, MCCB feeders, motor starter feeders, control supply transformers, both power and auxiliary/control bus bars, cable termination compartment etc. All these shall be housed in independent compartments separated from each other by metallic barrier.

5.16 Main horizontal bus bars shall be provided at the bottom in separate compartment for switchboards with top cable entry and at the top for switchboards with bottom cable entry. Vertical bus bars required for connection between main bus bars and outgoing feeders shall be in separate vertical chamber. One set of vertical bus bars can be provided for feeding outgoing feeders in two panels on either side of the vertical bus bar.

5.17 All components including bus bars and cable termination shall be accessible only from the front side for repair and maintenance.

5.18 Each outgoing feeder shall be in multitier arrangement having minimum height of individual module as defined in switchboard data sheet. All feeders shall be of modular design with height in multiples of standard unit size.

5.19 All auxiliary devices for control, reset, indication, measurement and protection except the bimetallic relays shall be mounted on the front side of the respective compartment. Components requiring frequent inspection during operation shall be easily accessible. The design shall be such that all power ON/OFF or START / STOP and relay reset operations shall be performed without opening the panel door.

5.20 Each vertical panel shall be provided with space heater to prevent moisture condensation rated for 240V AC supply, provided with a switch, fuse or double pole MCB and thermostat having variable setting range of 30-70 °C. The panels shall be provided with suitable illuminating LED lamp with switch and fuse or MCB. Further, one number 240V AC, 6/ 16A, 5 Pin socket for owner's use shall be provided inside panels.

5.21 Main bus bars shall be of high conductivity electrolytic aluminium/ copper having uniform current rating throughout their length. Horizontal and vertical bus bars shall be sized depending upon the maximum expected current and to limit the specified maximum operating temperature at specified design ambient temperature.

5.22 The hotspot temperature of busbars, including joints, at design ambient temperature shall not exceed 95°C under normal operating conditions. However, for silver plated joints, the allowable maximum temperature shall be 115°C.

5.23 Minimum clearance between live parts, between live parts/neutral to ground shall be 19 mm. However, clearances between terminals of components shall be as per applicable individual standards for respective components.

5.24 Adequately sized auxiliary copper bus bars running horizontally in a separate enclosure / compartment shall be provided for space heaters, control supply and metering requirements. Necessary tee-off connections shall be used for distributing auxiliary supply to each vertical panel.

5.25 All horizontal and vertical bus bars shall be insulated with heat shrink PVC sleeves of 1100 V grade and removable shrouds shall be provided for joints. All bus bars shall be prominently marked with Red, Yellow and Blue colour rings for easy phase identification at regular interval and at every power tap off point and designed to withstand specified short circuit currents for one second.

5.26 Copper earth bus of minimum 30x6 mm^2 size for fault level upto 31.5 kA and minimum 50x6 mm^2 size for fault level above 31.5 kA shall be provided throughout the length of the switchboard with provision for interconnection to earthing grid at two ends. All non-current carrying metallic parts of the mounted equipment shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.

5.27 Inside the switchboards, the wiring for power, control, signalling, protection and instrument circuits shall be done with FRLS, PVC/XLPE insulated copper conductors & BIS approved having 660/1100 V grade insulation.

5.28 For modules rated above 100 A, preferably copper strip connections shall be used. The controls connections shall be done with 660V grade PVC/XLPE insulated FRLS wires having stranded copper conductors. Minimum size of control wire shall be 1.5 mm^2 copper for circuits having fuse rating 10 A or less. For higher fuse rating control circuits, minimum 2.5 mm^2 copper conductor shall be used. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Transparent shrouds shall be used on outgoing power terminals.

5.29 Clamp type terminals shall be acceptable for wires upto 10 mm^2 size, for conductors larger than 10 mm^2, bolt type terminals with crimping lugs shall be provided. Each wire shall be terminated at a separate terminal. A minimum of 10% spare terminal shall be provided on each terminal block. Shorting links shall be provided for all CT terminals.

5.30 Components of similar modules of same sizes shall be identically located and wired. Control supply change over switch shall be provided in case the switchboard is with two bus-sections.

5.31 In open doors condition of compartment, all live parts or terminals of all door-mounted, internal components and bus contact openings shall be IP-2X protected.

5.32 Unless otherwise specified elsewhere, the switchboard assembly and components shall be suitable for use in pollution degree 3 environment as per IS/IEC.

6.0 EQUIPMENT / COMPONENTS SPECIFICATION

6.1 All circuit breaker shall be air break type. All switches shall be load break, heavy duty/motor duty, air break type with the operating handle mounted on the compartment door, complete with necessary interlock and defeat mechanism. All switches drives other than rotary switches shall be lockable in OFF position. Rating of switches for starter module shall meet the requirements of AC-23 duty as per IS/ IEC 60947 and minimum rating shall be as specified in job specification/data sheets.

6.2 The incomers & buscoupler shall be provided with 4 pole load break switch/breaker.

6.3 All contactor controlled starter feeders shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947. However, contactor controlled motor feeders shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947 considering energy efficient motors of IE-3 type, unless otherwise specified elsewhere.

6.4 All fuses shall be non-deteriorating HRC cartridge link type, BIS approved. Power fuses shall be pressure fitted type and shall preferably have ribs on the contact blades to ensure good line contact. It shall be possible to handle fuses during off load conditions with full voltage available on the terminals. Wherever required fuse pullers shall be provided. The fuse base shall be so located in the modules to permit insertion of fuse pullers and removal of fuse links without any problem.

6.5 The contactors shall be air break type, equipped with three main contacts and provided with 1NO+1NC potential free spare auxiliary contacts wired to the terminal block for owner's use. The main contacts of contactor for motor starter module shall have AC-3 or AC-4 rating as per package requirements. Unless specified otherwise, the coil of the contactor shall be suitable for operation on 240 V, 1 Phase, AC supply.

6.6 Bimetal relays shall be provided for protecting the motor from thermal overload. Bimetal thermal overload relays shall be manually reset type with the reset push button provided on the cubical door. Bimetal relays shall be three elements, positive acting ambient temperature compensated type with adjustable setting range and built-in single phasing prevention feature, which operates even with 50% rated current at the time of single phasing.

6.7 MCCBs shall be provided with spring assisted quick make/ break manually operated trip free mechanism. 'ON' and 'OFF' position of the operating handle of MCCB shall be displayed and the operating handle shall be mounted on the door of the compartment. MCCB's as part of motor starter module shall be current limiting type and type tested for type-2 co-ordination as per IS/ IEC-60947 considering energy efficient motors of IE-3 type unless otherwise specified elsewhere.

6.8 Current transformers for metering shall have an accuracy class 1.0 and instrument security factor not greater than 5. Protective current transformers shall have an accuracy class 5P and an accuracy limit factor greater than 10.

6.9 All measuring AC instruments shall be moving iron, flush mounting type and of 96 x 96 mm square pattern instruments for incomer and outgoing feeders. The accuracy class for all instruments shall be 1.0 as per IS-1248. Ammeters for motor feeders shall have a non-linear compressed scale at the end to indicate motor starting current and red mark for the full load current. The KW/KWH meters shall be suitable to measure unbalanced loads on 3 phases 4-wire system. Test terminal block shall be provided for KWH meters.

6.10 Digital meters shall be provided, if specified in job specifications/datasheets. All digital meters shall be highly reliable, accurate, compact and self powered. Digital meter data shall be saved in case of power failure.

6.11 All Control/selector switches shall be rotary back-connected types having a cam operated contact mechanism with knob type handle. Ammeter selector switch shall have make before break feature on its contacts. The selector switch shall generally have 4 positions, three for reading 3 phase currents and the fourth position for off. The voltmeter selector switch shall also have 4 positions. Three positions shall be used to measure phase-to-phase voltage and fourth shall be OFF position.

6.12 Auxiliary relays/contactors shall generally be used for interlocking and multiplying contacts.

6.13 MCB shall have minimum breaking capacity of 9kA unless otherwise specified. Positive ON/OFF indication shall be provided.

6.14 Indicating lamps shall be cluster LED type of minimum 8mm-diameter size. The following indicating colours shall be used.

Closed/on	:	Red
Open/off	:	Green
Fault trip	:	Amber
Control supply on	:	White

6.15 Push button colours shall be as follows:

Stop/open/emergency stop	:	Red
Start/close	:	Green
Reset/test	:	Yellow/Black/White

The 'Stop' push button shall be stayput type.

All motor starter feeders shall have Stop and Reset push buttons and On and Trip indication lamps.

6.16 A centrally located engraved nameplate shall be provided for the switchboard. Each module shall have engraved nameplate bearing data as per approved drawings. Nameplate or polyester adhesive stickers shall be provided for each equipment mounted on & inside the switchboard. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram. Special warning labels shall be provided on removable covers or doors giving access to cable terminals and bus bars.

Engraved nameplates shall preferably be of 3- ply (Black-White- Black) lamicoid sheets or anodised aluminium. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the switchboard shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

7.2 For testing requirements refer Inspection & Test Plan No. 6-81-1012. Prior notice of minimum 4 weeks shall be given to EIL/owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

7.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1012.

8.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation .The equipment shall be properly packed for transportation by ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special precaution notations such as Fragile, This side up, centre of gravity, weight, Owner's particulars, Purchase order number etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

औद्योगिक किस्म के नियंत्रण स्टेशन के लिए विनिर्देश

SPECIFICATION FOR INDUSTRIAL TYPE CONTROL STATIONS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	18.01.21	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	RSR	PG	SM
5	11.03.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	SV	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	JM	ANPS	UAP	DM
3	24.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian standards
CEA	Central Electricity Authority
CT	Current Transformer
DC	Direct Current
EIL	Engineers India Limited
FRLS	Flame Retardant Low Smoke
GI	Galvanised Iron
IEC	International Electrotechnical Commission
IP	Ingress Protection
IS	Indian Standards
LED	Light Emitting Diode
LV	Low Voltage
NC	Normally Closed
NO	Normally Open
PB	Push Button
PO	Purchase Order
PVC	Poly Vinyl Chloride
SMD	Surface Mount Device
SS	Stainless Steel
SWG	Standard Wire Gauge
VFD	Variable Frequency Drive
XLPE	Cross Linked Poly Ethylene

Electrical Standards Committee

Convenor: Mr. Parag Gupta

Members:
Mr. M.K. Sahu
Ms. Arvind NP Singh
Mr. Harish Kumar
Ms. Shalini Verma
Mr. Raman Sood
Mr. V.K. Jain
Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of industrial type control stations and accessories suitable for installation in non-hazardous/ safe outdoor areas.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS:

IS: 5	:	Colours for ready mixed paints and enamels.
IS: 1248	:	Direct acting indicating analogue measuring instruments and their accessories.
IS / IEC: 60529	:	Degrees of protection provided by enclosures (IP code).
IS / IEC: 60947	:	LV switchgear and control gear.

2.2 In case of imported equipment, IEC standards or equivalent standards shall be applicable, if these standards are equivalent or more stringent than the applicable Indian Standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 TECHNICAL REQUIREMENTS

5.1 Construction

5.1.1 The enclosures of the control stations shall be made of either sheet steel or cast light metal alloy, unless otherwise specified.

5.1.2 The control stations shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. Suitable canopy shall be provided for protection against rain from top, back and two sides. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanized sheet steel/ stainless steel minimum SS-304 (as specified in purchase specifications).

5.1.3 All control stations shall be suitable for 240V AC as well as for 110V/220V DC control supply.

5.1.4 The control stations shall be provided with gaskets made of non-inflammable and self-extinguishing material.

5.1.5 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as dark admiralty grey, shade 632 of IS-5/ RAL 7031. All unpainted parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving, then these shall be greased with grease which does not solidify.

5.1.6 All accessories like nuts, bolts, washers etc. and operating shaft of push buttons, switches etc. shall be made of stainless steel SS-304. Alternatively, nickel-plated brass material may be used for the operating shafts of push buttons, switches etc.

5.1.7 The control stations shall be provided with two earthing studs (minimum M10 bolt, nut with spring and plain washer) with lugs on the external surface of the enclosures suitable for termination of 8 SWG GI wire. No screw type fixing arrangement shall be allowed.

5.1.8 The control stations shall be provided with undrilled gland plate. However, double compression nickel-plated brass cable glands shall be supplied loose to suit the specified cable sizes. The cable termination chamber of the control station shall be large enough to provide a minimum space of 100 mm between top of the cable gland and bottom of the terminal block.

5.1.9 The control stations shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

5.1.10 A tag plate indicating Tag Number shall be provided on each control station. The tag plate shall be engraved, 3 ply laminate fixed with screws.

5.2 Component Specification

5.2.1 Push buttons for START/ OPEN and STOP/ CLOSE shall be of GREEN and RED colour respectively. Each push button shall have two NO and two NC contacts. The STOP push button shall be mushroom type with stay put feature and lockable in pressed position. Refer Sketch 1 for wiring and other details for various types of control stations

5.2.2 All selector switches shall have minimum two poles for each position. Each position of switch shall be indelibly marked on the control station. The configuration of selector switch shall be LOCAL-OFF-REMOTE.

5.2.3 All ammeters shall be of moving iron type having an accuracy class of 1.5 and suitable for 1 Ampere CT secondary. Minimum size of ammeter shall be either 72 mm x 72 mm or 65 mm diameter. 80% of the scale length shall cover 100% of the CT primary current uniformly and the balance 20% of the scale shall cover 100-800% of the CT primary. A red mark corresponding to the full load current of the motor shall be provided on the ammeter dial. The ammeter front glass shall be toughened.

5.2.4 Indicating lamp(s), wherever provided, shall be clustered LED type or SMD chip type LED with colour lens of minimum 25 mm diameter.

5.3 Terminals & Wiring

5.3.1 The control stations shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. Each terminal for external cable connection shall be suitable for termination of 2.5 mm^2 (unless otherwise specified) stranded copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.

5.3.2 All internal wiring shall employ 1.5 mm^2, 660V/ 1100V grade, FRLS type, XLPE/ PVC insulated copper conductor wires. All termination shall be with suitable lugs.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

6.2 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1014.

6.3 All equipment shall be subjected to various routine / acceptance tests as per Inspection and Test Plan no. 6-81-1014.

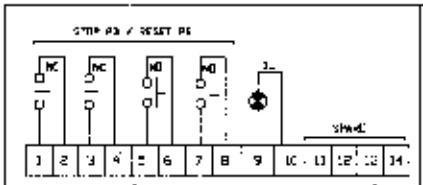
7.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

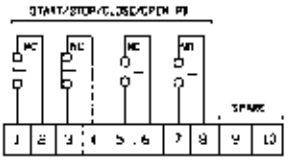
The equipment may be stored outdoors for long periods before installation. The packing shall be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

SKETCH–1

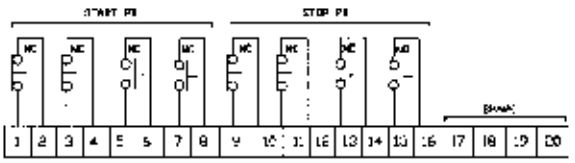
WIRING DETAILS OF CONTROL STATIONS



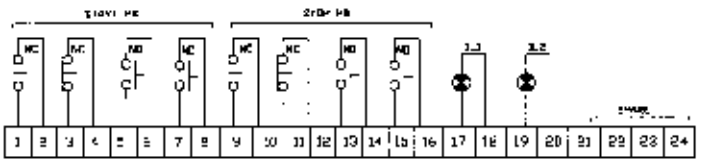
TYPE–A1 (STOP P.B. WITH LAMP)
OR
(RESET P.B. WITH LAMP)
(CABLE SIZE : 4Px2.5 Sq.mm)



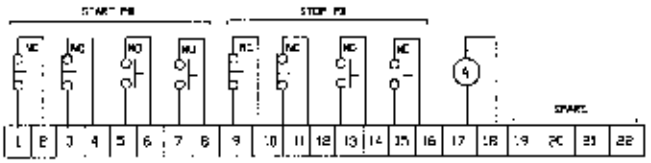
TYPE–A2
(START PB) OR (STOP PB) OR (CLOSE PB) OR (OPEN PB)
(CABLE SIZE : 2Px2.5 Sq.mm)



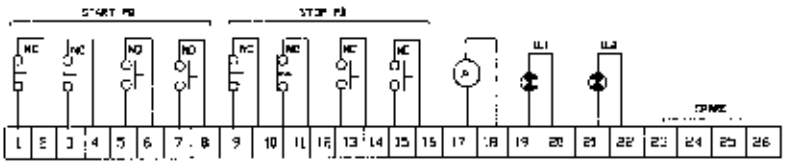
TYPE–B1 (WITH START & STOP PBs) OR (WITH CLOSE & OPEN PBs)
(CABLE SIZE : 4Px2.5 Sq.mm)



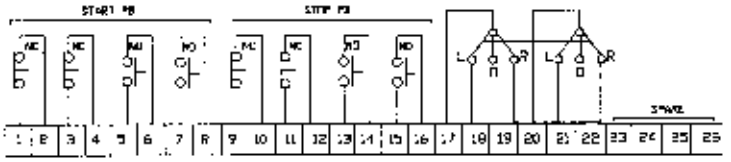
TYPE–B2 (WITH START & STOP PBs & INDICATION LAMPS)
OR
(WITH CLOSE & OPEN PBs & INDICATION LAMPS)
(CABLE SIZE : 6Px2.5 Sq.mm)



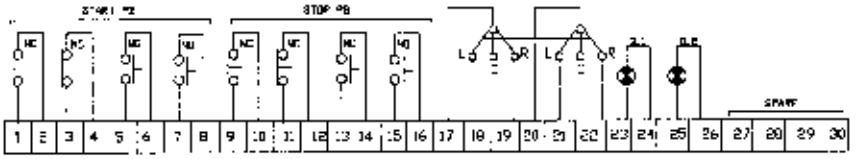
TYPE–C1 (WITH START & STOP PBs & AMMETER)
(CABLE SIZE : 4Px2.5 Sq.mm)



TYPE–C2 (WITH START & STOP PBs, AMMETER & INDICATION LAMPS)
(CABLE SIZE : 6Px2.5 Sq.mm)



TYPE-D1 (WITH START & STOP PBs & L-O-R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm)



TYPE-D2 (WITH START & STOP PBs, L-O-R SELECTOR SWITCH & INDICATION LAMPS)
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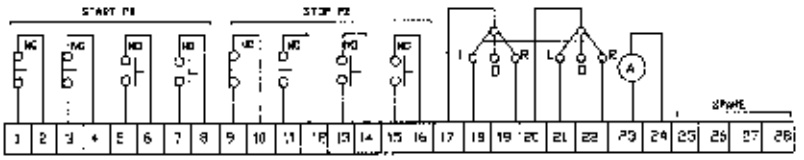
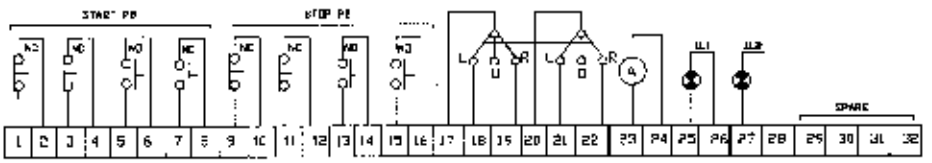
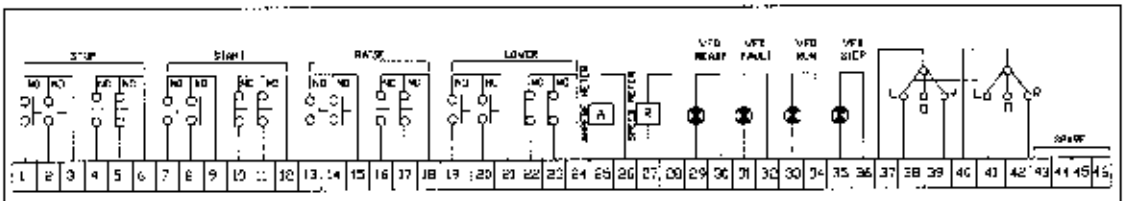


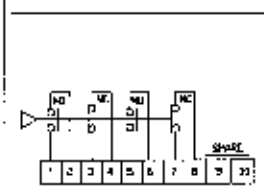
TYPE-E1 (WITH START & STOP PBs, AMMETER & L-O-R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm)



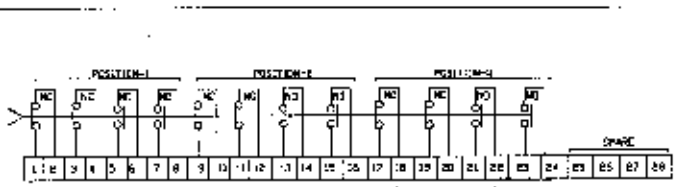
TYPE-E2 (WITH START & STOP PBs, AMMETER, L-O-R SELECTOR SWITCH & INDICATION LAMPS)
(CABLE SIZE : 12Px2.5 Sq.mm)



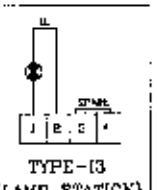
TYPE-F (WITH START & STOP PBs, RAISE & LOWER PBs, L-O-R SWITCH, AMPERE METER, SPEED METER & INDICATING LAMPS) (REFER NOTE-5,6,7)
(CABLE SIZE : 12Px2.5 Sq.mm)



TYPE-I1
SEL SWITCH (2POSITION)



TYPE-I2 SEL SWITCH (3POSITION)



TYPE-I3
(LAMP STATION)

GENERAL NOTES:

1. SHORTING LINKS SHALL BE PROVIDED BY VENDOR. REQUIREMENT SHALL BE INFORMED DURING VENDOR DRAWING REVIEW.
2. WIRING DETAILS SHALL BE READ IN CONJUNCTION WITH MR/TENDER.
3. CABLE SIZES AS INDICATED ABOVE ARE TENTATIVE AND MINIMUM. EXACT CABLE SIZES SHALL BE INFORMED DURING VENDOR DRAWING REVIEW. VENDOR TO PROVIDE REQUIRED SIZE OF CABLE TERMINATION CHAMBER WITH SUITABLE TERMINALS, CABLE ENTRIES, CABLE GLANDS AND LUGS. CONDUCTOR SIZE SHALL BE 2.5 SQ.MM, UNLESS OTHERWISE SPECIFIED.
4. AMMETER WHEREVER PROVIDED, SHALL BE ANALOGUE TYPE UNLESS OTHERWISE SPECIFIED. 4-20 MA TYPE SHALL BE PROVIDED IF DEFINED IN MR/TENDER.
5. FOR VFD CONTROL STATIONS, LAMP SUPPLY VOLTAGE SHALL BE SAME AS VFD CONTROL SUPPLY VOLTAGE.
6. FOR VFD CONTROL STATIONS, IF EXTERNAL SUPPLY IS REQUIRED FOR METERS, THEN SAME SHALL BE AS VFD CONTROL SUPPLY VOLTAGE.
7. METERS IN VFD CONTROL STATIONS SHALL BE SUITABLE FOR 4-20mA TRANSDUCER OUTPUTS AND SHALL BE CALIBRATED FOR THE ACTUAL MOTOR CURRENT. FOR VFD HAVING BYPASS FACILITY, METERS SHALL BE CAPABLE OF READING BYPASS MODE FULL LOAD AND STARTING CURRENTS AS WELL AS VFD MODE DRIVE CURRENT.
8. NUMBER AND COLOUR OF INDICATING LAMPS SHALL BE AS PER THE JOB SPECIFATION/TENDER
9. CONTROL STATIONS TYPE "I" ARE TYPICALLY FOR INSTRUMENTATION USE.
10. ALL PUSH BUTTON AND CONTROL SWITCH CONTACTS SHALL BE RATED FOR MINIMUM 6A AT 240V(AC-16) AND 1A AT 220V/110V(DC-13) DUTY. CONTACT RATINGS FOR CONTROL STATIONS FOR INSTRUMENTATION USE SHALL BE AS PER INSTRUMENTATION REQUIREMENT
11. THE EXACT DESCRIPTION OF PB'S WHETHER START/STOP OR OPEN/CLOSE SHALL BE INFORMED DURING VENDOR DRAWING REVIEW.
12. ALL L O R SELECTOR SWITCHES SHALL BE LOCKABLE IN OFF POSITION.

अनइन्टरप्टेड पावर सप्लाई सिस्टम के लिए विनिर्देश

SPECIFICATION FOR UNINTERRUPTED POWER SUPPLY SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
8	06.03.24	REVISED AND ISSUED AS STANDARD SPECIFICATION	MB / MHR	RS	MKS	MN
7	24.04.18	REVISED AND ISSUED AS STANDARD SPECIFICATION	MHR	RS	BRB	RN
6	05.08.13	REVISED AND ISSUED AS STANDARD SPECIFICATION	NN	RS	UAP/JMS	DM
5	08.09.08	REVISED AND ISSUED AS STANDARD SPECIFICATION	AM	NS	JMS	VC
4	09.04.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	HKM	RSG	VPS	AS

Abbreviations:

AC	:	Alternating Current
ACDB	:	AC Distribution Board
Ah	:	Ampere-hour
Amp	:	Ampere
BS	:	British Standard
CD	:	Compact Disk
CEA	:	Central Electricity Authority
CFL	:	Compact Fluorescent Lamp
CRCA	:	Cold Rolled Cold Annealed
DC	:	Direct Current
DCS	:	Distributed Control System
DG	:	Diesel Generator
EMC	:	Electromagnetic Compatibility
Hz	:	Hertz
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IGBT	:	Insulated Gate Bipolar Transistor
IP	:	Ingress Protection
IS	:	Indian Standards
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
MCCB	:	Moulded Case Circuit Breaker
MR	:	Material Requisition
MSL	:	Mean Sea Level
NEMA	:	National Electrical Manufacturers Association
Ni-Cd	:	Nickel Cadmium
PC	:	Personal Computer
PCB	:	Printed Circuit Board
PIV	:	Peak Inverse Voltage
PO	:	Purchase Order
P.U.	:	Per Unit
PVC	:	Poly Vinyl Chloride
RFI	:	Radio Frequency Interference
ROM	:	Read Only Memory
RS	:	Recommended Standard
SMPS	:	Switch Mode Power Supply
SPN	:	Single Phase Neutral
UPS	:	Uninterrupted Power Supply
V	:	Volt
VDE	:	Verband Deutscher Electrotechniker
VRLA	:	Valve Regulated Lead Acid

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CONTENTS

1.0 SCOPE

The scope of this specification is to define the requirements of design, manufacture, testing, packing and dispatch of static Uninterrupted Power Supply (UPS) system.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards:

IS: 5	:Colours for ready mixed paints and enamels
IS: 1248	:Direct acting indicating analogue electrical measuring (Part 1, 2, 4 and 9) instruments and their accessories.
IS: 12021	:Control transformers for switchgear and control gear for voltages not exceeding 1000V AC
IS: 13314	:Solid state inverters run from storage batteries
IS/IEC 60269- 1 &2	: LOW-VOLTAGE FUSES
IS: 13703 part 4	:Low-Voltage Fuses for Voltages not Exceeding 1000 V AC or 1500 V DC - Part 4 : Supplementary Requirements for Fuse Links for the Protection of Semiconductor Devices
IS: 13947 (Part-5/ Sec-2)	:Low voltage switchgear and control gear specification.
IEC-60146-1-1	:General requirement & line commutated inverters (specification of basic requirements)
IEC 62040-1	:Uninterruptible power systems (UPS) - Part 1: Safety requirements
IEC 62040-2	:Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements.
IEC 62040-3	:Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements
IEC 62040-4	:Uninterruptible power systems (UPS) - Part 4: Environmental aspects - Requirements and reporting.
IEEE-519	:Recommended practices and requirements for harmonic control in electrical power systems

2.2 In case of imported equipments, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/ specifications/ data sheets and statutory regulations, the most stringent requirement shall prevail and owner's/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

3.4 The UPS system shall be an integrated system comprising static rectifiers, battery, static inverters, static switches, manual by pass switch, AC distribution board, voltage stabiliser in bypass, isolating and protection devices and all other equipment/ accessories required for completeness of the system whether specifically mentioned herein or not, but necessary for completeness and satisfactory performance of the system.

3.5 The UPS system shall be suitable to feed all loads connected to the output which are primarily instruments, DCS, computers, disc drives and other SMPS equipment leading to high crest factor of the load.

3.6 The inverter shall be transistorised (IGBT) type or with the latest proven technology. All components shall be of a high quality and reliability that satisfy with the requirements of a secure AC power to vital equipments with respect to performance, controlling, monitoring and safeguarding function in continuously operating petrochemical process units, petroleum refineries, gas processing facilities, utility and other miscellaneous industrial plants. Components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short circuits and switching surges etc.

3.7 The design of the UPS shall be such as to minimise the risk of short circuits and shall ensure human and operational safety.

3.8 The vendor shall be responsible for design, engineering and manufacturing of the complete system to fully meet the intent and requirements of this specification and enclosed data sheets. Selection, sizing and suitability of all equipments and components used for UPS system shall be vendor's responsibility.

3.9 The UPS shall be single phase or three phase system as indicated in the data sheets.

3.10 The batteries shall meet the requirement of battery Data Sheet/ battery specifications attached with the bid document

4.0 SITE CONDITIONS

The UPS system shall be suitable for installation and satisfactory operation in a closed building (substation, control room, satellite rack room etc.) with restricted natural air ventilation in tropical, humid and corrosive atmosphere. The UPS system shall be designed to operate under site conditions as specified in the data sheet. If not specifically mentioned therein, design ambient temperature of 40^0C and altitude not exceeding 1000m above MSL shall be considered for the UPS.

5.0 TECHNICAL REQUIREMENTS

5.1 Input Power Supply

5.1.1 The UPS shall be suitable for input power supply as defined in the data sheet. If not specified therein the UPS shall be suitable for the following input power supply.

Voltage	:	415V ± 10%
Frequency	:	50 Hz ± 5%

In addition to above variations, the input voltage may be subject to transient variations comprising voltage dip to 80% of normal voltage during motor start-up and voltage interruption during short

circuit as well as frequency variations due to large motor start up. UPS system shall be designed to operate satisfactorily while deriving the input power from an emergency diesel generator set.

UPS system shall also operate satisfactorily on input power supply having:

- the ratio of negative to the positive sequence components not exceeding 5% and total harmonic distortion of not more than 5%.

Total Harmonic Distortion is the ratio in percentage of r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component of alternating quantity.

5.1.2 The manufacturer shall specify the current rating of input feeder to UPS from client switchboard based on 150% overload at minimum battery voltage and including the UPS efficiency.

5.1.3 The UPS shall be designed to ensure that harmonic components in the input current are limited as per IEEE519. Suitable filters as required shall be provided.

5.2 UPS Configuration and Operational requirements

The UPS system shall have one of the following basic configurations as specified in data sheet and drawings.

5.2.1 Single UPS with Bypass (Refer Sketch 1)

In UPS system having this configuration, a single rectifier and inverter shall be provided. Under normal conditions when AC mains power is available, the rectifier shall simultaneously feed DC power to inverter as well as for float/rapid charging of the battery.

The AC supply to loads shall be fed from inverter output. In case of any fault in the inverter, the load shall be automatically transferred to stabilized bypass supply and retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

In case of AC input power failure or battery charger failure, the battery shall supply power to inverter without any interruption. The charger shall be designed for simultaneously feeding complete inverter load and for float/rapid charging the battery to its rated capacity. Charger shall be equipped with 'On Line' automatic as well as manual charging facility.

5.2.2 Parallel Redundant UPS with bypass (With 1x100% battery)(Refer Sketch 2)

In UPS system having this configuration, two sets of rectifiers and inverters shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the battery and simultaneously to inverters. In case of failure in one rectifier, the other rectifier shall feed the complete load and the battery without any interruption.

In case of incoming supply failure or failure of both rectifiers, the battery shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the battery to its rated capacity. Each rectifier shall be equipped with 'On Line' automatic as well as manual charging facility.

Normally both inverters will be synchronised with each other and with stabilized bypass supply. Both inverters shall operate in parallel and share the load equally.

The load sharing controls shall not be subject to common mode failure and any failure of the load sharing controls shall not result in the loss of vital power.

When a disturbance/fault occurs in any one of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter. In case both the inverters develop a fault, the complete load shall be transferred to stabilized bypass supply through the static switches and retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

5.2.3 **Parallel Redundant UPS with bypass (With 2x50% batteries)(Refer Sketch 3)**

In UPS system having this configuration, two sets of rectifiers and inverters shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the 2 x 50% batteries and simultaneously to inverters. In case of failure in one rectifier, the other rectifier shall feed the complete load and the battery without any interruption.

In case of incoming supply failure or failure of both rectifiers the 2 x 50% batteries shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the 2 x 50% batteries to its rated capacity. Each rectifier shall be equipped with 'On Line' automatic as well as manual charging facility.

Normally both inverters will be synchronised with each other and with stabilized bypass supply. Both inverters shall operate in parallel and share the load equally.

The load sharing controls shall not be subject to common mode failure and any failure of the load sharing controls shall not result in the loss of vital power.

When a disturbance/fault occurs in any one of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter. In case both the inverters develop a fault, the complete load shall be transferred to stabilized bypass supply through the static switches and retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

5.2.4 **Hot Stand-by Redundant UPS with bypass**

In UPS system having this configuration, the arrangement of rectifiers/inverters and the operating philosophy is same as described in Cl.5.2.2 and Cl.5.2.3 above, except that only one inverter shall be operating at one time. The other inverter shall not be sharing the load but shall be synchronised with the running inverter and stabilized bypass supply and remain ready to accept the load in case of fault in the running inverter. Retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

5.2.5 **Dual Redundant UPS**

In UPS system having this configuration, the arrangement of rectifiers/inverters and the operating philosophy is same as described in Cl.5.2.1 above except that there shall be two nos. identical, fully independent, 100% rated, single UPS with bypass (sketch-1) and output connected to individual ACDB

5.2.6 In all UPS configurations, the facility for uninterrupted manual transfer in either direction through static switches shall also be provided.

5.2.7 For ease of maintenance, it shall be possible to isolate inverters and static switches from load through manually operated make before break switches. In case of larger rating UPS, where it is not possible to provide one power switch with make before break feature, combination of breakers with the control scheme having make before break logic may be provided which ensures momentary paralleling before tripping of selected breaker.

5.3 UPS Design and Performance Requirements

5.3.1 Incoming AC supply shall be converted to DC through three phase full wave controlled rectifiers. The rectifiers shall operate according to the constant voltage current limiting principle and shall incorporate a "Soft Start" feature to gradually accept load on initial energising.

5.3.2 The rectifier section of the UPS system shall be capable of precise regulation to prevent damage to the battery. The output voltage of rectifier's DC bus without the battery shall be stabilised to within ± 1% of set value during load variation between 0 to 100% of the rectifiers and specified mains input supply voltage variation.

5.3.3 Suitable protection shall be provided in the control circuits to guard against instability of phase controlled rectifiers due to electrical oscillations which may be present in the input supply as caused by emergency DG set.

5.3.4 The UPS system including the stabilised by-pass shall be galvanically isolated from input power supply system by providing double wound transformers having copper winding. All transformers shall be natural air cooled, dry type suitable for location inside the panel. All rectifiers shall also have a double wound transformer at its input.

5.3.5 An RFI filter shall be provided. The production of radio frequency interference voltage shall not exceed the value for category C3 as per IEC 62040-2. The performance of UPS system shall not get affected or in any way be degraded by the use of portable radio transmitter receiver in the vicinity of the UPS system and or UPS room.

5.3.6 Transient/surge protection circuit shall be provided in the input circuit to rectifiers to protect the UPS from surges & voltage spikes.

5.3.7 The UPS system shall be designed to draw power from mains supply at a minimum power factor of 0.85 while working at rated load in normal operating UPS configuration.

5.3.8 The UPS shall be provided with automatic sequence and power walk in circuit(s) with time delay of up to 15 sec. such that the rectifiers and inverters can start operating automatically when incoming AC power is restored allowing the UPS to be loaded automatically.

5.3.9 UPS system offered with DC-DC buck boost converter in DC link circuit may be considered acceptable as per manufacturer standard proven practice. DC-DC converter shall be with same IGBTs as provided in inverter circuit.

5.3.10 Facility for initial charging of batteries shall also be provided at a voltage level recommended by the battery manufacturer. The inverters may be disconnected during initial charging of the battery.

5.3.11 For battery sizing, the following factors shall be considered unless specified otherwise in the data sheet:

a. Load Power Factor of 0.8

b. Minimum ambient temperature as specified in Data sheet.

c. $$\text{Battery Current} = \frac{\text{Inverter rated kVA} \times \text{Rated load p. f.}}{\text{DC-DC converter efficiency}^{**} \times \text{Inverter Efficiency}^{*} \times \text{End cell voltage} \times \text{No. of cells}}$$

* at 50% load on each inverter for parallel redundant UPS

** DC - DC Converter Efficiency to be considered if provided

d. Aging factor of 0.8

e. Back up time of 30 minutes in case of mains power failure unless specified otherwise in data sheet

f. Minimum end cell voltage for lead acid/VRLA battery 1.75 V per cell and 1.0 V per cell for Ni-Cd battery.

g. Battery state of charge factor of 0.95.

5.3.12 The rectifiers/chargers shall be designed to completely charge the Lead acid and Nickel cadmium batteries in a maximum time of 10 hours after complete discharge and at the same time meeting the inverter input requirements when the inverter is delivering its rated output at 0.8 p.f. Facilities shall be provided to initiate battery rapid charge operation by manual & automatic means. An auto charging sequence should be provided for the rapid and float charging based on current sensing. Battery charger for VRLA battery shall be sized to provide boost charging of the battery up to 90% of rated Ampere hours within a duration of 24 hours and to 100% within 4 days. In addition to above, the charging shall be transferred from rapid to float mode after a preset time adjustable through 0-24 hours timer as back up protection against over charging.

5.3.13 The rectifiers shall be sized based on the maximum inverter input load when inverter is delivering its rated output at 0.8 rated p.f. and recharge the battery to nominal rated capacity of the battery. The DC load imposed by the inverters shall be considered under the most severe operating conditions where only one rectifier is operating but the UPS load is equally shared by all the inverters. The rating of each rectifier shall be not less than the value calculated as follows:

For Lead Acid Batteries = Inverter input current* + 0.14Ah (10 hr. Rating of the battery)
For Nickel- Cadmium Batteries = Inverter input current* + 0.2Ah (5 hr. Rating of the battery)
For VRLA Batteries = Inverter input current* + 0.2Ah (10 hr. Rating of the battery)

$$\text{* where Inverter input current} = \frac{\text{Rated kVA capacity of UPS X Rated load power factor}}{\text{Battery charging voltage X Inverter efficiency}}$$

5.3.14 The DC rectifiers shall sense the battery charging current and adjust the DC bus voltage to maintain the charging current to preset level. A separate current limit circuit shall also be provided for adjustment of battery current. The rectifiers shall be protected against reverse battery connection at DC link voltage bus. Subsequent to a discharge cycle when battery is connected to rectifier, the battery current shall be monitored, controlled and limited to set value automatically irrespective of the inverter input current.

5.3.15 The battery may be taken out of service for maintenance, during which period it shall be possible for the inverter to continue operation by drawing power from the rectifier. Ripple content at the DC link shall not exceed 2% even with battery disconnected.

5.3.16 Battery/ DC link shall be provided with a sensitive earth leakage detection.

5.3.17 The inverter shall be of the current limiting type (short circuit proof) and have nominal output voltage and frequency as specified in the data sheet. The inverter output voltage and frequency shall not exceed the operational tolerances, as measured at the output terminals of the unit during the following conditions of UPS loading:

- Load variations between 0-100% of the rated output of UPS
- Load power factor over the range of 0.7 lagging to unity.
- Load current waveform having a relative harmonic content varying between zero and 50%, the latter waveform having a crest factor not exceeding 2.5 and individual harmonics not exceeding the following values :

3rd harmonic	-	44% of fundamental
5th harmonic	-	33% of fundamental
7th harmonic	-	18% of fundamental
9th harmonic	-	7% of fundamental

11th harmonic - 10% of fundamental

The Relative harmonic content is the ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the total non-sinusoidal periodic waveform i.e. relative harmonic content =

$$\sqrt{[1-(\frac{\text{rms value of the fundamental component of current or voltage}}{\text{rms value of total waveform of current or voltage}})^2]}$$

- DC input voltages over the range corresponding to battery rapid charge and battery discharge operation during the specified discharge times.

The UPS output voltage waveform shall be sinusoidal with a relative harmonic content not exceeding 5% for both linear and non linear loads.

5.3.18 The inverter shall control the output voltage of the UPS such as to maintain synchronism with the mains bypass voltage during variations in mains frequency up to the limits specified.

During variations in mains frequency exceeding these limits, the inverter shall revert to internal frequency control.

5.3.19 It shall be possible to vary the inverter output voltage steplessly within ± 5% of the specified output voltage. This adjustment shall be possible to be made when the inverter is in operation.

5.3.20 The steady state output voltage and frequency (free running) variation of inverters shall not exceed ± 1% from the set value for specified input power supply conditions from no load to full load condition and load power factor variation from 0.7 lag to 1.0.

5.3.21 The UPS system shall be able to operate satisfactorily on rated loads (in kVA) with power factors in the range of 0.7 lag to 1.0. The overall efficiency of the UPS system shall not be less than 80% at rated load and 0.8 pf.

5.3.22 The UPS shall have capacity to deliver a minimum overload of 125% for 10 minutes and 150% for 1 minute. UPS shall be provided with current limit circuit to avoid excessive loading beyond its permissible overload withstand capability.

5.3.23 The inverters shall be 'phase locked' to the stabilized bypass power supply as long as stabilized bypass supply frequency remain within ± 4% of nominal. When bypass supply frequency variation exceeds the above limits, the inverters shall be de-linked from mains. Free running frequency tolerance limit shall not exceed ± 1%. Facility shall also be provided for adjustment of range of synchronising frequency.

5.3.24 Unless otherwise specified, the UPS system output voltage variation shall not exceed ± 10% and complete recovery to normal steady state shall be within 0.1 Sec. The phase angle disturbance shall be less than 120° ± 3 % in case of 3 phase inverter. The above requirement shall be complied for following transient disturbances.

a) 100% step load and unload (For single UPS and hot stand by UPS)
b) 50% step load (for parallel redundant UPS)
c) Momentary interruption in power supply
d) Load transfer to stabilized bypass supply
e) Complete load transfer to other healthy inverter when one of the two parallel inverters develop a fault.

5.3.25 For 3 phase UPS system, the maximum output voltage and angle variation between the phases should not exceed 6% and 3 degrees respectively even under the condition of 100% unbalanced loading of the 3 phase output.

5.3.26 UPS system shall be suitable both for floating output or earthing of one leg / star point in case of single phase/ three phase system respectively. However ACDB shall be provided with dedicated neutral busbar (in addition to earth bus-bar for body earthing) for system earthing for grounding of secondary side of isolation transformer including providing earthing connection from transformer secondary to neutral bus-bar. Sizing calculation for neutral busbar and connecting conductor shall be provided by vendor during detailed engineering.

5.3.27 The stabilized bypass supply shall be designed to regulate the output voltage within $\pm$1% of the rated voltage over complete range of load from no load to full load and for specified input supply voltage variation. The type of Voltage stabiliser in stabilized bypass supply shall be as indicated in data sheet.

5.3.28 The stabilized bypass supply shall have a continuous current rating equivalent to the rated output of the UPS unit and be capable of conducting a current ten times the rated output for the duration more than the fault clearing time of the type of fuse provided. The load transfer devices shall comprise of continuously rated static elements in both inverter and stabilized bypass supply.

5.3.29 Adequately rated static switches in required number & configuration shall be provided in the inverter(s) output and stabilized bypass supply to ensure positive isolation of faulty inverter section such that the other inverter and bypass circuits do not feed into the fault leading to under voltage / trip. The short time rating of all the static switches shall be at least 10 times the rated output for the duration more than the fault clearing time of the type of fuse provided.

5.3.30 Facility shall be provided to manually and automatically initiate transfer of the load from inverters to the stabilized bypass supply and from stabilized bypass supply to the inverters. Under voltage and over voltage sensing levels to initiate transfer shall be adjustable. The maximum transfer time between inverters and bypass supply shall not exceed 4 msec and 20 msec in synchronous and asynchronous mode respectively.

5.3.31 The criteria for load transfer:

A) Load transfer from inverter to the stabilized bypass supply shall be as follows:

(i) The load transfer shall only be possible when:

- The stabilised bypass output voltage is within $\pm$ 5% of rated UPS output voltage and
- The mains bypass frequency is within $\pm$ 4%.

(ii) Auto-transfer of the load from inverter to stabilized bypass supply shall be initiated when:

- The inverter output voltage drops below 95% of nominal output voltage under steady state condition and/or if the inverter output voltage falls below 90% of the nominal value under transient conditions.

OR

- The inverter output voltage exceeds 105% of the nominal output voltage under steady state condition and/or if the inverter output voltage reaches 110% of the nominal value under transient conditions.

OR

- The inverter output current exceeds its tolerable limits.

B) Retransfer of load from stabilized bypass supply to the inverter shall be as follows:

(i) The load transfer shall be possible when-

- The inverter output voltage is within ± 5% of nominal output voltage for more than 5 sec. and inverter output and stabilised bypass supply are synchronised

Retransfer of load from stabilised by pass to the inverter shall be done manually only unless otherwise specified in the data sheet

If automatic retransfer of load to the inverter is specified in the data sheet, then the retransfer of load to the inverter shall be inhibited following four automatic transfers of load to stabilised by pass within a period of 5 minutes.

5.3.32 All breakers shall be adequately rated for continuous rating as well as breaking capacity as applicable. Paralleling of breaker/ switch/ contactor poles to achieve the required current rating is not acceptable. All output isolating device shall be double pole type.

5.3.33 All electronic power devices including thyristors, transistors (IGBTs), diodes etc. shall be rated under operating conditions for approximately 200% of the maximum current carried by the device. All other electrical components such as transformers, reactors, breakers, contactors, switches, bus bars etc. shall be rated for at least 125% of the maximum required rating. No electronic device shall be subjected to PIV greater than 50% of its rated value.

5.3.34 All the thyristors, power transistors, diodes and other electronic devices of UPS shall be protected with high speed semiconductor fuses. I^2t co-ordination between fuse and semi-conducting power devices shall be ensured.

5.3.35 The outgoing circuits of ACDB shall be protected by semiconductor fuses. Each inverter shall be designed to clear a fault in any of the branch circuits up to a minimum rating of 30% of the system capacity without the assistance of the stabilized bypass supply. In case of any fault in branch circuits, the load connected to the healthy circuits shall not get affected. The fault clearing time shall be less than 4 msec.

5.3.36 All PCBs shall be provided with a transparent epoxy coating for environmental protection and tropicalisation. They shall be suitably located away from heat sources. Conformal coating shall be done for all PCB, electronic equipments as per min. Class 3C2 (Harsh environment) of IEC 60721-3-3. Alternatively, it shall comply with ANSI/ ISA S71.04 class G3 or IEC 60068-2-60 for mixed flow gas test or ASTM B845. Supporting documents shall be provided for the same.

5.3.37 All electronic control and monitoring printed circuit cards shall be installed in standardised electronic equipment frames and shall be fitted with suitable means for easy removal. The frames shall incorporate guides for PCB's to facilitate correct insertion of PCB's and shall allow access to the wiring side of the connectors. All PCBs shall be placed in a manner to avoid replacement of a PCB by a wrong spare PCB. Monitoring points shall be provided on each of the PCB's and the PCB shall be firmly clamped in position so that vibration or long usage do not result in loose contacts. Failure of each PCB shall be indicated by visual alarms. Visual fault diagnostics shall preferably identify faults up to various sections in the card.

5.3.38 Forced ventilation of panel, if provided, shall be supplemented by 100% redundant fan. In normal operation, normal & redundant fans shall run together. The power supply for the fans shall be tapped from the inverter output. However, the rating of the UPS as specified in the data sheet shall be the net output of UPS after deducting power consumption for fans etc. However in case of non-operation of 50% of running fans the UPS output shall not be affected. The fans shall be arranged to facilitate removal of faulty fan for maintenance without requiring system shutdown. All fans shall be equipped with monitoring facilities to provide an alarm in the event of fan failure.

5.3.39 Maximum noise level from UPS system at 1 metre distance, under rated load with all normal cooling fans shall not exceed 75 dBA

5.4 Construction

5.4.1 Rectifier/charger and inverter, stabilized bypass supply and static switch sections shall be suitably housed in sheet steel panels complete with all interconnections.

UPS panels, ACDB and cell booster enclosures shall be fabricated from structural/CRCA sheet steel. The frames shall be fabricated by using minimum 2mm thick CRCA sheet steel while the doors and covers shall be made from 1.6 mm thick CRCA sheet steel. Wherever, required suitable stiffeners shall be provided.

The panels shall be free standing, fitted with suitable louvers for ventilation and cooling fans as required. Hinged doors shall be provided at the front and back with dust tight gaskets. Inter-panel sheet steel barriers shall be provided. The enclosure shall provide minimum IP-31 degree of protection, if not specified otherwise in the data sheet. The maximum and minimum operating height of the switches shall be 1800 mm and 300 mm respectively.

5.4.2 Power cables shall be with aluminium / copper conductors and control cables shall be with copper conductors. All the cable connections shall be from bottom and front of the panel, if not specified otherwise in the data sheet. A removable bolted gland plate shall be provided along with single compression type nickel plated brass cable glands for external cable connections. Clamp type terminals shall be used for connection of all wires up to 10 mm^2. Bolted type terminals suitable for cable lugs shall be provided for wire size above this. Tinned copper lugs for all external connections shall be provided with the panels. Terminals shall be provided for all external connections. Interconnection cables for cubicles located side to side shall be supplied. All interconnecting cables, as required between UPS system and ACDB, UPS system and batteries shall be in the scope of vendor.

5.4.3 Bus bars shall be used in all power circuits which are rated above 100 Amp. Copper conductors PVC/XLPE insulated cables or wires of 660V grade shall be used for power circuits rated less than 100 Amp. Bus bars shall be colour coded and live parts shall be shrouded to ensure complete safety to personnel intending routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall have suitable name plate and device tag numbers as per the schematic diagram. All wires shall be ferruled and terminals shall be numbered.

5.4.4 MCCBs and load break power switches shall be mounted inside the panel. The control switches shall be rotary type, mounted on the door and shall be externally operable. An 11W CFL lamp controlled through a door switch shall be provided for illumination in each panel. All instruments shall be analogue/digital, switchboard type, back connected, 72 x 72 mm. square (for Analogue type). Analogue instruments shall be preferred. Analogue instruments' scale shall have red mark indicating maximum permissible operating rating. Separate test terminals shall be provided for measuring and testing of the equipment to check the performance.

5.4.5 A suitably sized earth bus shall be provided at the bottom of the panels including ACDB running through the panels line up with provision for earth connection at both ends to purchaser's main earth grid. The minimum size of earth bus shall be 25 x 3 mm^2 copper (or equivalent aluminium). All potential free metallic parts of various equipments shall be earthed suitably to ensure safety.

5.4.6 All panels shall be of same height so as to form a panel line up which shall have good aesthetic appearance. ACDB can be of different height that of UPS panels.

5.4.7 Inside the panels, the controls connections shall be done with 600/1000V grade PVC/XLPE insulated wires having stranded copper conductors. 1.5 mm^2 size wires shall normally be used for circuits with control fuse rating of 10 Amp. or less. For control circuit having fuse of 16 Amps, 2.5 mm^2 size wires shall be used. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire minimum of 0.5 mm dia.

5.4.8 All control wiring shall preferably be enclosed in plastic channels or otherwise neatly bunched together. Each wire shall be identified at both ends by PVC ferrules. Ferruling of wires shall be as per relevant IS.

5.4.9 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finished coat.

5.4.10 After preparation of the under-surface, the panels shall be spray painted with two coats of epoxy-based final paint or shall be powder-coated. Spray painted finished panels shall be dried in stoving ovens in a dust-free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.5 Cell Booster

5.5.1 Cell booster shall be suitable for charging not only the new cells before being introduced to the battery bank but also any treatment to be given to the individual weak cells. Quantity of such boosters shall be as defined in the MR. Cell booster shall be suitable for 240 V ± 10%, 50 Hz ± 3% SPN input power supply. Cell booster output voltage shall be in the range of 0-18V and 0-12V for Lead Acid and Nickel Cadmium batteries respectively. Cell booster current rating shall be as under:

For Lead Acid battery = 0.14 x Ah of cell (10 hr. Rating of the cell)
For VRLA battery = 0.2 x Ah of cell (10 hr. Rating of the cell)
For Ni-Cd battery = 0.2 x Ah of cell (5 hr. Rating of the cell)

Cell booster shall have heavy duty switch fuse or MCCB on AC incomer and DC output, AC voltmeter, DC ammeter and voltmeter, indicating lamp for AC/ DC power ON. The output voltage and current of cell booster shall have manual control using a full wave controlled rectifier bridge. Suitable interlock shall be provided so as to ensure that the variac/ controlled rectifier is at its minimum position while switching on the cell booster. Cell booster shall be portable type with wheels. Each cell booster shall be supplied with 5 m long flexible copper conductor, PVC insulated and braided cable for AC incomer power supply and DC output connection to the battery.

5.6 A.C. Distribution Board

Sheet steel enclosed AC distribution board shall be provided. It shall accommodate AC feeders as indicated in the data sheet. The distribution board shall be floor mounted, fixed type with compartmentalised construction unless otherwise indicated in the data sheet. Form of internal separation for ACDB shall be "Form-3B" as per IEC-61439. The switchboard shall be provided with 2 I/Cs (one from UPS & another from Bypass supply) with adequately rated Switch/MCCB/ACB. It shall be possible to operate the switches without opening the doors. Switches shall be provided with door interlock. Vertical cable alley of minimum 200mm width with suitable supports shall be provided for the termination of outgoing cables. Suitable supports shall be provided for supporting incoming and outgoing cables. All outgoing switches shall be air insulated load break type. Fuses on outgoing feeders shall be fast acting semiconductor type and cable entry shall be from bottom. Isolation transformers (if required) shall be mounted inside ACDB. HRC fuses shall be provided for isolation transformer feeders. The gland plate of the distribution board shall be non-magnetic type where single core cables are used as specified in the data sheet. Cable glands shall be of brass and single compression type and cable lugs shall be of tinned copper.

5.7 Alarm, Control, Indication and Metering Requirements

If not specified otherwise in the data sheets, following schedule shall be followed for alarm, control, indication and annunciation. Any additional devices/features considered necessary for reliable operation and maintenance shall also be included in various panels and same shall be highlighted separately. An illuminated one line diagram indicating operational status shall be provided on the front of the panel. Metering, indications, audio-visual alarm shall be provided. Parameters/ information indicated shall be available by menu driven LCD display or by other means directly or indirectly.

5.7.1 **Metering**

5.7.1.1 Rectifier

a) Incoming line voltages (For all the three phases).
b) Input line currents.(For all the three phases)
c) DC voltage at each rectifier output.
d) Battery current.

5.7.1.2 Inverters

a) AC voltage at each inverter output (AC voltages for 3 phase inverter)
b) AC current at each inverter output (AC currents for 3 phase inverter)
c) Frequency meter at each inverter output

5.7.1.3 Stabilised bypass supply

a) Frequency meter for incoming supply.
b) Voltmeter with selector switch for incoming supply.

c) Ammeter with selector switch for incoming supply.

5.7.1.4 ACDB

Following shall be provided for each of the ACDB incomers:

a) Voltmeter (voltmeter selector switch shall also be provided for 3 phase inverter).
b) Ammeter (ammeter selector switch shall also be provided for 3 phase inverter).
c) Power factor meter

5.7.2 **Indications**

All indicating lamps shall be LED type. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. LEDs shall be provided for following:-

5.7.2.1 a) AC mains `ON' - Rectifier.
b) AC mains `ON' - Bypass.

5.7.2.2 Rectifiers (for each rectifier)

a) Rectifier output `ON'
b) Battery on float charge
c) Battery on rapid charge

5.7.2.3 Inverters (for each inverter)

a) DC input `ON'
b) Load on inverter.
c) Inverter synchronised with mains.

5.7.2.4 Load on bypass.

5.7.3 **Audio-Visual Alarm** (separately for each circuit)

5.7.3.1 a) Mains failure
b) Battery charger failure
c) Battery fault
d) Inverter temperature high
e) Low voltage from inverter
f) Load on bypass
g) Inverter overloaded
h) All power Fuse failures
i) DC earth fault

5.7.3.2 Two nos changeover contacts shall be wired to the terminal strip, 1 no for common remote alarm of 'UPS fault' in owner's panel and 1 no for 'load on bypass supply' annunciation.

5.7.4 UPS shall also be provided with provision to hook up all indication and audio visual alarm, as specified in clause no.: 5.7.2 and 5.7.3 above, with owner's PC through RS232/RS485 / fibre optic port through serial interface.

5.7.5 **Controls**

a) All the switches for starting, shut down and testing sequence.
b) Primary input circuit breakers for feeding chargers, bypass line and DC bus from battery including backup protection.
c) Inverter ON/OFF switch (to initiate inverter operation)
d) Static switch transfer test Push Button.

5.8 Reliability

All necessary care shall be taken in selection, design, manufacture, testing and commissioning of the equipment for ensuring high system reliability. Following design consideration shall be taken into account to ensure maximum availability of the system.

5.8.1 There shall be no common device, between main and redundant units (e.g. master oscillators etc.) in order to ensure that the failure of the same does not cause shutdown of more than one unit.

5.8.2 It shall be possible to take out any individual power circuit for maintenance without affecting the total UPS supply.

5.8.3 Series-parallel combination of smaller devices to achieve required rating shall not be acceptable.

5.8.4 Vendors shall offer their nearest higher standard size that will meet the requirement of the specified UPS rating.

5.9 Fault Diagnostic Unit

If specified in the data sheet, each UPS set shall have provision for adding microprocessor based 'ON line' fault diagnostic unit. This shall supervise the UPS operation continuously. It shall identify and locate faults immediately so that corrective action can be taken. Fault Diagnostic unit shall be compatible to hook up with owner's PC through RS232/RS485 interface. The software shall be provided on a CD ROM.

The fault diagnostic unit shall have provision for automatic print out facilities for time, input/output voltages, currents, frequency as a minimum under the following conditions.

- UPS power source changeover from mains to battery.
- UPS power source changeover from battery to mains.
- Changeover from inverter to stabilized bypass supply and vice versa.
- Changeover from one inverter to other inverter.
- Changeover time in case of inverter to stabilized bypass supply and from one inverter to other inverter.
- UPS failure.
- Type of failure incident along with diagnostic report.

In addition to the above, any other feature which vendor feels may be useful shall be provided and highlighted separately.

If any Additional equipment (e.g. bin connector, adaptor cards etc.) are required for connecting this unit with UPS system as well as with owner's PC, the same are also to be included in the vendor's scope.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the equipment shall be subjected to inspection by EIL / Owner or by an agency authorised by the Owner. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. Tests shall be carried out at manufacturer's works under his care and expense.

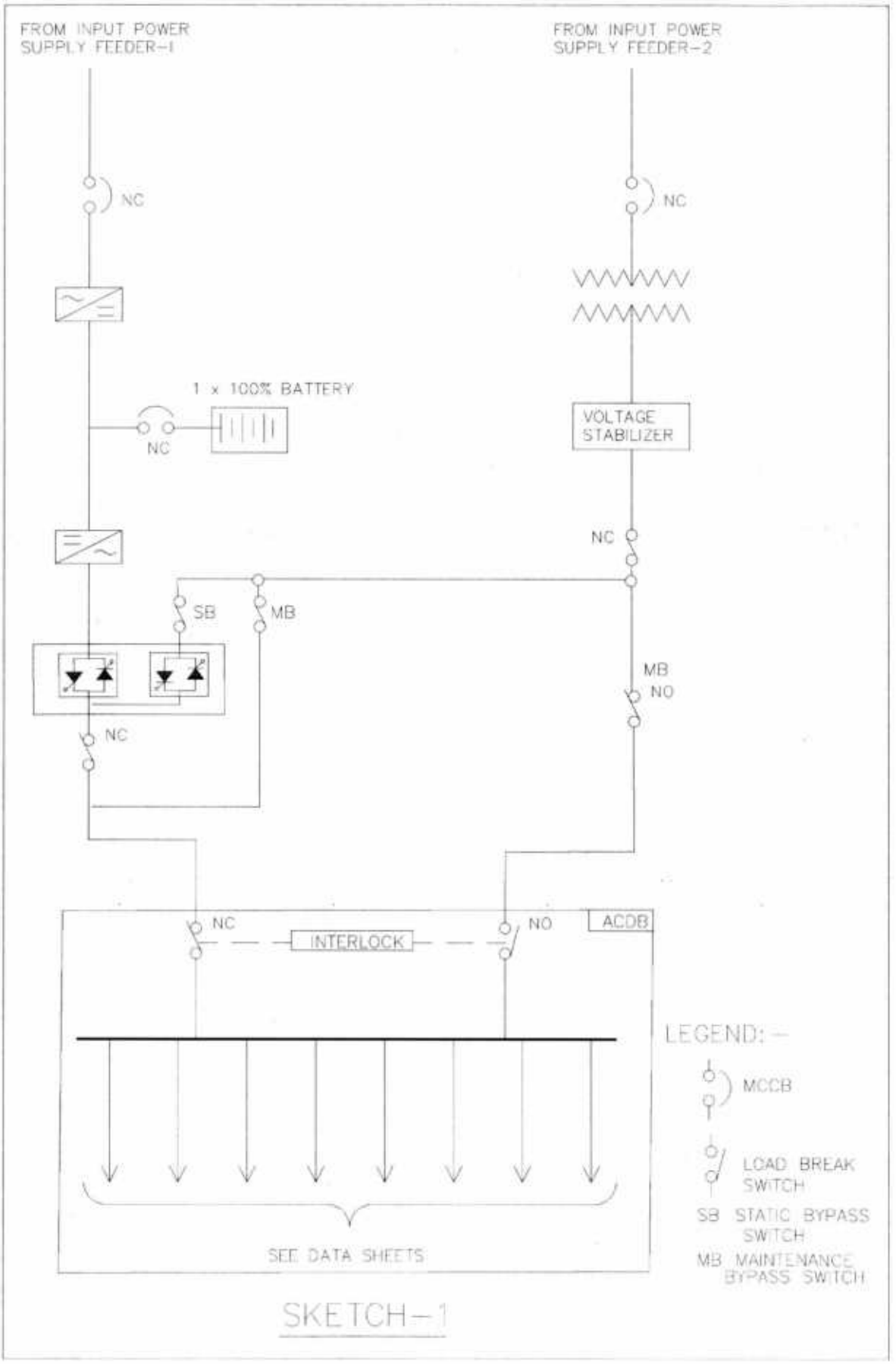
6.2 For testing requirement, Inspection and test plan for uninterrupted power supply system (6-81-1017) shall be followed.

7.0 SITE ACCEPTANCE TESTS

Vendor shall furnish Site Acceptance Tests procedure to be followed. Final acceptance testing along with the batteries shall be done at site. It shall be Vendor's responsibility to arrange necessary instruments and tools as required by their commissioning engineer for these tests.

8.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation .The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special notations such as Fragile', 'This side up', ' centre of gravity', 'weight', 'Owner's particulars', 'PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. In order to prevent movement of equipment/ components within the crates, proper packing supports shall be provided. A set of instruction manuals for erection, testing and commissioning, a set of operation and maintenance manuals and a set of final drawings shall be supplied along with the shipment duly enclosed in a waterproof cover.



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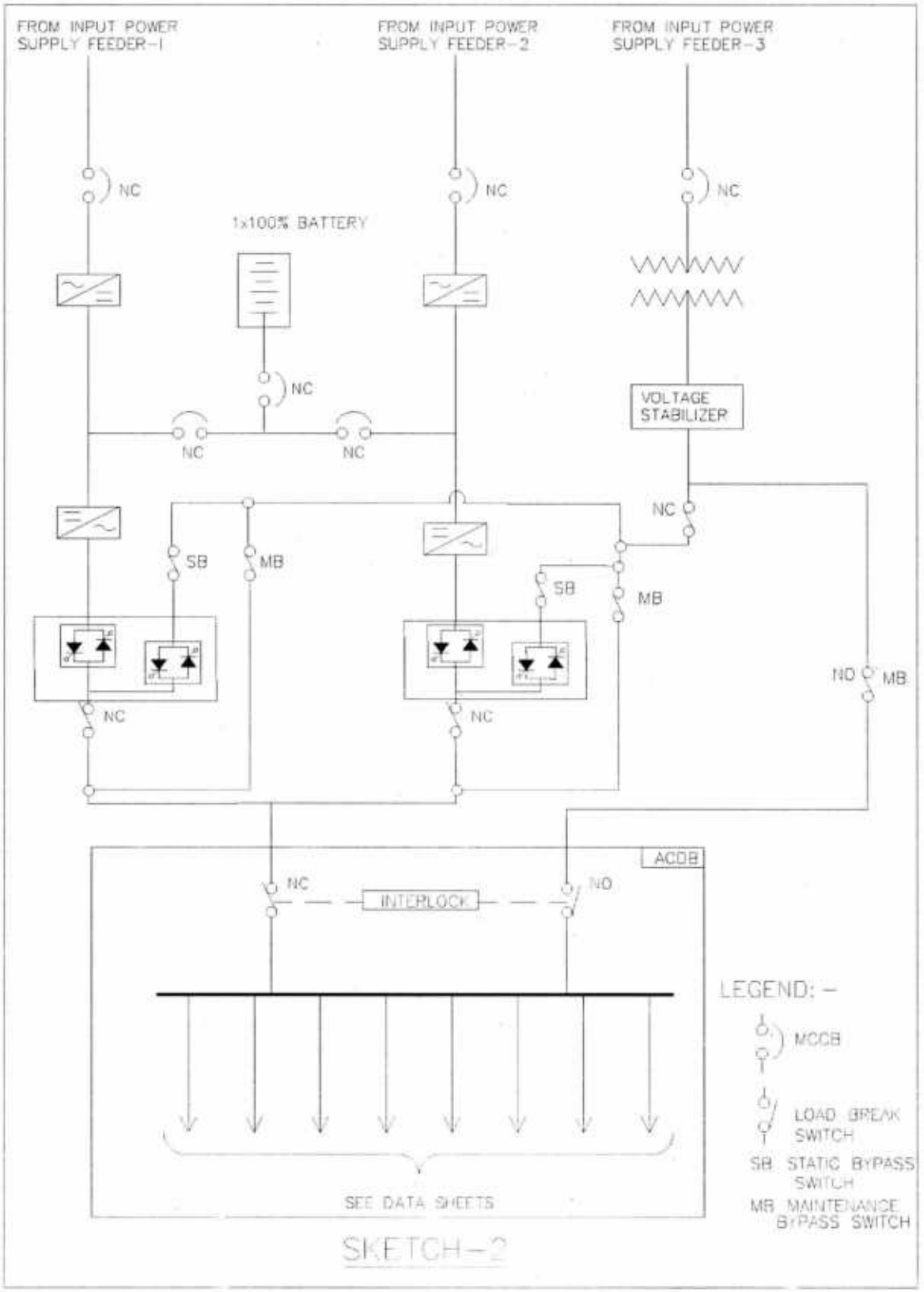

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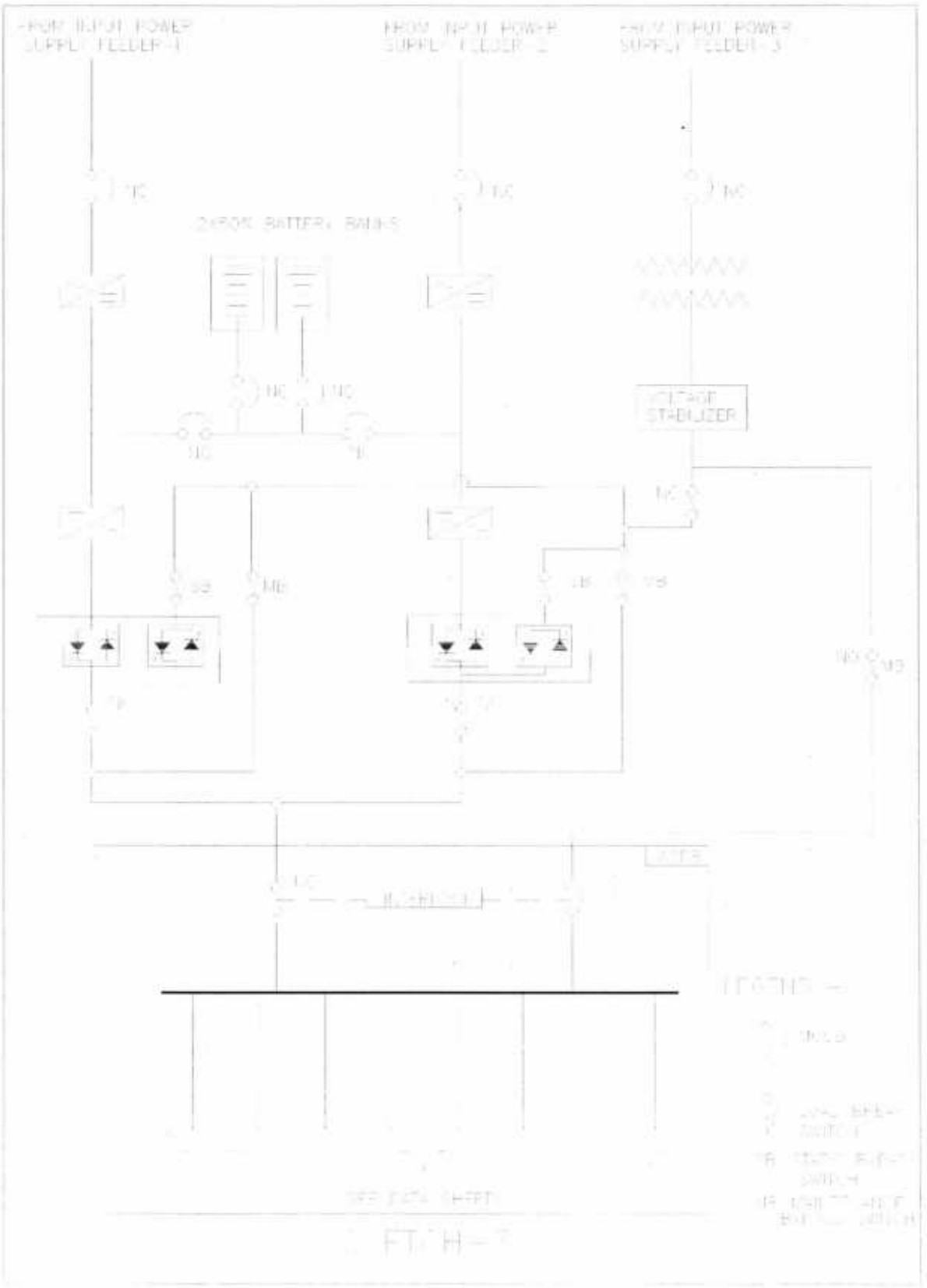

मध्यम वोल्टेज स्वीचबोर्ड के लिए विनिर्देश

SPECIFICATION FOR MEDIUM VOLTAGE SWITCHBOARD

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	08.12.2021	REVISED AND ISSUED AS STANDARD SPECIFICATION	CA/RKS	SA	PG	SM
5	21.12.2016	REVISED AND ISSUED AS STANDARD SPECIFICATION	CA/RKS	SA	BRB	RN
4	23.03.2011	REVISED AND ISSUED AS STANDARD SPECIFICATION	DA	SG	UAP	DM
3	01.03.2005	REVISED AND ISSUED AS STANDARD SPECIFICATION	SSM	RR	AAN	SKG
2	19.11.2001	REVISED AND ISSUED AS STANDARD SPECIFICATION	SSM	AAN	VPS	GRR

Abbreviations:

A	:	Ampere	kA	:	kilo Amperes
AC	:	Alternating Current	kVA	:	kilo Volt Ampere
ACB	:	Air Circuit Breaker	kW	:	kilo Watt
ASB	:	Auxiliary Service Board	LDB	:	Lighting Distribution Board
BIS	:	Bureau of Indian Standard	LED	:	Light Emitting Diode
CEA	:	Central Electricity Authority	LOTO	:	Lock Out Tag Out
CPRI	:	Central Power Research Institute	LV	:	Low Voltage
			mA	:	milli Ampere
CRCA	:	Cold Rolled Cold Annealed	MCB	:	Miniature Circuit Breaker
CT	:	Current Transformer	MCC	:	Motor Control Center
DC	:	Direct Current	MCCB	:	Moulded Case Circuit Breaker
EIL	:	Engineers India Limited	NC	:	Normally Closed
EPDM	:	Ethylene Propylene Diene Monomer	NO	:	Normally Open
			PCC	:	Power Control Center
FRLS	:	Flame Retardant Low Smoke	PMCC	:	Power cum Motor Control Center
HDPE	:	High Density Poly Ethylene	PT	:	Potential Transformer
HRC	:	High Rupture Capacity	PVC	:	Poly Vinyl Chloride
IEC	:	International Electrotechnical Commission	R-C	:	Resistor-Capacitor
			SWG	:	Standard Wire Gauge
IP	:	Ingress Protection	V	:	Volt
IS	:	Indian Standard	VA	:	Volt Ampere
Ics	:	Rated service short circuit current	XLPE	:	Cross Linked Poly Ethylene
Icu	:	Rated ultimate short circuit current			
Icw	:	Rated short time withstand current			

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Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

1.1 This specification covers the requirements of design, manufacture, testing, packing and supply of fixed and draw out type medium voltage switchboards.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS unless otherwise specified.

IS : 1248	:	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories.
IS: 2705, Part I	:	Current transformers - General requirements
IS : 2824	:	Method for determining the proof and the comparative tracking indices of solid insulating materials.
IS : 3618	:	Phosphate treatment of iron and steel for protection against corrosion.
IS : 5082	:	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes.
IS : 5578	:	Guide for marking of insulated conductor.
IS : 11353	:	Guide for uniform system marking and identification of conductors and apparatus terminals.
IS : 13703	:	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
IS : 16227 / IEC: 61869	:	Instrument transformers.
IS/IEC: 60255	:	Measuring Relays and Protection Equipment.
IS/IEC: 60269	:	Low voltage fuses.
IS/IEC: 60529	:	Degree of protection provided by enclosures (IP Code).
IS/IEC: 60947	:	LV Switchgear and control gear.
IS/IEC: 61439	:	Low voltage switchgear and control gear assemblies.
IEC: 61641	:	Enclosed low-voltage switchgear and control gear assemblies - Guide for testing under conditions of arcing due to internal fault.

2.2 In case of imported equipments, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner/EIL in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The switchboards shall be suitable for installation and satisfactory operation in an air-conditioned/pressurised substation or in a covered shed/enclosed electrical room (e-room) or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

4.2 The switchboards shall be designed to operate under specified site conditions. If not specifically mentioned, a design ambient temperature of 40° C and altitude not exceeding 1000 metres above mean sea level shall be considered.

4.3 All the equipment described in this specification shall be suitable for continuous duty with the specified ratings under the mentioned ambient conditions unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Medium voltage switchboard shall be metal enclosed fully draw out or fixed, as specified in datasheet/ job specification, free standing, floor mounting, compartmentalised, modular type suitable for indoor installation. Draw out type switchboards shall be with form of internal separation "Form-4b" whereas Fixed type switchboards shall be with form of internal separation minimum "Form-3b" as per IS/IEC 61439 unless otherwise specified elsewhere. The switchboard shall be a type tested assembly (TTA) as per IEC 61439.

5.2 The switchboard enclosure shall be dust and vermin proof and shall provide a degree of protection not less than IP-41 as per IS/IEC 60529.

5.3 The switchboard shall be assembled out of vertical panels of uniform height, not exceeding 2450 mm in a single line up.

5.4 It shall be possible to extend the switchboard, in either direction at a later date. End of bus bars shall be suitably drilled for this purpose. Panels at extreme end shall have openings, which shall be covered with plates screwed to the panel.

5.5 The switchboard shall be designed to ensure maximum safety during operation, inspection, connection of cables, relocation of outgoing circuits and maintenance, with the bus bar system energised and without taking any special precautions.

5.6 Adequate means shall be provided to prevent shorting of power and / or control terminals due to accidental dropping of maintenance tools etc. inside the switchboard. Checking and removal of components shall be possible without disturbing adjacent equipment/ modules/ feeders.

5.7 All identical equipments and corresponding parts shall be fully interchangeable.

5.8 The frame, of individual vertical panels shall be fabricated using pressed and cold rolled sheet steel. The sheet steel used for panel shall be of minimum 2 mm (14SWG) CRCA except the doors and covers that may be made of 1.6 mm (16SWG) CRCA. Wherever required, stiffeners shall be provided to increase mechanical strength of large size doors and covers.

As an alternative to CRCA, Aluzinc/ pre-galvanised sheet steel can also be provided for internal inter-panel partitions only as per vendor's standard manufacturing practices. However, all external surfaces shall be of CRCA with specified paint shade.

5.9 The switchboard shall be provided with integral base frame for each vertical panel. The switchboard integral base frame shall be suitable for tack welding.

5.10 All openings, covers and doors shall be provided with gaskets of Neoprene/HDPE/EPDM or equivalent around the perimeter to make the switchboard dust and vermin proof.

5.11 All hardware shall be corrosion resistant. All joints and connections of the panel members shall be made of galvanized or zinc passivated or chromium plated high quality steel bolts, nuts and washers, secured against loosening.

5.12 Suitable removable type eyebolts/ lifting hooks shall be provided for lifting of the panel/shipping section. These eyebolts/ lifting hooks, when removed shall not leave any opening in the panels.

5.13 Non-magnetic cable gland plates (min. 3 mm thick) shall be provided for termination of single core cables.

5.14 The switchboard shall be formed using distinct vertical panels each comprising of the following compartments.

5.14.1 A metal enclosed horizontal bus bar compartment running at the top or rear, unless otherwise specified.

5.14.2 Individual feeder modules in multitier mode.

5.14.3 Vertical bus bars serving all feeder modules in the vertical panel.

5.14.4 Cable termination compartment.

5.14.5 Perforated sheet steel / insulating material enclosed, horizontal auxiliary bus bars for control, interlock, indication and metering running horizontally.

5.15 Metal sheets shall be provided between two adjacent vertical panels running upto the full useful height of the switchboard.

5.16 MCC/ MCC part of PMCC shall be of single/double front execution as specified in data sheet/job specification. However circuit breaker panels shall be in single front execution only.

5.17 Motor starter and MCCB/switch fuse modules shall not be accommodated at front and rear of ACB Incomer and bus coupler panels.

5.18 The MCC/ASB/LDB switchboards shall be provided with castle-key interlock between incomers and bus-coupler switches for manual changeover of supplies unless otherwise specified elsewhere.

5.19 All metering and protection equipment associated with a particular circuit, as specified in data sheet, shall be housed in separate and independent compartment earmarked for that particular circuit and in the fixed portion of the vertical panel in case of breaker panels.

5.20 All auxiliary devices for control, reset, indication, measurement and protection such as push buttons, control and selector switches, indicating lamps, measuring instruments and protective relays shall be mounted on the front side of the respective compartment. The design shall be such that all power ON / OFF or START / STOP and relay reset operations shall be performed without opening the panel door.

5.21 Unless otherwise specified elsewhere, the switchboard assembly and components shall be suitable for use in pollution degree 3 environment as per IS/IEC.

5.22 In open doors condition of compartment, all live parts or terminals of all door-mounted, internal components and bus contact openings shall be IP-2X protected.

5.23 LOTO arrangement

5.23.1 Pad locking arrangement shall be provided for rack in operation of breaker as well as for the panel door meeting LOTO requirements.

5.23.2 LOTO arrangement shall be provided be provided for each module of draw-out switchboard PCC/PMCC/MCC etc. and shall include provision for the following:

a) Provision for hooking lockout devices by multiple lock arrangement to prevent opening of panel door and racking-in of circuit breaker.

b) Provision for attaching tag-out device for warning against energisation and to provide information regarding date of isolation, agency working on the equipment, etc.

c) Provision for Hasp such that the same shall be put-in and closed in the locking arrangement of the breaker/switch and panel door.

5.24 The panel shall be internal arc tested as per IEC 61641 requirements for full short circuit current for a duration of 0.1 second (minimum) unless specified otherwise in job specification/ datasheet and shall be qualified to comply with all the 7 criteria as per IEC 61641. However

where the circuit is protected by a current limiting device, then duration shall be 0.2 second (minimum) as per IEC 61641.

5.25 The Depth of MCC/ASB/LDB panels in double front execution shall be preferably limited to 1000 mm and in no case depth shall exceed 1200 mm.

5.26 For switchboards rated upto and including 5000A, forced cooling for any of the equipments and components i.e. bus bars, circuit breakers etc. shall not be provided.

5.27 The switchboard shall be supplied complete with supports for clamping outgoing and incoming cables.

5.28 The Bus PT shall be provided in the respective bus section of switchboard.

5.29 All breakers/ load break switches of incomers and bus coupler(s) shall be with 4 poles unless otherwise specified elsewhere.

5.30 Space Heaters & Panel Illumination

The switchboard panels shall be provided with space heaters to prevent moisture condensation. The space heater shall be located in the bottom part of each panel and shall be supplied from 240 V AC auxiliary buses for space heater. The space heater shall be provided with a switch, fuse or double pole MCB and thermostat having adjustable setting range of 30-70° C. Further, one number 240V AC, 6/16A, 5 Pin socket for owner's use shall be provided inside panels. The panels shall be provided with LED light of required wattage with switch and fuse or MCB.

5.31 Auxiliary Bus Bars

5.31.1 Auxiliary bus bars (solid – rectangular or circular), each of minimum size 16-mm^2 copper, shall be provided for the following applications.

a) Panel space heater supply and motor space heater supply.

b) AC Control supply.

c) DC Control supply.

d) AC PT supply for energy meters, voltage operated relays etc.

5.31.2 Tee-off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.

5.31.3 Provision for hook up of external AC space heater/ DC control supply to be provided either in bus PT panel or bus coupler panel.

5.32 Bus Bar

5.32.1 Bus bars shall be of high conductivity electrolytic aluminium or copper supported on insulators made of non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in Indian standards.

5.32.2 The main bus bars shall have uniform current ratings throughout their length as specified in data sheet/job specification. The current rating of the neutral shall be half that of the phase bus bars. Removable neutral links shall be provided on feeders to permit isolation of the neutral bus bar. The neutral bus bar shall be provided alongside of the phase bus bars.

5.32.3 Both horizontal and vertical bus bars, bus joints, risers, connecting bus bar links/ terminals to equipment and supports shall be capable of withstanding dynamic and thermal stresses of the specified short circuit currents.

5.32.4 Only zinc passivated or chromium plated high tensile strength steel bolts, nuts and washers shall be used for all bus bar joints and supports.

5.32.5 The hot spot temperature of bus bars, conductors, including joints, at design ambient temperature shall not exceed 95^0 C under normal operating conditions. However, for silver plated joints, the allowable maximum temperature shall be 115°C.

5.32.6 The current rating as defined for switchboard, bus bar and components in data sheet/enquiry document are for design ambient temperature at site conditions and for being inside the panel/ cubicle at fully loaded condition. The vendor shall suitably derate the nominal rating to suit the above condition considering ambient temperature inside panel/ cubicle.

5.32.7 All bus bars shall be insulated with heat shrunk PVC sleeves of 1100 V grade. Red, yellow and blue colour shall be used for phase bus bars and black colour shall be used for neutral bus bars. Alternatively, colour bands at suitable intervals along PVC sleeved bus bars may be provided. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute. Removable type shrouds shall be provided for joints & tap off points.

5.32.8 Minimum clearance between live parts, between live parts/neutral to earth shall be 19 mm. However clearances between terminals at components shall be as per applicable individual standards for respective components.

5.32.9 Vertical bus bars for circuit breaker panels shall be sized depending upon the rating and number of breakers per vertical panel. However vertical bus bars of all other panels shall be of uniform cross section.

5.33 Wiring and Terminals

5.33.1 Inside the switchboards, the wiring for power, control, signalling protection and instrument circuits shall be done with BIS approved FRLS, PVC/XLPE insulated copper conductor wires having 660/1100 V grade insulation. The wiring shall preferably be enclosed in flame retardant plastic channels or neatly bunched together.

5.33.2 PVC/ XLPE insulated copper conductor of cross section 1.5 mm^2 may normally be used provided the control fuse rating is 10 A or less. For higher fuse ratings minimum 2.5 mm^2 copper conductor shall be used. Each wire shall be terminated at a separate terminal. CT circuit wiring shall be done with 2.5mm^2 copper conductor.

5.33.3 Shorting links/suitable arrangement for shorting CT secondary shall be provided.

5.33.4 Each wire shall be identified at both ends by PVC ferrules.

5.33.5 Inter panel wiring within each shipping section shall be switchboard vendor's responsibility. For wiring between shipping sections, vendor shall provide terminal blocks on adjoining shipping sections and supply suitable jumpering wires. Inter-panel wiring shall be taken thorough PVC sleeves or rubber grommets.

5.33.6 A minimum of 10% spare terminals shall be provided on each terminal block.

5.33.7 Conductors shall be terminated with adequately sized compression-type lugs for connection to equipment terminals and strips. Stranded conductors shall be soldered at the ends/ crimped with suitable lugs before connections are made to the terminals. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal.

5.33.8 Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spare input and output contacts of numerical relays, auxiliary relays, contactors, timers, etc shall be wired up to the terminal strips/block (ensuring that two terminals are provided for each contact).

5.34 Earthing

5.34.1 All panels shall be connected to a tinned copper earth bus bar running throughout the length of the switchboard at the bottom of the panels.

5.34.2 The minimum earth bus size shall be 30x6 mm^2 copper for fault level up to 31.5kA and 50x6 mm^2 copper for fault level above 31.5kA.

5.34.3 All doors and movable parts shall be earthed, using flexible copper connections, to the fixed frame of the switchboard. Provision shall be made at the end panels of each switchboard to connect the earthing bus bar to the plant earthing grid at two ends.

5.34.4 All non-current carrying metallic parts of the mounted equipment shall be earthed. Minimum 4 nos. 10 mm diameter bolts with nuts shall be provided on the earth bus for termination of fourth core of cable per vertical panel.

5.35 Nameplate

5.35.1 A nameplate with the switchboard designation shall be fixed at the top of the central panel. A separate nameplate giving details for each feeder compartment of all panels shall be provided. Danger nameplate shall be provided at the front and rear of each panel.

5.35.2 The nameplates for feeder compartments shall be in two parts. One part shall have necessary details pertaining to the compartments number of vertical panel of the switchboards. The other parts shall be removable and shall contain all details regarding the feeder number for drives/equipment controlled by the particular module as per approved single line diagram.

5.35.3 Blank nameplates shall be provided for all spare and vacant modules.

5.35.4 Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the switchboard. Special warning plates shall be provided on removable covers or doors giving access to cable terminals and bus bars.

5.35.5 Special warning labels shall be provided inside the switchboards also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.

5.35.6 Engraved nameplates shall preferably be of 3- ply (Black-White- Black) lamicoid sheets or anodised aluminium or traffolyte. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

5.36 Painting

5.36.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL-7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.36.2 All unpainted steel parts shall be zinc passivated, chromium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 SPECIFIC REQUIREMENTS OF AIR CIRCUIT BREAKER PANELS

6.1 The breaker panels shall have distinct bus bar, breaker and cable compartments.

6.2 The design of each compartment shall be such as to prevent movement of vermin from a particular compartment to any other compartment of the panel when the breaker is withdrawn and compartment door is closed.

6.3 In order to minimise accidental access and avoid accidents due to falling tools, all the outgoing links shall be shrouded.

6.4 Outgoing air circuit breaker can be mounted in a maximum of two-tier execution while the incoming/bus coupler air circuit breaker shall be in single tier execution only.

6.5 Cable Compartment

6.5.1 Separate compartment, totally enclosed from all sides, shall be provided for cable termination, on the rear/front side. Access to cables shall be from the rear/front side after opening the cabling compartment cover.

6.5.2 The incoming / outgoing cable termination shall be staggered for each circuit and barriers of sheet steel or insulating material shall be provided between terminations of two circuits such that maintenance on one circuit could be carried out while the other circuit is live. Suitable clamping arrangements shall be provided for cables and cable termination. Terminal blocks shall not be used for supporting the cables.

6.5.3 The incoming supply for PCC/ PMCC panels shall be through top entry bus ducts or through bottom entry cables unless specified otherwise. The outgoing cables shall have bottom entry unless specified otherwise.

6.5.4 The cable terminations shall be suitably sized for receiving specified number of cables per termination and provision shall be made for terminating each outgoing cable with a separate bolted connection. In case the total number of cables entering a particular panel cannot be accommodated in the cabling compartment of the panel, an extension panel of full height shall be added to the cabling compartment for accommodating extra cables. Alternatively, in view of extra cables, provision for back to back connections of cables may be offered.

6.6 Circuit Breaker Compartment

6.6.1 The circuit breaker compartment shall be fully draw-out. Suitable guides shall be provided to facilitate easy withdrawal of the circuit breaker.

6.6.2 The current transformers for the ammeter/protection circuits shall be mounted on the fixed portion of the compartment. However, current transformers associated with built-in releases may be mounted on the breaker trolley.

6.6.3 All terminals except wiping/sliding type control terminals shall be shrouded with plastic covers to prevent accidental contact. For direct termination, clip-on shrouded type terminals shall be provided.

6.6.4 There shall be three positions for the draw out trolley viz:

- "Service" position - In this position both power and control circuits shall be connected. This shall be the normal operating position of the circuit breaker.
- "Test" position - The power contacts shall be disconnected in this position but the control connections shall not be disturbed, testing provision for the entire control circuitry shall be available in test mode including close and trip of breakers.
- "Drawout" Position - both power and control circuits shall be disconnected in this position and breaker removed from the cubicle.

6.6.5 The circuit breaker shall be lockable in "service" and "test" positions. Safety shutters shall be provided when the breaker is in withdrawn/drawout position.

6.6.6 The earth connection must remain connected in "Test" position. Earthing of the unit shall be done with a "pin" or with scrapping earth connections.

6.6.7 The earth connection shall make before the main power / control contacts make and break after the power /control contacts are disconnected. Earthing connection through a plug and socket connection shall not be acceptable

6.7 Interlocks

Following interlocks shall be provided:

6.7.1 Compartment doors shall be interlocked against opening when breaker is in closed condition. However, it shall be possible to defeat this interlock for inspection purposes.

6.7.2 It shall not be possible to push "in" a drawn out circuit breaker in closed condition or withdraw a circuit breaker in closed condition.

6.7.3 It shall be possible to operate a circuit breaker only in the defined "Full in" or "service" and "test' position inside the panel. It shall not be possible to operate the breaker in intermediate positions while inserting or withdrawing circuit breaker.

6.8 Any unused circuit breaker compartment shall be fully equipped and provided with compartment door, vertical bus bars rated for breaker ratings envisaged in the vertical panel and control terminals/ wiring etc. such that the same could be used for housing outgoing breakers in future without any modifications to the panel.

7.0 SPECIFIC REQUIREMENTS OF FEEDERS OTHER THAN ACB FEEDERS

7.1 The design of drawout feeder modules shall not change for single front or double front execution. Separate vertical bus bars shall be provided for each front side modules.

7.2 All identical feeder modules shall be interchangeable.

7.3 Each vertical panel shall have a separate cable alley. The width of this cable alley shall be sufficient to accommodate all the cables and shall have free access for cable terminations and in any case shall not be less than 250 mm minimum. The cable alley width more than 250 mm shall be provided in case of requirement of termination of large number of outgoing cables as required. Cable alleys shall be provided with suitable doors.

7.4 Sheet steel barrier shall be provided between individual compartments and cable alley. This barrier shall be provided with opening for power and control connections and it shall be possible to safely carryout maintenance work on cable connections to any one circuit in the cable alley with the bus bars and the adjacent circuits live.

7.5 Maintenance and connection of cables to any modules shall be possible without having to take out the modules from its position from the panel.

7.6 The outgoing feeder trolleys for drawout type switchboard shall be fully drawout and shall have the following features.

7.6.1 It shall be possible to withdraw the trolley without having to unbolt or unscrew any power and control connections to the equipment mounted on the withdrawable trolley.

7.6.2 Both power and control connections shall be drawout type. All line and bus PTs shall be in drawout execution only. However, outgoing modules having size more than half of the useful vertical height of the panel may be in mixed combination of drawout /fixed type.

7.6.3 Control supply transformer modules may be provided in fixed execution.

7.6.4 The trolley withdrawal shall be by means of crank and screw arrangement. Alternatively movement on guided rollers or swivelling guide levers for self guided movement may also be acceptable. Plug in operation shall be independent of manual force. An insulating handle for racking in/ out modules shall be provided, as required.

7.6.5 For drawout type feeders of size equal to or greater than half the useful vertical height of panel, positive clamping arrangement shall be provided on the top portion of the trolley in addition to clamping arrangement at the bottom, to ensure all round positive pressure on the power drawout contacts once the trolley is plugged in. Alternatively fixed execution can be accepted for feeder with higher rating, equal to or greater than 400A in case of vendor's standard design, subject to Owner's approval.

7.6.6 Power drawout contacts shall preferably be located towards the bottom portion of each trolley. The trolley shall be lockable in fully plugged in position and devices shall be provided to ensure positive plugging in. In test position, power contacts shall be totally isolated and a device shall be provided for indication of test position. In test position, testing provision for the entire control circuitry shall be available.

7.7 The incomer and bus tie feeders with load break switches rated 800A and above may be in fixed execution

7.8 Various compartment sizes in a vertical panel shall be multiples of a basic dimension. However the minimum module size for switch fuse/MCCB feeder and motor starter/contactor feeder shall not be less than that defined in data sheet/job specification. Vertical bus bars shall be pre-drilled at regular intervals for complete flexibility for changes in size of modules.

7.9 All switch drives other than rotary control switches, shall be lockable in 'OFF' position.

7.10 The switches/Moulded case circuit breakers shall be interlocked with the compartment door to prevent opening of the door when the switch/ moulded case circuit breaker is in 'ON' position and to prevent switching on when the door is open. A defeat mechanism for this interlock shall also be provided.

7.11 The maximum height of the operating handle and switches shall not exceed 1900 mm and the minimum height shall not be below 250 mm.

7.12 Unused modules in the panel shall be fully equipped with hinged door & vertical bus bars and shall be suitable for mounting power and control terminals for starter modules and cradle for future use.

7.13 The power contactor in starter/ feeder modules of PMCC/ MCC shall be provided with R-C circuit across the AC supply contactor coil and surge suppressor/ diode in case of DC supply contactor coil. Further, low burden auxiliary contactors shall be provided in each contactor controlled motor starter modules for receiving start and stop command from remote.

8.0 SWITCHGEAR MODULES

8.1 Switchboard shall be completely lined up in one straight row with the type and quantities of feeders as defined in switchboard data sheet. Generally the feeders of three main categories are identified as circuit breaker, motor starters and MCCB or switch fuse.

8.2 Starter modules required for motor control shall be of the following types and internal control wiring of all starter modules of each type shall be identical for all ratings.

8.2.1 FVNR Full Voltage Non -Reversing starter with minimum 18 control terminals.

8.2.2 FVR Full Voltage Reversing starter with minimum 24 control terminals.

8.2.3 FVNR - HD Full Voltage Non -Reversing Heavy Duty starter with long starting time such as for compressors and fans etc. with minimum 18 control terminals.

8.3 Switch fuse/MCCB /contactor feeder modules shall be of following types and internal control wiring of all modules of each type shall be identical for all ratings.

8.3.1 SFU/MCCB Switch Fuse Unit or MCCB modules with no control terminals.

8.3.2 SFC/MCCB+C Switch Fuse Contactor or MCCB with contactor modules with 18 control terminals.

8.4 Control transformer shall be provided for each FVR/FVNR/SFC starter/MCCB+C starter/feeder modules or bus section of the PMCC/MCC switchboard having contactor control feeders as specified in the datasheet/job specification or elsewhere. Each control transformer of starter/feeder module shall be sized for taking control supply load of all components of starter module. In case control transformer is provided in bus section, same shall be sized for control supply load of entire switchboard. Switchboard having two bus sections and coupled by bus tie shall have manual changeover switch for the control transformers. The control transformer shall have at least 10% spare capacity. The control transformer secondary shall be earthed at one end.

8.5 To facilitate site modification due to changes in motor KW ratings and to minimise spares inventory, overload relays and power fuse links shall meet the following requirements.

8.5.1 All bimetal overload relays shall be separately mounted type with connecting links rated for the maximum rating of the contactor in a starter module.

8.5.2 Bimetal overload relays of various current ranges required for motors likely to be connected to a contactor must be identical in dimension for inter-changeability. In case offered relays are with different dimension for any particular starter module, special mounting plate suitable for mounting different relays shall be provided in all the modules of that size.

8.6 Heavy duty starters shall be provided with saturable type, current transformer operated; overload relays only, which shall be suitable for motor starting time of 15-60 seconds.

8.7 All contactor controlled starter feeders shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947. However, contactor controlled motor feeders shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947 considering energy efficient motors of IE-3 type, unless otherwise specified elsewhere.

9.0 SWITCHBOARD COMPONENTS

9.1 Circuit Breakers

9.1.1 Circuit breakers shall be air break, draw-out type and 3/4 poles as specified in the datasheet/job specifications and in this specification above. Circuit breaker shall be suitable for Ics=Icu=Icw=100% for 1sec.

9.1.2 The circuit breakers shall be provided with mechanically operated emergency tripping device. This device shall be available on the front of the panel. Mechanically operated 'closing' device shall be provided for all breakers. However mechanical closing shall be inhibited for all breakers in service position.

9.1.3 The circuit breakers shall be provided with minimum 4 NO + 4 NC contacts, wired and available for owner's use. In case contacts are directly not available in breaker, auxiliary latching type relays shall be used to multiply the auxiliary contacts of the breakers.

9.1.4 Circuit breaker's Open and closed positions; Service and test locations and spring charged condition shall also be indicated mechanically in addition to electrical indications.

9.1.5 Unless otherwise specified, all circuit breakers in the switchboard shall be provided with electrical power operating mechanism. Wherever circuit breakers are provided in place of Isolators, Breaker can be manually operated type.

9.1.6 **Operating Mechanism**

a) Electric power operating mechanism shall be motor wound spring charged stored energy type. However, manual-operating mechanism may be of the spring charging stored energy type or spring assisted type. For circuit breakers with electrical power operating mechanism, provision shall also be made for manual spring charging. Closing time of circuit breakers with manual operating mechanism shall be independent of the speed of the operating handle.

b) All stored energy operating mechanisms shall be equipped with the following features:

i) Failure of springs, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation.

ii) Closing of circuit breakers shall be prevented unless the spring is fully charged.

c) All electrical power operating mechanisms shall be suitable for remote operation and shall be equipped with the following features:

i) Provided with universal motor operable on AC or DC control supplies.

ii) Provided with emergency manual charging facility. The motor shall be automatically, decoupled (mechanically) once the manual-charging handle is inserted.

iii) Closing operation of circuit breaker shall automatically initiate charging of the spring for the next closing operation without waiting for tripping of circuit breaker.

iv) Closing operation shall be completed once the closing impulse is given and the first device in the control scheme has responded even though the control switch / Push Button is released, provided no counter trip impulse is present.

9.1.7 Circuit breaker trip and closing coils, in case of electrically operated breakers and trip coil in case of mechanically operated breakers and circuit breaker indication shall be suitable for satisfactory operation on a control supply system indicated in data sheets/job specification.

9.1.8 Circuit breakers shall be provided with anti-pumping and trip free feature.

9.1.9 Circuit breakers shall be provided with operation counters.

9.1.10 Releases are not required to be provided with breakers where relays are used. However breaker-having AC control supply voltage shall be provided with under voltage release unless specified otherwise.

9.2 Switches

9.2.1 All switches or fuse switches shall be load break, heavy duty/motor duty, air break type provided with quick make/break manual operating mechanism. The operating handle shall be mounted on the door of the compartment having the switch.

9.2.2 Rating of switches for starter module shall meet the requirements of AC-23 duty as per IS/ IEC 60947 and minimum rating shall be as specified in job specification/data sheets.

9.3 Fuses

9.3.1 Fuses shall be non-deteriorating HRC cartridge link type.

9.3.2 Power fuses shall be pressure fitted type and shall preferably have ribs on the contact blades to ensure good line contact.

9.3.3 It shall be possible to handle fuses during off load conditions with full voltage available on the terminals. Wherever required fuse pullers shall be provided. The fuse base shall be so located in the modules to permit insertion of fuse pullers and removal of fuse links without any problem.

9.4 Contactors

9.4.1 The contactors shall be air break type, equipped with three main contacts and minimum 1NO+1NC auxiliary contacts. The main contacts of a particular contactor for motor starter module shall have AC-3 or AC4 ratings, as specified in data sheet

9.4.2 Unless specified otherwise, the coil of the contactor shall be suitable for operation on 240 V, 1 Phase, AC supply.

9.5 Thermal Overload Relay

9.5.1 Bimetal relays shall be provided for protecting the motor from thermal overload.

9.5.2 Bimetal relays shall be manually reset type with the reset push button brought out on the front of the panel. The reset push button shall be capable of being operated without opening the compartment door.

9.5.3 Bimetal relays shall be three elements positive acting ambient temperature compensated type with adjustable setting range.

9.5.4 Bimetal relays shall have built-in single phasing prevention feature, which operates even with 50% rated current at the time of single phasing.

9.5.5 The rating of Bimetal relay shall be selected by vendor based on type-2 coordination and full load current of IE-3 motor.

9.6 Moulded Case Circuit Breakers

9.6.1 MCCBs shall be provided with spring assisted quick make/ break manually operated trip free mechanism. Wherever specified, MCCB shall be suitable for remote tripping operation and the tripping device shall be suitable for the specified control supply voltage. MCCB shall be suitable for Ics=Icu=100%.

9.6.2 MCCBs shall be provided with a tripping device with inverse time characteristic for over load protection and instantaneous characteristics for short circuit protection and MCCB rated above 125A shall preferably have adjustable settings.

9.6.3 'ON' and 'OFF' position of the operating handle of MCCB shall be displayed and the operating handle shall be mounted on the door of the compartment housing MCCB.

9.6.4 Each MCCB shall be provided with minimum 1 NO + 1 NC auxiliary contact and 1NO contact for tripping indication/alarm for owner's use.

9.6.5 MCCBs shall be provided with solenoid/ motorised closing mechanism to make them suitable for remote closing operation if specified. The closing solenoid/motor shall be suitable for specified control supply voltage.

9.6.6 MCCB's as part of motor starter module shall be current limiting motor duty type and type tested for type-2 co-ordination as per IS/ IEC 60947 considering energy efficient motors of IE-3 type unless otherwise specified elsewhere.

9.7 Relays

9.7.1 Type of relay shall be numerical, communicable, static or electro-mechanical type as specified in the data sheet /job specification.

9.7.2 All electro-mechanical protective relays shall be back connected, of drawout type, suitable for flush mounting, and fitted with dust-tight covers. Alternatively, "plug-in" type relays will also be acceptable. Auxiliary relays and lock out relays are acceptable in fixed execution.

9.7.3 The protective (static or electro-mechanical type) relay cases shall have a provision for insertion of a test plug at the front for testing and calibration purpose using an external power supply. It shall be possible to test the relays without disconnecting the wiring and without withdrawing the relays. The insertion of the test plug shall automatically short circuit the CTs and permits extension of external power supply to the relay.

9.7.4 Each protective relay shall be provided with minimum 2 numbers potential free contacts of required configuration.

9.7.5 Each tripping relay shall be of lockout type with hand reset coil cut-off contact.

9.7.6 Protective relays shall be preferably mounted on the front side and upper part of the panel and mounting of relays on the lower portion shall be avoided.

9.7.7 Earth Leakage Relay shall be manually hand reset type. In case hand reset feature is not available in the offered relay model, vendor to provide external hardware logic for manual hand resetting of the earth leakage relay.

9.7.8 Stabilizing resistor shall be provided along with the relays including numerical relays as required to avoid spurious tripping.

9.8 Instrument Transformers (CTs/PTs)

9.8.1 Current transformers shall generally conform to IS:16227 and any special requirement with respect to numerical relay shall be taken care by the vendor.

9.8.2 For general guidance the vendor shall note that the protective current transformers shall have an accuracy class "5 P" and an accuracy limit factor of minimum "20". However CTs for restricted earth fault shall be of class "PS"/"PX". Vendor shall co-ordinate the knee point voltage, magnetising current for PS class CTs to avoid saturation and mismatching of CTs provided at other end by other vendor.

9.8.3 Current transformers for metering shall have an accuracy class 1.0 and instrument security factor not greater than 5.0.

9.8.4 The current transformers in breaker feeders shall be capable of withstanding the applicable peak momentary short circuit and the symmetrical short circuit current.

9.8.5 The voltage transformers shall be cast resin type transformers and PT shall generally conform to IS:16227. PT shall be provided with HRC fuses on primary side and Miniature circuit breakers with auxiliary contact on the secondary side.

9.9 Measuring Instruments

9.9.1 All measuring instruments shall be of 96 x 96 mm square pattern, flush mounting type for incomer and outgoing feeders in the switchboard. The accuracy class for all instruments shall be 1.0 as per IS: 1248.

9.9.2 All auxiliary equipment such as shunts, transducers, CT, PT, etc. as required shall be included in the supply of the switchboard.

9.9.3 All AC ammeters and voltmeters shall be of moving iron type. Ammeters for motor feeders shall have a non-linear compressed scale at the end to indicate motor starting current and red mark for the full load current.

9.9.3 The KW/KWH meters shall be suitable to measure unbalanced loads on 3 phases 4-wire system. Test terminal block shall be provided for KWH meters.

9.9.4 Digital meters shall be provided, if specified in job specification/data sheets. All digital meters shall be highly reliable, accurate, compact and self powered. Digital meter data shall be saved in case of power failure. Field programming from front of the meter shall be possible and shall have RS232/485 port in case specified in the job specification/data sheet.

9.10 Control/ Selector Switches

9.10.1 All control/ selector switches shall be rotary type, having a cam-operated contact mechanism. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles and shall be lockable type. Knob type handle shall be provided for other control/ selector switches.

9.10.2 Ammeter selector switches shall have make before break feature on its contacts. The selector switch shall generally have 4 positions, three for reading 3 phase currents and the fourth position for off. The voltmeter selector switch shall also have 4 positions. Three positions shall be used to measure phase-to-phase voltage and fourth shall be OFF position.

9.11 Push Buttons

Push button colours shall be as follows:

Stop /open/emergency stop	:	Red
Start/close	:	Green
Reset/test	:	Yellow / Black /White

The stop push button shall be stay put type & shall have protective hood to avoid accidental operation.

9.12 Indication

9.12.1 Clustered LED type indicating light with minimum 8 mm diameter size shall be provided for indications.

9.12.2 Breaker positions (Close, Open, spring-charged, test position, service position) electrical indications, with colors as given below, shall also be provided:

Breaker 'Closed'/ ON	:	Red lamp
Breaker 'Open'/ OFF	:	Green lamp
Breaker auto-trip	:	Amber lamp
Trip circuit healthy	:	White lamp
Spring charging	:	Blue lamp

9.12.3 Outgoing feeder (Close, Open, trip) electrical indications, with colors as given below, shall also be provided:

'Closed'	:	Red lamp
'Open'	:	Green lamp
'Trip'	:	Amber lamp

9.13 Auxiliary Relays/Contactors

Auxiliary relays/contactors shall generally be used for interlocking and multiplying contacts. However, in the case of numerical relays, the interlocking logic shall be built in the relay itself.

9.14 Timers

For re-acceleration duty, timers shall be electronic type or static type. The time settings, where specified, shall be accurately set before despatch of the switchboard. Timer provided for control of capacitor feeder and re-acceleration feeders shall have minimum setting of 0-5 minutes.

9.15 Miniature Circuit Breaker

MCB shall provide high mechanical and electrical life, reliable protection of circuits against overload and short circuit and shall have minimum breaking capacity of 9 kA unless otherwise specified. Positive ON/OFF indication shall be provided.

10.0 INSPECTION, TESTING AND ACCEPTANCE

10.1 During fabrication, the switchboard shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

10.2 For testing requirements refer Inspection & Test Plan No. 6-81-1018. Prior notice of minimum 4 weeks shall be given to EIL/owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

10.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1018.

11.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation .The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special precaution notations such as 'Fragile', 'This side up', 'Centre of gravity', 'weight', Owner's particulars, Purchase order number etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be supplied duly enclosed in a waterproof cover along with the shipment.

बैटरी चार्जर
के लिए विनिर्देश

SPECIFICATION
FOR
BATTERY CHARGER

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	03/12/21	REVISED AND REISSUED AS STANDARD SPECIFICATION	SKS	RS	PG	SM
5	17/11/16	REVISED AND REISSUED AS STANDARD SPECIFICATION	PB/MHR	RS	BRB	RN
4	11/04/11	REVISED AND REISSUED AS STANDARD SPECIFICATION	RS	PG	UAP	DM
3	10/09/08	REVISED AND REISSUED AS STANDARD SPECIFICATION	RS	NS	JMS	VC
2	25/03/02	REVISED AND REISSUED AS STANDARD SPECIFICATION	VCB	JMS	VPS	GRR

Abbreviations:

AC	:	Alternating Current
Ah	:	Ampere-hour
BIS	:	Bureau of Indian Standards
CEA	:	Central Electricity Authority
CRCA	:	Cold Rolled Cold Annealed
DC	:	Direct Current
DCDB	:	Direct Current Distribution Board
ECS	:	Electrical Control System
EIL	:	Engineers India Limited
EMC	:	Electro Magnetic Compatibility
FRLS	:	Flame Retardant Low Smoke
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
LED	:	Light Emitting Diode
MCB	:	Miniature Circuit Breaker
MCCB	:	Moulded Case Circuit Breaker
MR	:	Material Requisition
MSL	:	Mean Sea Level
Ni-Cd	:	Nickel Cadmium
PC	:	Personal Computer
PCB	:	Printed Circuit Board
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
RFI	:	Radio Frequency Interference
RMS	:	Root Mean Square
TCP/IP	:	Transmission control protocol/Internet Protocol
V	:	Volt
VDE	:	Verband Der Elecktrotechniker
VRLA	:	Valve Regulated Lead Acid
XLPE	:	Cross Linked Poly Ethylene

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Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the design, manufacture, testing at manufacturer's works, packing and supply to site of Battery Chargers and Distribution Boards.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS/ IEC/ IEEE:

IS 1248	Direct acting indicating analogue electrical measuring instruments and accessories.
IS 3700	Essential rating and characteristics of semi-conductor devices.
IS 4411	Code of designation of semi-conductor devices.
IS 5001	Guide for preparation of drawings for semi-conductor devices and integrated circuits.
IS 5469	Code of practice for the use of semi-conductor junction devices.
IS 6619	Safety code for semiconductor rectifier equipment.
IS 12021	Control transformers for switchgear and control gear for voltages not exceeding 1000VAC.
IS 13703	Low voltage fuses for voltages not exceeding 1000VAC or 1500V DC.
IS 14901	Semiconductor Devices - Discrete Devices and Integrated Circuits
IS 16539	Semiconductor Converters
IS/IEC 60269	Low-Voltage Fuses
IS/IEC 60947	Low voltage switchgear and control gear.
IS/IEC 61439	Low-Voltage Switchgear and Control gear assemblies
IEC 60068	Environmental testing.
IEC 60146	Semiconductor converters general requirements and line commutated convertors.
IEEE 519	Recommended Practice and Requirements for Harmonic Control in Electric Power system.

2.2 In case of imported equipment, the standards of the country of origin shall be applicable, if these standards are equivalent or more stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

2.5 In case of any conflict between various referred standards/ specifications/ datasheets and statutory regulations, the most stringent requirement shall prevail and Owner's/ EIL's decision in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user to place order for spares and services.

4.0 SITE CONDITIONS

The Battery Chargers shall be suitable for installation and satisfactory operation in a pressurised or non-pressurised substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere. The Battery Chargers shall be designed to operate under site conditions as specified in the data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000 m above MSL shall be considered for all equipment.

5.0 TECHNICAL REQUIREMENTS

5.1 Input Power Supply

5.1.1 The Battery Chargers shall be suitable for input power supply as defined in the data sheet. If not specified therein, these shall be suitable for the following input power supply:

Voltage : 415V ± 10%
Frequency : 50 Hz ± 3%

In addition to the above variations, the input voltage may be subject to transient variations comprising of voltage dips up to 20% of normal voltage during motor start-up, voltage interruptions during short circuits as well as frequency variations due to large motor start-up. The Battery Chargers shall operate satisfactorily with a total harmonic distortion of up to 5% in the input power supply.

The Battery Chargers shall also be designed to operate satisfactorily while drawing input power from an emergency diesel generator set.

5.1.2 The incoming power supply to the Battery Charger system shall be provided by 2 independent feeders. One feeder shall supply power to each rectifier.

5.2 Battery Charger

5.2.1 **Design Basis**

5.2.1.1 The Battery Charger system shall have two chargers (Charger-1 & Charger-2). Both chargers shall be of identical design and rating. The battery to be connected to the chargers shall be of Nickel Cadmium/ flooded electrolyte Lead Acid/ VRLA type as indicated in the data sheet. Battery Chargers for flooded Lead Acid and Nickel Cadmium batteries shall be sized to provide quick charging of the battery within a duration of 10 hours. Battery Chargers for VRLA battery shall be sized to provide quick charging of the battery up to 90% of rated Ampere hours within a duration of 12 hours and to 100% within 32 hours. Each charger shall be sized for the most stringent of the following duty conditions, whichever is higher:

a. Offline quick charging of the battery assembly. The charger shall be sized as under:

Charger rating in Amps. = 0.14 Ah(C_{10}) of battery (for Lead Acid battery)
= 0.2 Ah(C_{10}) of battery (for VRLA battery)
= 0.2 Ah(C_5) of battery (for Nickel Cadmium battery)

b. Online float charging of the battery assembly while feeding the complete DC load. The charger shall be sized as under:

Charger rating in Amps. = 1.15 x Average DC load + float charging current
(Average DC load = Area under the battery duty cycle/ battery duty cycle duration).

5.2.1.2 Each charger shall have a 3 phase full wave, controlled rectifier bridge with protective devices.

5.2.1.3 Independent current limits shall be provided for charger load current and battery charging current. Subsequent to a discharge cycle and completion of quick charging, when battery is connected to charger under float mode, the battery current shall be monitored, controlled and limited to set value automatically irrespective of the value of load current. Fast acting semi-

conductor fuses shall be provided for protection against internal short circuits. In case of external short circuits, the chargers shall be protected by rapid shutdown of the semi-conducting power devices. The high speed semi-conductor fuses used for rectifier protection shall be complete with trip indication.

5.2.1.4 Filter circuits consisting of smoothing choke and condenser, complete with protection to limit the ripple content at the output, shall be provided.

5.2.1.5 Silicon blocking diodes shall be provided in the charger output circuit to prevent back-feed from battery into the charger and filters.

5.2.1.6 Protection against reverse battery connection and DC earth fault relay for earth leakage detection shall be provided.

5.2.1.7 Silicon blocking diodes (min. 4 nos.) connected to 80% tap of the battery bank shall be provided to maintain continuity in the DC supply to the load.

5.2.1.8 Internal cooling of the charger unit shall preferably be by natural ventilation. If forced air cooling is necessary, a redundant air cooling fan shall be provided. The charger components shall be capable of delivering their rated output with one forced air cooling fan out of service. Under this condition, maximum continuous temperature of components shall not exceed the permissible limits. In case of chargers with forced cooling, loss of ventilation alarm/ trip with override facilities shall be provided.

5.2.1.9 Selection, sizing and suitability of all components used for various applications shall be vendor's responsibility and the rating of components shall be increased, if required, to suit associated components during execution of the order without any claim for extra price or time.

5.2.1.10 The DC system shall be unearthed. However, a high impedance earth fault relay shall be provided for the protection of the battery.

5.2.1.11 Each charger shall be galvanically isolated from the input power supply by providing a double wound transformer at its input. The transformer shall be natural air cooled, dry type suitable for location inside a panel.

5.2.1.12 RFI filters shall be provided to suppress the radio frequency interference to permissible limits. The production of radio frequency interference voltages shall not exceed the value of suppression grade N as defined in VDE-0875. Battery charger shall be designed to comply with EMC requirements as per IEC 60146/ IS16539. Additional RFI/ EMC filters as required to comply with EMC requirement shall be provided.

5.2.1.13 Transient/ surge protection devices shall be provided in the input circuit of chargers to protect them against surges & voltage spikes.

5.2.1.14 The Chargers shall be designed to draw power from mains supply at a minimum power factor of 0.85 lag while sharing the rated load in normal operating configuration.

5.2.1.15 The chargers shall be designed to ensure that the harmonic component in the input currents are limited as per recommendations of the latest edition of IEEE-519, so as not to cause undue harmful effects on other sensitive equipment operating on the same supply bus. Suitable filters/ harmonic traps shall be provided, as required, for this purpose.

5.2.1.16 All breakers shall be adequately rated for the required continuous rating and breaking capacity as applicable. Paralleling of breaker/ switch/ contactor poles to achieve the required current rating is not acceptable. All output isolating devices shall be double pole type. The DC contactors shall be operated with a DC control supply using ON/ OFF selector switches and not push buttons.

5.2.1.17 All the thyristors, diodes and other power electronic devices shall be protected with high speed semiconductor fuses. I^2t co-ordination between fuse and semi-conducting power devices shall be ensured.

5.2.1.18 The Battery Chargers shall be specifically designed to limit float and quick charging voltages to the battery to limits recommended by the battery manufacturer. Output voltage shall be limited to maximum −10% of nominal system voltage when the battery is float charged while feeding the load. Vendor shall specifically ensure that the charger output voltage does not exceed the recommended limits of operation under any conditions of internal/ external fault or operation, including:

- Filter capacitor fuse failure of either charger
- DC output switch OFF of either charger
- DC output fuse blown of either charger.

Other specific current/ voltage limits during normal charging/ operation of the chargers shall also be incorporated in the design of the chargers.

5.2.2 **Operation and Performance**

5.2.2.1 **Operation (Option – I)**

The DC system shall comprise of 2 Nos. Float cum quick Chargers (each rated for 100% capacity) with 1 set of battery (Refer typical scheme block diagram option – I). All functionalities & operation shall be available for both Auto & Manual mode of operation of chargers.

a. Normal operation requires that the battery assembly shall be float charged simultaneously by both Chargers-1 & 2 while feeding the DC load, the chargers thus operating in parallel and equally sharing the total load.

b. However in case of failure of either of the chargers, the other charger shall float charge the battery while feeding the complete DC load. Faulty charger shall automatically get disconnected from the healthy system.

c. In case of AC mains failure or failure of both the chargers, the battery shall continue to supply the load.

d. The process of changeover from float to quick charging and reverting from quick to float charging shall be selectable in Automatic or Manual mode by means of an Auto/ Manual selector switch. In Automatic mode, the changeover from float to quick charging shall be initiated through a current sensor, set at a preset value. Similarly, the changeover from quick to float charging shall also be automatic based on current sensing. In Manual mode, both change over from float to quick charging and from quick to float charging shall be performed manually using push buttons. When quick charging mode is selected, the battery charger shall initially charge the battery under constant current mode followed by constant voltage (finishing charging) mode or as per the battery manufacturer's recommendation. Changeover from constant current to constant voltage (finishing charging) mode shall be fully automatic. A backup synchronous or digital timer shall also be provided for initiating the changeover to float mode by default after a preset time period. The timer range shall be 0 to 24 hours or the nearest available as per manufacturer's standard range.

e. In the event of failure of the charger feeding the load, when battery is being quick charged by the other charger, continuity in DC supply shall be maintained from the battery to the load through 80% tap of the battery bank followed by full battery supplying the load through contactor C-2 (refer block diagram Option – I). The healthy charger shall changeover to float mode from quick mode and shall feed the DC load while float charging the battery.

f. Interlock shall be provided to ensure that when either of the chargers is selected in quick charging mode, it will be disconnected from both the DC load and the other charger operating under float charging mode. Further interlock shall be provided to prevent operating both chargers under quick mode.

g. The chargers shall have facility for manual mode of operation in the event of failure of controller under closed loop control. The selection shall be done through Auto/ Manual selector switch.

h. Energisation of contactor for DC critical lighting shall be initiated by means of an AC mains failure relay complete with Auto/ Manual selector switch, On/ Off push buttons etc.

5.2.2.2 **Operation (Option – II)**

a) The DC system shall comprise of 2 nos. Float cum quick Chargers (each rated for 100% capacity) and 2 sets of Batteries (each of the battery sets rated for 50% AH capacity unless specified otherwise in datasheet/ job specification). (For typical scheme, refer block diagram Option - II). All functionalities & operation shall be available for both Auto & Manual mode of operation of chargers.

b) Normal operation requires that Battery–1 shall be float charged by Charger-1 while Battery-2 shall be float charged by Charger-2. In this case both the chargers 1 and 2 shall feed the DC load by operating in parallel and equally sharing the total load.

c) Selection of Float / quick mode shall be Automatic or Manual based on the position of selector switch for Auto / Manual selection.

d) In case of failure of either of chargers, the other charger shall float charge both the batteries while feeding the complete DC load. Faulty charger shall automatically get disconnected from the healthy system.

e) In case of AC mains failure or failure of both the chargers, both the batteries shall continue to supply the load by equally sharing the load current.

f) After restoration of power supply, one of the Charger (say Charger-1) shall float charge Battery-1 and also feed the complete DC load while the other Charger-2 shall quick charge Battery-2. Upon completion of quick charge of Battery-2, Charger-2 shall switchover to float mode and shall float charge Battery-2 and also feed the complete DC load while the other Charger-1 shall switchover to quick mode and shall quick charge Battery-1.

g) The process of changeover from float to quick charging and reverting from quick to float charging mode shall be selectable in Automatic or Manual mode by means of Auto / Manual selector switch.

h) In automatic mode, the changeover from float to quick charging shall be initiated through a current sensor set at a preset value. Similarly, the changeover from quick to float charging shall also be automatic based upon current sensing and through timer.

i) In manual mode, both the changeovers i.e. from float to quick charging and from quick to float charging shall be performed using push buttons. When quick charging mode is selected, one of the battery charger (say Charger-1) shall initially charge the battery under constant current mode followed by constant voltage (finishing charging) mode or as per the battery manufacturer's recommendation. Changeover from constant current to constant voltage (finishing charging) mode shall be fully automatic. A back-up synchronous or digital timer shall also be provided for initiating the changeover to float mode by default after a preset time period. The timer range shall be 0 to 24 hours or the nearest available as per manufacturer's standard range.

j) In the event of failure of charger feeding the load (say Charger-1), when Battery-2 is being quick charged by the other Charger-2, Charger-2 shall changeover to float mode and continuity of 100% DC supply to the load shall be maintained from the Charger-2 while float charging both Battery-1 as well as Battery-2 after providing suitable time delay.

k) In an event of AC mains failure, when one of the Charger (say Charger-1) is float charging the Battery-1 and supplying the 100% DC load while the other Charger-2

was quick charging Battery-2, continuity of 100% DC supply to the load shall be maintained from Battery-1 (through 100% tap). Further, Battery-2 (which was being quick charged) shall also be made available, after providing suitable time delay, to feed the DC load by operating in parallel with Battery-1 and sharing the total load.

l) Interlock shall be provided to ensure that when either of the chargers (say Charger-1) is selected in quick charging mode, it will be disconnected from both the DC load as well as the other Charger-2 operating under float charging mode. Further interlock shall be provided to prevent operating both chargers under quick mode.

m) The chargers shall have facility for manual mode of operation in the event of failure of controller under closed loop control. The selection shall be done through Auto/Manual selector switch.

n) Energisation of contactor for DC critical lighting shall be initiated by means of an AC mains failure relay complete with Auto/Manual selector switch, On/Off push buttons etc.

5.2.2.3 **Performance**

a. Both chargers shall be of solid state design, constant voltage and current limit type. The output voltage shall be stabilised to within $\pm 1\%$ of set value in float charging mode for mains steady state voltage and frequency variation of $\pm 10\%$ and $\pm 3\%$ respectively, and load variation of 10 to 100% at any temperature up to the design ambient temperature specified in the data sheet. However, the variation in output voltage can be up to $\pm 2\%$ for chargers with rated output voltage up to 24V.

b. Under constant current quick charging condition, the DC output current shall be maintained within $\pm 2\%$ of set value.

The output voltage dynamic response of the charger unit with battery disconnected shall not vary more than $\pm 10\%$ of nominal output voltage in the event of step load of up to 50% of the rated output. The output voltage shall be restored to a value within the steady state limits within 250 msec.

c. The maximum allowable RMS ripple voltage, with battery disconnected, shall be equal to or less than 2% of the nominal output voltage.

d. The maximum noise level from the chargers measured at 1 metre distance in any position, at any load between 0- 100% with all normal cooling fans running shall not exceed 75 dB(A).

5.2.2.4 **Controls**

The minimum controls shall include but not be limited to those shown in the block diagrams (OPTION-I or OPTION-II as applicable):

5.2.2.5 **Panel Metering and Indication**

These shall include but are not limited to those shown in the block diagrams (OPTION-I or OPTION-II as applicable):

LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos. LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm.

5.2.2.6 **Annunciation**

Static type audio-visual annunciator with annunciation windows, acknowledge, test and reset push buttons and hooter shall be provided on each charger for the following annunciations. Any additional relays/ components, including DC under voltage relay and current sensors, required for this purpose shall be provided in the chargers. Facility for bypassing the audio alarm on each charger shall also be provided.

- DC under voltage
- DC overvoltage
- DC earth leakage
- AC incoming power supply failure
- AC input fuse blown-off
- Thyristor/ diode failure or Thyristor/ diode protection fuse failure
- DC output fuse blown-off
- DC battery fuse blown-off
- Filter Capacitor fuse blown-off
- Load on Battery (using current direction sensing with time delay)
- Battery under voltage/ Disconnected during discharge (using zero current sensing)
- Cubicle fan failure/ cubicle temperature high (for chargers with forced cooling).

One summary alarm potential-free contact each for Battery, Charger-1 and Charger-2 shall be wired to terminal block for remote annunciation.

Charger shall also be provided with port to hook up all indication and audio visual alarm, as specified above with owner's PC/ ECS through serial interface with industry standard protocol i.e. RS-485/ TCP/IP/ IEC61850 etc.

5.2.2.7 **Printed Circuit Boards (PCBs)**

PCBs used in the chargers shall be made of glass epoxy material. The PCBs shall be firmly clamped in position so that vibration or continued usages do not result in loose contacts. All PCBs shall be fitted in a manner to avoid replacement of a PCB by a wrong spare card. The PCBs shall be provided with visual light emitting diode (LED) status indications, monitoring points/ test connections and setting potentiometers in a readily accessible location which is visible without removing the PCBs.

5.2.2.8 Conformal coating shall be done for all PCBs, electronic components complying to Harsh environment class G3 as per standard IEC60068.

5.2.2.9 Vendor shall provide adequate protection to the system.

5.3 Construction of Chargers/ Distribution Board

5.3.1 Each Battery Charger and DC distribution board shall be housed in a separate free standing cubicle with minimum IP-31 degree of protection. All panels shall be of the same height so as to form a panel line up which shall have good aesthetic appearance. Chargers-1 & 2 shall be installed side by side whereas DCDB may be located separately and interconnected to the charger through cables. The DCDB shall accommodate outgoing feeders as desired. Each panel shall be provided with a LED light of required wattage with a door operated switch and a thermostatically controlled MCB protected space heater.

The DCDB shall be compartmentalised with each outgoing feeder housed in a separate compartment and shall comply with form of internal separation, minimum "Form-3b" as per IS/IEC 61439. Cable alley of minimum 200 mm width with suitable supports shall be provided for the termination of cables for each vertical arrangement of outgoing feeders in DCDB.

5.3.2 The Charger, DCDB and Cell Booster enclosures shall be fabricated from structural/ CRCA sheet steel or Galvanised sheet steel. The frames shall be fabricated by using minimum 2 mm thick sheet steel while the doors and covers shall be made from minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. The panels shall be provided with suitable louvers for ventilation backed by wire mesh. They must be suitable for use in a tropical climate. Hinged doors shall be provided at the front and back as required. Inter panel sheet steel barriers shall be provided. Charger enclosure material shall comply with EMC requirements.

5.3.3 Bus bars shall be colour coded and live parts shall be shrouded to ensure complete safety to personnel intending routine inspection by opening the panel doors. All the equipment inside

the panel and on the doors shall have suitable nameplates and device tag numbers as per the schematic diagram. All wires shall be ferruled and terminals shall be numbered.

5.3.4 The DCDB incomer and main bus bars shall be rated based on the maximum load current considering an additional 10% design margin for contingencies. The rating shall be selected from standard available ratings and shall be adequate for the expected short circuit current. The bus bar voltage shall be higher than the recommended quick charging voltage for the system. The insulation for all equipment where provided shall be heat resistant, moisture proof and tropicalised.

5.3.5 All power and control switches shall be rotary/ cam operated type. All power switches shall be air insulated load break type. Vendor shall ensure that all equipment/ components such as incomer switches, outgoing DC switches, MCCBs, push buttons, indicating lamps, charger mode selector switches, voltage control switches, annunciator windows etc. are suitably located on the charger and distribution board door such that they can be operated without opening the front door. Power switches shall be provided with a door interlock. In case of difficulty in installation on the charger front panel door, the AC incoming power switches, DC outgoing switches and MCCBs may be installed within the panel provided that they are operable after opening the front panel door. However, all other selector/ control switches, push buttons, indicating lamps, annunciators, meters etc. shall necessarily be installed on the front panel door as specified above.

5.3.6 All instruments shall be switchboard type, back connected and maximum 96 x 96 mm square size. Accuracy class of all meters shall be 1%. Digital meters capable of displaying different parameters can be considered subject to Owner's/ EIL's approval. Analogue instrument scales shall have a red mark indicating maximum permissible operating rating.

5.3.7 All fuses shall be link type and shall be located inside the panel. Diazed fuses shall not be accepted.

5.3.8 All power and control wiring connections within the panels shall be carried out with 660V grade, PVC/ XLPE insulated, Flame Retardant Low Smoke (FRLS), BIS marked wires having stranded copper conductors. However, copper strip connections shall preferably be used for currents exceeding 100A. Control wiring for electronic circuits/ components shall be through copper flat ribbon cable or copper wire of minimum 0.5mm diameter. Ferruling of wires shall be as per relevant IS.

5.3.9 For all cabling external to panels, power cables shall be with aluminium/ copper conductors and control cables shall be with copper conductors. All cable connections shall be from the bottom of the panel. Removable bolted undrilled gland plates shall be provided for all external cable connections. Separate test terminals shall be provided for measuring and testing the equipment to check performance.

5.3.10 A suitably sized earth bus shall be provided at the bottom of the panels running through the panel line up with provision for earth connections at both ends to owner's main earth grid. All potential free metallic parts of equipment shall be suitably earthed to ensure safety.

5.3.11 The maximum height of the operating handles/ switches shall not exceed 1800 mm and the minimum height shall not be below 300 mm.

5.3.12 All components/ devices/ feeders shall be provided with screwed nameplates and lettering shall be of minimum 6 mm height.

5.3.13 Panels shall undergo manufacturer's standard cleaning and painting cycle. After preparation of the under surface, the panel shall be painted with two coats of epoxy based final paint. Colour shade of final paint shall be RAL 7032. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then they shall be greased.

5.4 Cell Booster

Cell booster shall be suitable for charging one to six cells within the time duration specified at Cl.5.2.1.1. It shall be suitable for charging not only new cells before being introduced to the battery bank but also for any treatment to be given to individual weak cells. Cell booster shall be suitable for 240 V $\pm$ 10%, 50 Hz $\pm$ 3% SPN input power supply. Cell booster output voltage shall be in the range of 0-18V and 0-12V for Lead Acid and Nickel Cadmium batteries respectively. Cell booster shall be sized as under:

For Lead Acid battery	=	0.14 x Ah(C_{10}) of cell
For VRLA battery	=	0.2 x Ah(C_{10}) of cell
For Ni Cd battery	=	0.2 x Ah(C_5) of cell.

Cell booster shall have a heavy duty switch fuse or MCCB on both AC incomer and DC output sides, along with AC voltmeter, DC ammeter, DC voltmeter and indicating lamps for AC/ DC power ON & reverse battery connection. The output voltage and current of cell booster shall be manually controlled using a suitably rated variac or a full wave controlled rectifier bridge. Suitable interlock shall be provided so as to ensure that the variac/ controlled rectifier is at its minimum position while switching on the cell booster. Cell booster shall be portable type with wheels. Each cell booster shall be supplied with 5 m long flexible copper conductor, PVC insulated braided cables for both AC incoming power supply and DC output connection to the battery. An industrial type 3 pin 15A plug shall be provided on AC incoming cable end and lugs shall be provided on DC outgoing cable end.

5.5 Reliability

All necessary care shall be taken in selection, design, manufacture, testing and commissioning of the equipment for ensuring high system reliability. The following design considerations shall be taken into account to ensure maximum availability of the system:

5.5.1 There shall be no common device between the two units, the failure of which could cause shutdown of more than one charger.

5.5.2 It shall be possible to attend to any individual power circuit for maintenance without affecting the total DC supply.

5.5.3 Series-parallel combination of smaller devices to achieve specified rating shall not be acceptable.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the equipment shall be subjected to inspection by EIL / Owner or by an agency authorised by the Owner, to assess the progress of the work and to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL's/ Owner's inspector.

6.2 For testing requirement, Inspection & test plan for battery chargers (Standard no. 6-81-1019) shall be followed. Prior notice of minimum 4 weeks shall be given to EIL/owner for witnessing the final testing of panel to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

6.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1019.

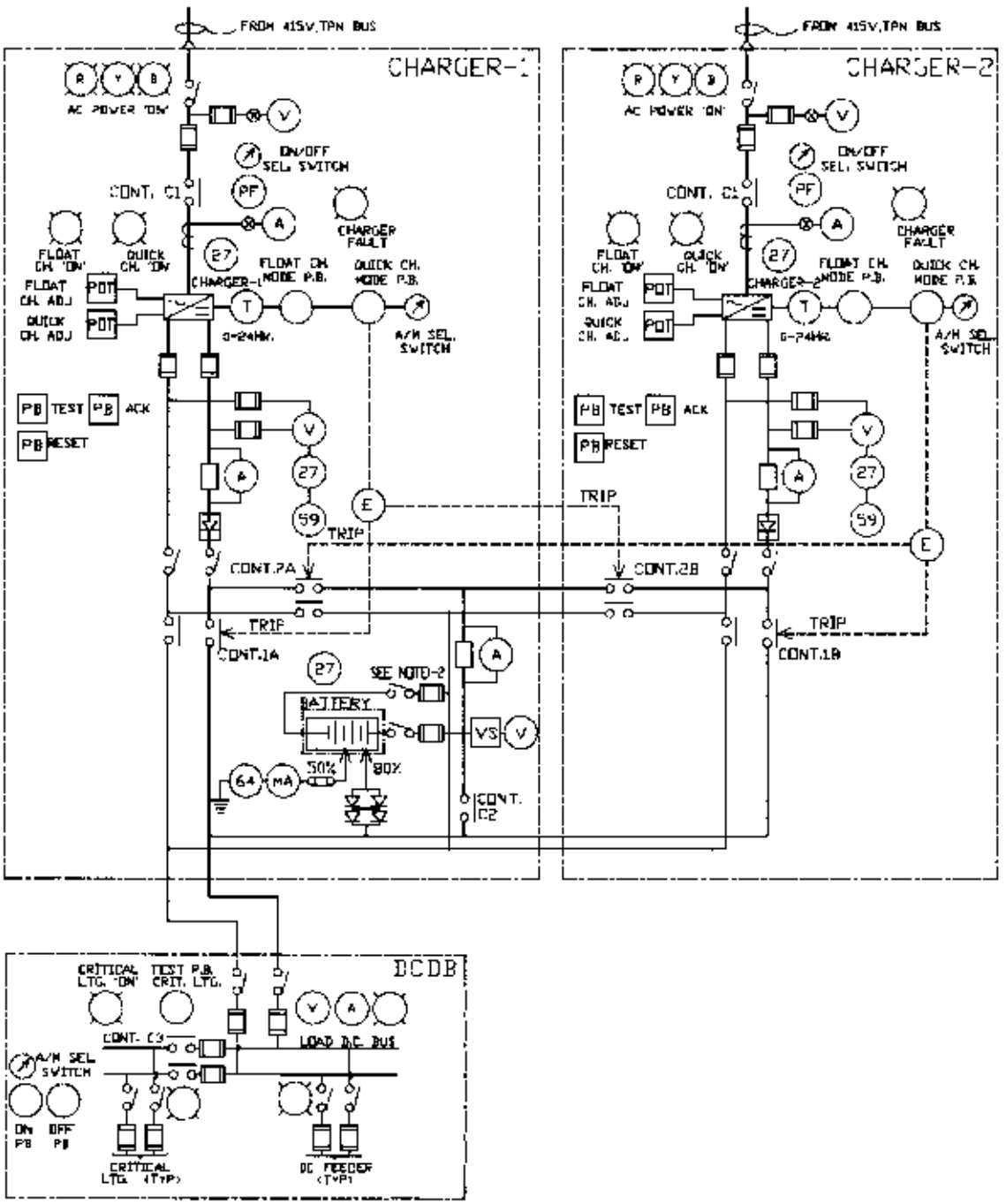
7.0 PACKING & DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/ rail or trailer. It shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's

particulars', 'PO Nos.' Etc., shall be clearly and indelibly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be supplied along with the shipment duly enclosed in a waterproof cover.

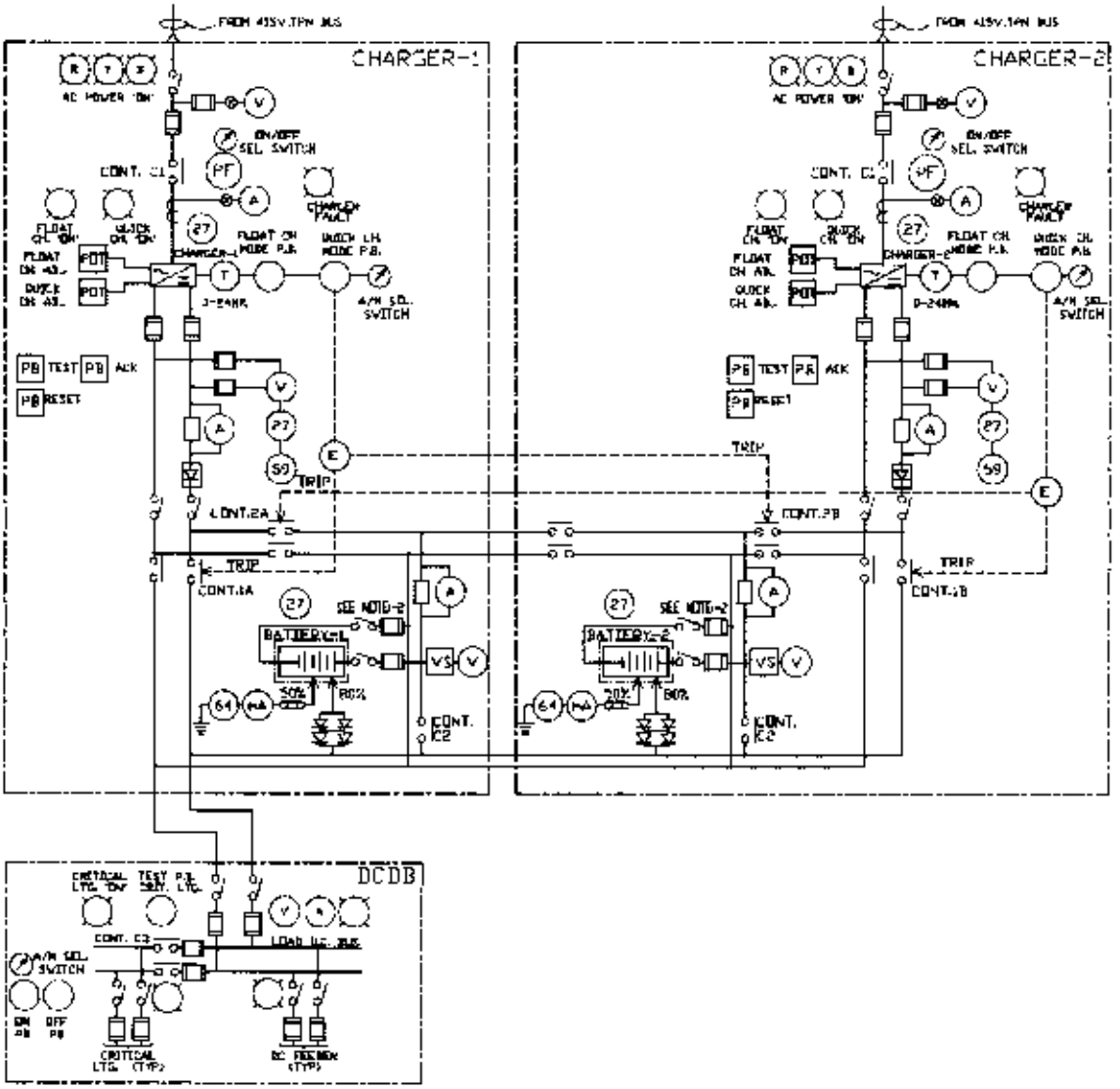
OPTION–I



NOTES:–

1. a) THE DC CONTACTORS SHALL HAVE A TESTED/ PUBLISHED DC RATING EQUAL TO OR EXCEEDING THE MOST STRINGEAST CURRENT CARRYING AND BREAKING REQUIREMENTS CONSIDERING ADEQUATE DESIGN MARGINS.
   b) PUSH BUTTONS ARE NOT ACCEPTABLE IN PLACE OF SELECTOR SWITCHES FOR THE ON/OFF SWITCHING OPERATIONS OF THE CONTACTORS.
   c) THE DC CONTACTORS SHALL BE OPERATED WITH A DC CONTROL SUPPLY
2. SUITABLY RATED DC MCCB CAN BE ACCEPTED IN PLACE OF SWITCH FUSE UNIT AT BATTERY OUTPUT

OPTION–II



1. a) THE DC CONTACTORS SHALL HAVE A TESTED/ PUBLISHED DC RATING EQUAL TO OR EXCEEDING THE MOST STRINGENT CURRENT CARRYING AND BREAKING REQUIREMENTS CONSIDERING ADEQUATE DESIGN MARGINS.
   b) PUSH BUTTONS ARE NOT ACCEPTABLE IN PLACE OF SELECTON SWITCHES FOR THE ON/OFF SWITCHING OPERATIONS OF THE CONTACTORS.
   c) THE DC CONTACTORS SHALL BE OPERATED WITH A DC CONTROL SUPPLY.
2. SUITABLY RATED DC MCCB CAN BE ACCEPTED IN PLACE OF SWITCH FUSE UNIT AT BATTERY OUTPUT.
3. BATTERY CONFIGURATION SHALL BE 2X50% AH CAPACITY UNLESS SPECIFIED OTHERWISE IN DATASHEET/ JOB SPECIFICATION

हाई वोल्टेज केपेसिटर बैंक के लिए विनिर्देश

SPECIFICATION FOR HIGH VOLTAGE CAPACITOR BANK

Rev No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	14.06.24	REVISED AND ISSUED AS STANDARD SPECIFICATION	DKC	ANPS	MKS	MN
6	30.12.17	REVISED AND ISSUED AS STANDARD SPECIFICATION	RS	ANPS	BRB	RN
5	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
4	25.04.08	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
3	20.09.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	VCB	JMS	VPS	GRR

Abbreviations:

AC	Alternating Current
APFC	Automatic Power Factor Correction
BIS	Bureau of Indian Standards
BS	British Standards
CEA	Central Electricity Authority
CRCA	Cold Rolled Close Annealed
CT	Current Transformer
DC	Direct Current
ECS	Electrical Control System
FO	Fiber Optic
FRP	Fibre Reinforced Plastic
HRC	High Rupturing Capacity
HV	High Voltage
IEC	International Electro technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Ingress Protection
IS	Indian Standards
LCD	Liquid Crystal Display
MDB	Main Distribution Board
NEMA	National Electrical Manufacturers Association
PCB	Poly Chlorinated Bi-phenyl
PF	Power Factor
PO	Purchase Order
PVC	Poly Vinyl Chloride
RVT	Residual Voltage Transformer
SWG	Standard Wire Gauge
USB	Universal Serial Bus
VDE	Verband der Elektrotechnik, Elektronik und Information stechnik
XLPE	Cross Linked Poly Ethylene

Electrical Standards Committee

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CONTENTS

1.0 SCOPE

The scope of this specification covers design, manufacture, assembly, shop testing and delivery of high voltage shunt capacitors suitable for indoor/ outdoor location as specified in data sheet and for APFC panels (Indoor) along with complete accessories, G.I. support structures, interconnecting bus bars and parts necessary for safe and efficient operation.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS: 5	: Colours for ready mixed paints and enamels.
IS: 1248	: Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2071	: High Voltage Test Technique
IS: 2705	: Current transformers
IS: 2099	: Bushings for alternating voltages above 1000V.
IS: 2544	: Porcelain post insulators for systems with nominal voltage greater than 1000V.
IS: 3618	: Phosphate treatment of iron and steel for protection against corrosion.
IS: 5082	: Wrought Aluminum and Aluminum alloy bars, rods, tubes and sections for electrical purposes.
IS: 5553	: Reactors
IS: 5578	: Guide for marking of insulated conductors.
IS: 8084	: Interconnecting bus bars for AC voltage above 1kV up to and including 36kV.
IS: 9402	: HV fuses for the external protection of shunt power capacitors.
IS: 10601	: Dimensions of terminals of high voltage switchgear and Controlgear
IS: 11353	: Guide for uniform system of marking and identification of Conductors & apparatus terminals
IS: 12672	: Internal fuses and internal overpressure disconnectors for shunt capacitors.
IS: 13925	: Shunt capacitors for AC power systems having a rated voltage above 1000/ 660V.
IEC 60282-1	: High voltage fuses — Current Limiting fuses
IS/IEC 60470	: High Voltage Switchgear Alternating Current Contactors and contactor based motor starters
IEC 60871	: Shunt capacitors for AC power systems having rated voltage above 1000V
IEC 60076	: Power Transformers
IEEE-519	: Recommended Practice and Requirements for harmonic Control in electric power Systems
IS/IEC 62271 (Part 1, 102, 103, 105, 109, 200, 201)	: High Voltage Switchgear and Controlgear
IEC 62271	: High Voltage Switchgear and Controlgear
IS / IEC: 60529	: Degrees of protection provided by enclosures (IP Code).

2.2 In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner/EIL in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/ spares to enable the end user to place order for spares and services.

4.0 SITE CONDITIONS

The capacitor banks and accessories shall be suitable for installation and satisfactory operation in a tropical, humid and corrosive atmosphere in outdoor open bays next to the substation building or inside the substation building (pressurized or air-conditioned) located in a safe non-hazardous area, as specified in data sheet. They shall be designed to operate under site conditions specified in the requisition/ data sheet. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000m above mean sea level shall be considered.

5.0 CONSTRUCTION

5.1 Outdoor Equipments

5.1.1 The capacitor banks shall comprise the following basic components. Other equipment, not specifically listed below but necessary for the safe and proper functioning of the capacitor bank shall be included:

- Capacitor units of appropriate kVAR rating
- Oil filled/ dry type Series reactor as per data sheet
- Residual voltage transformer (RVT)
- External expulsion/ HRC type fuses or internal element fuses
- Insulators and bushings
- Cable end boxes for incoming cable termination in Series reactor.
- PVC sleeved Aluminium or Copper bus bars/ insulated flexible cables for interconnecting the units to form the capacitor bank and for interconnecting the series reactor and the RVT
- Discharge resistors
- Galvanized support steel structure

5.1.2 The entire outdoor capacitor bank with post insulators, series reactor and RVT shall be supported on steel structures, which shall be designed and supplied by the capacitor supplier. The steel structure shall be so designed that the bottom-most portion of any insulator or bushing on the assembly shall be at a minimum height of 2.75m above ground level. The steel structure shall be galvanized. The amount of galvanizing shall be minimum 900 gm/ m^2 of surface area (0.12mm uniform thickness).

5.2 Indoor Equipments

5.2.1 The capacitor banks shall comprise the following basic components. Other equipment, not specifically listed below but necessary for the safe and proper functioning of the capacitor bank shall be included:

- Capacitor units of appropriate kVAR rating
- Dry type Series reactor
- Residual voltage transformer (RVT)
- HRC type fuses or internal element fuses
- Insulators and bushings
- Cable end boxes for incoming cable termination in Series reactor for pedestal mounted units
- PVC sleeved Aluminium or Copper bus bars/insulated flexible cables for interconnecting the units to form the capacitor bank and for interconnecting the series reactor and the RVT
- Discharge resistors
- Metal enclosure comprising of sheet steel units (for panel-mounted units)
- Pedestal (for non-panel mounted units).

5.2.2 Pedestal-mounted indoor units: The entire capacitor bank with insulators, series reactor and RVT shall be supported on a pedestal, which shall be designed and supplied by the capacitor supplier.

5.2.3 Panel-mounted indoor units: The entire capacitor bank along with APFC panel with insulators, series reactor, RVT, lightning arrestor, fuses and any other necessary equipment shall be mounted inside the panel, which shall be designed and supplied by the capacitor supplier. Capacitor bank shall be mounted inside a metal enclosure which shall comprise of sheet steel units. The capacitor panel shall be totally enclosed and dust and vermin proof, free standing, compartmentalized floor mounting type. If necessary, opening for natural ventilation shall be provided. These shall be louvered and provided with wire mesh having opening size less than 1mm. The enclosure shall have complete protection against approach to live parts or contact with internal moving parts (IP-4X) as per IS as applicable.

5.2.4 The bus-bars, incoming and outgoing feeder compartment and capacitor storage space shall be fabricated from cold rolled sheet steel. The sheet steel used for panel shall be minimum 14 SWG (2 mm) CRCA except that the doors and covers may be made of 16 SWG (1.6 mm) CRCA. Wherever required, stiffeners shall be provided to increase stiffness of large doors and covers.

5.2.5 All cubicles/panels shall be connected to an earth bus bar running throughout the length of the panel. The minimum earth bus bar size shall be 30 x 6 mm^2 Copper, up to short-circuit withstand capacity of 31.5 kA, and 50 x 6 mm^2 Copper, for a short-circuit withstand capacity above 31.5 kA. Doors on which electrical equipment is mounted shall have flexible earth connection to main frame work. Two numbers external earth terminals shall be provided for connection with earth conductor.

5.2.6 The mounting height of all components on panel door shall be between 300 to 1800 mm from floor.

5.2.7 Bus-bars shall be of electrolytic grade Aluminium or Copper. The bus-bar size shall be determined taking into consideration the continuous rating and fault level specified.

5.2.8 The vendor shall ensure that temperature within the cubicle is within acceptable limits and that the heat from capacitor bank does not get transferred to the switchgear assembly. The vendor may consider using ventilation fans for effective heat removal. In case of fan cooled panels, redundant cooling fans (N+1) shall be provided. In case redundant cooling fan is not possible to be mounted on panel, same shall be supplied loose.

5.2.9 The gland plate for the incoming cable shall be at least 600 mm from the incoming switch terminals for panel with voltage up to 11kV and 900mm for 22kV and 33kV voltage. The removable gland plate shall be undrilled and have a minimum thickness of 2mm.

5.2.10 If required, separate panels for indoor capacitor banks and APFC shall be provided.

5.2.11 All the cables entries shall be from bottom.

6.0 DESIGN FEATURES

6.1 Capacitor Units

6.1.1 The capacitor banks shall comprise of appropriate number of basic single-phase units which shall be connected in star formation.

6.1.2 The dielectric used in the capacitors shall be all polypropylene or mixed dielectric with low watt loss. The impregnant in the capacitors shall be non-toxic, non-PCB based and bio-degradable.

6.1.3 The capacitor units shall be assembled such that the capacitor banks are capable of withstanding the electro-dynamic and thermal stresses caused by transient over currents during switching. The capacitor units shall have overload capacity as per IS: 13925.

6.1.4 Capacitor banks shall be protected using internal element fuses or external expulsion/ HRC type fuses and protection provided thus shall conform to the requirements specified below. The internal design of series and parallel arrangement of elements shall be such that:

a. In the case of one element failure, there is no harmful over voltage across the remaining elements and no appreciable change in the operation of the capacitor bank

b. Operation of a single internal fuse element does not cause cascade fuse blowing

c. Permissible over voltages and surges do not cause internal element fuse blowing

d. Characteristic of external fuse, if provided, shall be coordinated with capacitor unit characteristics

e. External fuse, if provided, shall be rated to allow inrush current of the capacitor unit.

6.1.5 Discharge Resistors

Discharge resistors shall be provided to reduce the capacitor bank terminal voltage to a value equal to or less than 50V within 10 minutes after capacitor is disconnected from the electrical system. Separate discharge resistors shall be provided for each step. Alternatively, discharge resistors as part of each capacitor unit are also acceptable.

6.2 Bus Bars

All bus bars interconnecting the basic units as well as the series reactor and RVT shall be of high conductivity electrolytic Aluminum or Copper and shall be fully insulated by using heat shrinkable PVC/ FRP sleeves. All bus bar joints and tap-off connections shall be provided with removable FRP shrouds. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute. Bus bars shall be sized for 130% of the rated current of the capacitor bank.

6.3 Series Reactor

Series reactor shall be provided to limit the inrush current and to suppress harmonics/ avoid resonance condition. Series reactor shall be sized for 130% of the rated current of the

capacitor bank. The series reactor shall be mounted inside the capacitor cubicle (for indoor panel mounted capacitor bank) or shall be mounted on pedestal (for indoor pedestal mounted type capacitor bank) or shall be mounted on structure (for outdoor type capacitor banks). Oil immersed type Series reactor for outdoor type capacitor banks shall be housed in a separate completely enclosed weather protected unit suitable for outdoor installation.

The series reactor shall be designed to have linear V/ I characteristic. The series reactor shall be of oil-immersed/ dry type (for outdoor capacitor banks) and dry type (for indoor capacitor banks), with copper windings, air/ iron cored, non-magnetically shielded design and provided with a conservator (applicable for oil immersed series reactor). Temperature rise for oil and winding shall not exceed the limits as per relevant IS/ IEC.

6.4 Cable Boxes

For indoor pedestal mounted and outdoor type capacitor banks, a cable box suitable for termination of high voltage XLPE insulated Copper/ Aluminum conductor, screened and overall PVC sheathed cables of specified size shall be provided on the series reactor. The cable box shall be designed to withstand specified primary system fault level for 0.25 seconds. A cable box for termination of control cables shall be provided on the RVT. The cable boxes shall be provided with adequately sized cable entries and suitable double (for outdoor units)/ single (for indoor units) compression cable glands made of Nickel-plated Brass. Tinned Copper lugs shall be provided for the connection of all cable cores. In addition, cable boxes for outdoor type capacitor banks shall be weatherproof with minimum IP-55 degree of ingress protection.

6.5 Residual Voltage Transformer (RVT)

A continuously rated residual voltage transformer shall be provided for voltage monitoring and unbalance protection with primary connected in star (neutral connected to capacitor bank's neutral) and two secondary windings connected in star and open delta connection respectively. The secondary voltages per phase shall be $110/\sqrt{3}$ V and 110/ 3 V.

6.6 Insulators and Bushings

Bushings where applicable, shall comply with IS: 2099. The bushings shall be provided with creepage distances applicable to highly polluted environment as per the requirements of relevant IS.

6.7 APFC Panel

6.7.1 Each bus-section of the switchboard shall have a separate APFC controller. APFC control panel shall be microprocessor based. It shall be ensured that:

a) In normal operation with main switchboard bus coupler open, the capacitor bank shall be controlled by respective APFC controller.

b) If the bus-coupler is closed & one incomer breaker is open, then capacitor banks of respective buses shall be controlled by respective APFC controller by using Summation CTs or/ and with suitably designed logics.

6.7.2 APFC function shall be automatically switched off under following conditions:

a) Incomer bus bar fault or circuit breaker failure (Incomer, bus coupler and capacitor feeder)

b) Upstream transformer fault

6.7.3 APFC relay shall be suitable for CT secondary rating of 5A and 1A.

6.7.4 Following shall be provided in APFC panel as a minimum:

a) Suitably rated on-load triple pole door interlocked main isolator/Breaker

b) Suitably rated power fuses for each switching stage of capacitors.

c) Triple pole capacitor switching contactor for each switching stage capacitors.

d) Control circuit fuses / MCBs

e) R,Y,B Phase indication lamp

f) Voltmeter with phase selector switch

g) Power factor meter

h) Current transformer (installed in LV panel/ MDB)

i) Display for voltage, current, Apparent power (kVA), Reactive power (kVAr), Reactive power (kVAr) to reach target PF in APFC relay, APFC relay to switch in and out capacitor banks as per PF requirements.

j) Numerical relays with minimum protection features, such as unbalance, over load, under load, over and under voltage, over current and earth fault protection during switching ON condition.

k) AUTO/manual Selector switch shall be provided on APFC panel.

l) Potential free contacts for breaker switching

m) Time delay for control steps settable in the range of 1 to 120 s. However, necessary interlocks/ logic shall be provided to prevent "switching ON" of that capacitor bank which is under discharge cycle.

n) LCD display of set point and actual PF, active/reactive power

o) Remote disabling (ON/ OFF)

p) In/out of service alarm to the substation control

q) APFC panel shall support USB connection, which makes it possible to connect to a computer via a USB cable OR RS232/ RS485 port to APFC controller to access all APFC parameters on computer.

r) RJ45/FO/ any other port for communication on IEC 61850.

s) Bus bar voltage quality information (fundamental and harmonic load) shall be available at both APFC and ECS

t) On/OFF indications for each step.

u) Interconnection between the main circuit breaker and power fuses shall be done by rigid bus bars. Interconnection between the power fuses, contactors and the capacitors shall be done by insulated flexible cables. All bus bars and cables shall be suitably sized to carry the capacitor peak current.

v) All live parts shall be fully shrouded using polycarbonate or metallic shrouds. The terminals of the capacitor shall also be provided with the standard terminal shrouds as per capacitor manufacturer standard. However, HT insulation tape of requisite voltage grade may be used at jointing points between equipment & busbars where application of shrouds is not possible.

w) Power factor regulator shall be microprocessor based. It shall be with a LCD display to monitor and change the parameters. The regulator shall have soft keys to access and change the parameters. It shall be possible to select the system voltage, current transformer ratio, the type of switching etc. The regulator shall be common for all type and rating of capacitor panels.

6.7.5 The controller shall display locally and make available to ECS the following indications:

a) Switching status of the individual bank
b) Advisory mode
c) Auto Mode
d) Manual mode

6.7.6 In Advisory mode

a) APFC function shall be automatically switched to the advisory mode in case of switchboard bus bar fault or Incomer/ capacitor circuit breaker failure and in the advisory mode, no switch commands are issued to the controlled bank.

6.7.7 In Auto mode

a) The APFC relay shall automatically switch ON/ OFF the various steps of capacitor bank to maintain the desired power factor by obtaining the required inputs from the upstream switchboard.

6.7.8 In Manual Mode (Local- from APFC operator console)

a) The switching ON/OFF the various steps of capacitor bank to maintain the desired power factor shall be performed by the person manually.

6.7.9 If one of the shunt capacitor banks is out of operation due to an internal fault, it shall be automatically marked as unavailable for the APFC. Potential free contacts shall be provided for capacitor trip/Alarm for remote monitoring purpose, to indicate bank is unavailable.

6.7.10 The following actions shall be possible from the operator console:

a) Selection of Manual/Auto control mode. In auto mode, switching (ON/OFF) of capacitor steps shall be though APFC controller. In manual mode, switching (ON/OFF) of capacitor steps shall be using ON/OFF push button.

b) Edit the power factor reference in normal operation with paralleled transformers and in operation with open bus-couplers; the switching of the power factor references shall be done automatically if the bus-coupler opens for any reason; configuration of the sequence in which the controllable devices will be switched on;

c) If the fault occurs in the capacitor step during switching ON condition, APFC controller shall trip the capacitor step. If the same fault occurs next time, then controller shall not allow switching ON operation of such capacitor bank steps until fault is cleared.

d) Suspend automatically the capacitor switching (system freeze) if the system detects voltage outside a configurable bus voltage band; the maximum percentage of the violated limit shall be editable.

6.7.11 The capacitor switching shall be timely coordinated with the on-load tap changer actions; a sufficient time delay margin shall be allowed for the voltage control actions and for the damping out of power frequency voltage transients before a APFC-initiated capacitor bank switching. The bus PT voltage input shall be provided to the APFC controller. The APFC controller shall take action as per bus voltage. The time delay shall be 10min for switching ON the capacitor after switching OFF. Sufficient intermediate time delay shall be required between capacitor steps switching ON.

6.7.12 APFC shall have real time clock tracks & logs date and record of each event and interval record.

6.7.13 Password lock shall be equipped to APFC relay for bank setting protections from any unauthorized access

6.7.14 Each APFC panel shall be suitable for 240V/ 110V AC or DC for control supply and/ or measurements.

6.7.15 Supply of all cables between equipment supplied by the bidder is also included in the bidder's scope. If APFC panel and capacitor panels are placed separately and do not form the part of a common panel, then the maximum cable length between each capacitor bank and APFC panel shall be as specified in MR/ Tender/ datasheet.

6.8 Capacitor contactor

6.8.1 Vacuum type contractor shall be provided for each step of capacitor banks. The capacitor contactor shall be of either single phase with synchronized operation for three phases or three phase construction and shall be suitable for remote operation.

6.8.2 The capacitor contactor shall be suitable for indoor installation and shall have sealed weather proof type construction.

6.8.3 The operating mechanism shall be either through solenoid or spring charging motor. The control supply voltage for spring charging motor shall be 240V/ 110V AC or DC.

6.8.4 The capacitor contactor shall be suitable for min. 10000 electrical and min. 100000 mechanical operations at the rated current

6.8.5 HRC fuse used shall be suitable to be used in series with vacuum contactor.

6.8.6 In case of an emergency, it shall be possible to trip the vacuum switch from a device.

6.8.7 Provision to check the no. of operation of the capacitor contactor shall be provided in the APFC controller.

6.8.8 The contactor shall be of capacitor duty and suitable for back-to-back switching of the capacitor bank.

7.0 PAINTING AND MARKING

7.1 The enclosures of series reactor, RVT and casings of the capacitor units along with the supporting framework (wherever applicable) shall be painted after suitable treatment with

anti-rust paint. All metal surfaces shall undergo manufacturer's standard cleaning/ painting cycle. After preparation of the under surface, the panels shall be painted or powder coated with two coats of epoxy-based acid/ alkali resistant final paint. Colour shade of final paint shall be 632 of IS: 5/ RAL 7031 for all outdoor equipments and 631 of IS:5/ RAL 7032 for all indoor equipments. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then they shall be greased.

7.2 All nuts and bolts shall be Cadmium plated or Zinc passivated.

7.3 The capacitor bank shall be provided with a stainless steel nameplate indicating the rating and all technical particulars as per IS: 13925. The connection diagram indicating capacitors, series reactor, RVT and external fuses shall be shown on the rating cum diagram plate. Stainless steel nameplates shall be provided on each capacitor unit to indicate the rating, technical particulars and phase to which the unit is connected. For outdoor series reactor and RVT similar stainless steel nameplates indicating the rating and identifying the terminals clearly shall be provided.

8.0 SIZING CRITERIA

The offered capacitor bank in conjunction with the series reactor shall provide the specified minimum net capacitive kVAR at the rated nominal voltage. The vendor shall size and design the capacitor bank, series reactor and residual voltage transformer for the maximum continuous overvoltage that can appear across each of these elements, considering system voltage variation given in the data sheets and voltage rise because of series reactor. Insulation levels for capacitor units and other elements shall be chosen accordingly.

Series reactor shall be sized such that it is capable of continuously carrying the permissible capacitor bank over current, as specified in IS: 13925.

9.0 INSPECTION, TESTING AND ACCEPTANCE

9.1 All necessary routine and acceptance tests on capacitor units, series reactors & RVTs shall be done in the presence of purchaser or his representative. Two weeks' advance notice shall be given to the purchaser to enable him or his authorized representative to witness the tests. During the course of manufacturing, the purchaser or his authorized representative shall be free to visit the works and assess the progress of work and the manufacturer shall render him all possible assistance to do so.

9.2 For testing requirements, refer Inspection and Test Plan No. 6-81-1020. Prior notice of minimum 2 weeks shall be given to EIL/ Owner for witnessing the final testing to ensure satisfactory operation. Tests shall be carried out at manufacturer's works under his care and expense.

9.3 All routine testing of the series reactor and RVT shall be carried out as per applicable standards at the sub-supplier's works. Certified test reports for the type tests conducted by recognized testing agencies shall be submitted.

9.4 The type test and routine test on capacitor banks & its associated components shall be as per ITP.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into multiple sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation, i.e. by ship/ rail or trailer. It shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc. shall be clearly and indelibly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains and high ambient temperature. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment

अग्निरोधक प्लगों, साकेटों तथा हैंडलैम्पों के लिए विनिर्देश

SPECIFICATION FOR FLAMEPROOF PLUGS, SOCKETS AND HAND LAMPS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	31.08.20	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AR	ANPS	SA	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	29.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

BIS	Bureau of Indian Standards
BS	British Standard
CEA	Central Electricity Authority
COB	Chip On Board
DGMS	Directorate General of Mines Safety
DOB	Driver On Board
ES	Edison Screw
FRLS	Flame Retardant Low Smoke
FRP	Fibre Reinforced Plastic
GI	Galvanised Iron
HRC	High Rupturing Capacity
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronics Engineers
IP	Ingress Protection
IS	Indian Standard
LED	Light Emitting Diode
LV	Low Voltage
NABL	National Accreditation Board for Testing and Calibration Laboratories
NEMA	National Electrical Manufacturers Association
PCB	Printed Circuit Board
PESO	Petroleum and Explosives Safety Organisation
PVC	Poly Vinyl Chloride
RCCB	Residual Current Circuit Breaker
SPN	Single Phase Neutral
SS	Stainless Steel
TPN	Three Phase Neutral
VDE	Verband der Elektrotechnik, Elektronik und Information stechnik

Electrical Standards Committee

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Mr. Raman Sood
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Mr. Rajesh Sinha (Inspection)
Ms. N. P. Guha (Projects)

CONTENTS

1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of flameproof plugs, sockets, transformers, hand lamps and accessories suitable for installation in locations handling flammable liquids and gases/ vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	:	Colours for ready mixed paints and enamels.
IS-10322	:	Luminaires
IS-13383	:	Photometry of luminaires - Method of measurement
IS-16101	:	General lighting – LEDs and LED modules – Terms and definitions.
IS-16102	:	Self-ballasted LED lamps for general lighting services.
IS / IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General Requirements).
IS / IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures “d”).
IS / IEC 60529	:	Degrees of protection provided by enclosures (IP Code).
IS / IEC 60947	:	LV switchgear and control gear.

National Lighting Code (NLC)-2010

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner’s/ EIL’s decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 CERTIFICATION

The equipment shall have test certificates issued by NABL-approved/ Central Government labs in India/ IECEx-approved/ equivalent labs. All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location and marking as per

IS/IEC 60079 or IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license.

6.0 TECHNICAL REQUIREMENTS

6.1 Construction

6.1.1 The enclosures of the plugs, sockets, transformers and hand lamps shall be made of cast light metal alloy.

6.1.2 The equipment shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. The sockets for fixed installation, i.e. 415 V three phase sockets and 240 V single phase sockets, shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanised sheet steel/ FRP/ stainless steel minimum SS-304 (as specified in purchase specifications). The canopy shall be suitable for providing protection against rain from top, back and two sides.

6.1.3 The enclosures shall be provided with gaskets for IP, if required by equipment certification. Gaskets, wherever provided, shall be made of non-inflammable and self-extinguishing material.

6.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flame proof (Gas group IIA/ IIB) : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flame proof (Gas group IIC) : Light yellow shade 355 of IS-5/ RAL 1012

All unpainted steel parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving then these shall be greased. Grease, which does not solidify, shall be applied to flamepath.

6.1.5 Equipment shall be marked as per IS/IEC 60079.

6.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

6.1.7 All the non current carrying metallic parts of the equipment shall be inherently bonded together. The TPN sockets shall be provided with two earthing studs, with lugs on the exterior of the enclosure, suitable for termination of 10 mm dia. GI wire rope. Internal earth terminals shall be provided in each enclosure for all single phase plugs and sockets for connecting the earth core of the cables.

6.1.8 The terminal block enclosures shall be adequately sized to properly terminate the cables by taking into account the required bending radii of cable cores and shall have the following minimum gland to terminal distances:

Conductor Size	Up to 2.5 mm^2	Above 2.5 mm^2 & Up to 10 mm^2	Above 10 mm^2 & Up to 35 mm^2	Above 35 mm^2 & Up to 70 mm^2
Gland to terminal distance	35 mm	60 mm	100 mm	150 mm

6.1.9 The sockets shall be provided with 2 nos. suitably sized cable entries at the bottom for specified cable sizes and complete with 2 nos. flameproof double compression type nickel plated brass flameproof cable glands. The plugs shall be supplied with 1 no. suitably sized cable entry for specified cable size and complete with 1 no. double compression type nickel plated brass flameproof cable gland. Each socket shall be supplied with 1 no. flameproof nickel plated brass sealing plug, for plugging the unused cable entry.

6.1.10 The sockets shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

6.1.11 A tag plate indicating Tag Number shall be provided on each socket. A nameplate shall be provided to indicate the Name of Manufacturer, test certificate number, serial number, BIS license number, applicable gas group etc. as per IS/IEC 60079 and any additional marking required by statutory authority like approval no. etc. The nameplates shall be engraved type or laser-marked and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate. All tag plates shall be engraved, 3 ply laminate fixed with screws and name plate shall be Al anodized or SS-304 engraved or laser-marked and fixed with rivets.

6.2 Socket Outlets & Plugs

6.2.1 The sockets shall be provided with a switch and a mechanical interlock so as to break the electrical circuit before the plug is completely withdrawn and make the circuit after the plug is fully inserted.

6.2.2 In order to prevent accidental removal of plug from socket, the engagement and disengagement shall be by two separate and distinct movement and positions.

6.2.3 415V, 63A three phase flameproof plugs and socket meant for welding receptacle/ any other three phase auxiliary load, shall be provided with 4 pins (3P+E).

6.2.4 4 pin socket shall be provided with 63A, three pole heavy duty switch; whereas, 5 pin socket shall be provided with four pole (TPN) heavy duty switch. Heavy duty switch shall be suitable for AC duty rating as applicable.

6.2.5 Both 24V and 240V, 15A single phase flameproof plug and socket shall be provided with 3 pins (2P+E).

6.2.6 Provision shall be made so that it shall not be possible to insert 24V plug on to a 240V socket.

6.2.7 The sockets shall be provided with either a spring loaded hinged cover, or with a cap connected through metallic chain, to close the same when not in service.

6.2.8 Scraping earth connection shall be provided between the plug and socket. Earth pin of plug shall first engage with earth pin of switch socket.

6.2.9 The plug assembly shall be mechanically rugged, light and shall not unduly stress the socket or its own pins when fitted on to the socket. The diameter of the earth pin of the plug and socket shall be at least 1.1 times the diameter of the phase pins.

6.3 240V/ 24V Portable Transformer units

6.3.1 The 240V/ 24V portable transformer unit shall be supplied complete with 240V/ 24V transformer having a 24V socket on the secondary side and 5 meter length of 3x1.5 mm^2 copper conductor, PVC insulated, metal braided flexible cable, duly terminated in the transformer primary at one end and having 240V plug on the other end. The socket outlets and plugs shall meet the requirements of clause 6.2 above.

6.3.2 The 240V/ 24V transformer shall be designed for 30VA rating on continuous basis. Insulation Class shall be "B", as a minimum. Automatic protection employing earth leakage detection scheme with 30mA current sensitivity shall be provided to disconnect supply on occurrence of an earth fault. 30mA RCCB (preferable)/ HRC fuses shall be provided on primary and secondary side of the transformer. The transformer shall have an earthed screen between primary and secondary winding.

6.3.3 Suitable handle for carrying the transformer unit shall be provided.

6.3.4 Alternatively, 24V socket outlet (as per Cl. 2.5 above) shall be provided with a built-in 240V/24V 30VA transformer duly protected by HRC fuse in phase on primary side. In this case, a separate portable 240/24V transformer unit is not required.

6.4 24V Hand Lamp units

6.4.1 Each hand lamp unit shall be supplied complete with 15 meter length of 3x1.5 mm² copper conductor, PVC insulated, metal braided flexible cable, duly terminated in the hand lamp at one end and having 24V plug on the other end. The plug shall meet the requirements of clause 6.2 above.

6.4.2 The well glass provided shall be clear and toughened type. Hand lamp shall be provided with 10W, 24V AC LED lamp with ES27 cap having minimum output of 900 lumens. Alternatively, if specified in MR, it shall be with lens/ glass and 20W, 24V AC COB/ discrete LED with driver/ LED PCB with DOB having minimum output of 1800 lumens. The minimum output for 10W or 20W shall be guaranteed at 18V to 26V.

6.4.3 Hand lamp shall be provided with either galvanised steel or epoxy powder coated mild steel protective wire cage using minimum 3mm welded steel construction and having mesh dimension not exceeding 50mm x 50mm.

6.4.4 Suitable handle for carrying the hand lamp unit and a stand type guard suspension hook shall be provided.

6.5 Terminals & Wiring

6.5.1 All equipments shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. The terminals shall be suitable for termination of stranded conductors. Tinned copper lugs shall be provided for cable termination.

6.5.2 All internal wiring shall employ adequately sized, 660V grade, FRLS type, PVC insulated Copper conductor wires, colour coded for phase, neutral and earth, with minimum conductor sizes as below:

TPN Plugs and sockets:	16 mm²
SPN Plugs and sockets:	2.5 mm²

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works, under his care and expense.

7.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports applicable PESO/ DGMS approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.

7.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1021.

7.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test Plan no. 6-81-1021.

8.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity',

'Weight', 'Owner's particulars','PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

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SPECIFICATION FOR GRID CONNECTED ROOFTOP SOLAR PHOTOVOLTAIC POWER SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	30.05.19	ISSUED AS STANDARD SPECIFICATION	DR/PB	PG	BRB	RKT

Abbreviations:

AC	Alternating Current	LAN	Local Area Network
ACDB	AC Distribution Board	LCD	Liquid Crystal Display
BIS	Bureau of Indian Standards	MCCB	Moulded Case Circuit Breaker
BS	British Standard	MC4	Multi-Contact with 4 mm dia. contacts pins
CEA	Central Electricity Authority	MNRE	Ministry of New & Renewable Energy
CPP	Captive power Plant	MOV	Metal Oxide Varistor
CRCA	Cold Rolled Cold Annealed	MPPT	Maximum Power Point Tracker
CT	Current Transformer	MS	Mild Steel
DC	Direct Current	NABL	National Accreditation Board for Testing and Calibration Laboratories
DG	Diesel Generator	NEMA	National Electrical Manufacturer's Association
EIL	Engineers India Limited	PCU	Power conditioning Unit
EMC	Electro Magnetic Compatibility	PIV	Peak Inverse Voltage
EMI	Electro Magnetic Interference	PV	Photo Voltaic
EPDM	Ethylene Propylene Diene Monomer	PVC	Poly Vinyl Chloride
EVA	Ethyl Vinyl Acetate	RFI	Radio Frequency Identification
FF	Fill Factor	SAT	Site Acceptance Test
FO	Fibre optic	SLD	Single Line Diagram
FRLS	Flame Retardant Low Smoke	SPD	Surge Protection Device
FRP	Fibre-Glass Reinforced Plastic	SPV	Solar Photo Voltaic
GI	Galvanised Iron	STC	Standard Test Conditions
GRP	Glass Reinforced Plastic	TPN	Three Phase Neutral
HMI	Human Machine Interface	UV	Ultra Violet
IEC	International Electro-technical Commission	V	Volt
IEEE	Institute of Electrical and Electronics Engineers	V_m	Maximum Power Voltage
IGBT	Insulated Gate Bipolar Transistor	VT	Voltage Transformer
I_m	Maximum Power Current	W_p	Watt peak
IP	Ingress Protection	XLPE	Cross Linked Poly Ethylene
IS	Indian Standards	XLPO	Cross Linked Poly Olefin
JB	Junction Box		

Electrical Standards Committee

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Members:
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Mr. Parag Gupta
Mr. M.K. Sahu
Ms. N.S. Bhattacharya
Mr. Saeed Akhtar (Inspection)
Ms. N.P. Guha (Projects)

CONTENTS

1.0 SCOPE

1.1 The intent of this specification is to define the functional and design requirements for Grid Connected Solar Photo Voltaic (SPV) Power System installed on building roof top meant for generating electrical energy from solar energy. This specification also covers the requirements for selection, design, engineering, manufacture, testing at manufacturer's works, packing & dispatch, installation, testing and commissioning at site of the system.

1.2 The contractor shall be responsible for design, engineering and manufacturing of the complete system to fully meet the intent & requirement of this specification and job specification/ datasheets. Contractor shall ensure that the design, product selection and installation are carried out as per good engineering practices, which shall also include the requirements of safety, reliability, ease of maintenance and operation.

1.3 Compliance with this specification and /or approval of any of the contractor's documents shall not relieve contractor of his responsibility towards the completeness and satisfactory operation of the Solar Photovoltaic Power system.

2.0 CODES AND STANDARDS

2.1 The equipment & system shall comply with the requirements of latest revision of IEC and relevant BIS and other Indian/ International standards as applicable including the following:

a)	IEC 62446:	Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection.
b)	IEC 61215 / IS 14286:	Design Qualification and Type Approval for Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
c)	IS/ IEC 61701:	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules
d)	IEC 61853-1/ IS 16170-1:	Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating
e)	IEC 61730-1, 2:	Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction, Part 2: Requirements for Testing
f)	IS/ IEC 60947	Low-voltage switchgear and control gear
g)	IEC 62759-1:	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units
h)	IEC 62109-1, 2	Safety of power converters for use in photovoltaic power systems Safety compliance (Protection degree IP 65 for outdoor mounting, IP 31 for indoor mounting)
i)	IS/ IEC 61683:	Photovoltaic Systems – Power conditioners: Procedure for Measuring Efficiency
j)	BS EN 50530 (IEC 62891)	Overall efficiency of grid-connected photovoltaic inverters
k)	IEC 62116/ IEEE 1547/ UL 1741:	Utility-interconnected Photovoltaic Inverters - Test Procedure of Islanding Prevention Measures
l)	IEC 60255-27:	Measuring relays and protection equipment - Part 27: Product safety requirements
m)	IEC 60068-2 (1,2,14,27,30 & 64):	Environmental Testing of PV System – Power Conditioners and Inverters
n)	IEC 61000- 2,3,5:	Electromagnetic Interference (EMI), and Electromagnetic

		Compatibility (EMC) testing of PV Inverters (as applicable)
o)	IEC 62093 & IEC 60068-2:	Design Qualification Environmental Testing.
p)	BS EN 50618:	Electric cables for photovoltaic systems (BT(DE/NOT)258), mainly for DC cables
q)	IS/IEC 60947- 1, 2, 3; EN 50521:	General requirements for connectors- safety
r)	IEC 60269-6:	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
s)	IEC 62208 & IEC 60529:	General Requirements for Junction Boxes/ Enclosures.
t)	IEC 62124:	PV Standalone system design verification
u)	IEC 60364-7-712:	Electrical installation of buildings Requirements for SPV power supply systems
v)	IEC 61643-11:2011 / IS 15086-5:	Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods
w)	IEEE 519	Recommended practices and requirements for harmonics control in electrical power systems
x)	NBC 2016	National Building Code of India 2016

2.2 Any other regulations laid down by the Central, State or Local Authorities from time to time shall also be referred.

2.3 In case of imported equipments, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.4 The equipment and system shall comply with the National Solar Mission guidelines of India and MNRE guidelines & specifications.

2.5 The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.6 In case Indian standards are not available for any equipment, standards issued by IEC/BS/ /IEEE/ or equivalent agency shall be applicable.

2.7 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The SPV system shall be suitable for installation and satisfactory operation on the rooftop of buildings located in a tropical, humid and corrosive atmosphere.

4.2 All the equipment shall be suitable for the site conditions specified in the enquiry document/ data sheets. If not specifically mentioned therein, a design ambient of 40°C, an altitude not exceeding 1000m above mean sea level and maximum wind velocity as mentioned in datasheet/ job specification shall be considered.

4.3 All equipment of the system are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 SYSTEM DESIGN REQUIREMENTS

5.1 The equipment and materials shall be designed for the following grid power supply conditions unless otherwise mentioned:

a) Grid Supply (at the point of interconnection)

i)	Voltage	: 415 V AC ± 10%
ii)	Frequency	: 50 Hz ± 3%
iii)	Maximum Fault Level (for 1 second)	: Refer data sheet
iv)	System Neutral Earthing	: Solidly earthed (unless otherwise specified)
v)	No. of Phases	: TPN

b) SPV System Voltages

i)	PV module voltage/ array voltage	: To be decided by the Contractor
ii)	Power Conditioning Unit input voltage	: To be decided by the Contractor
iii)	DC voltage	: To be decided by the Contractor
iv)	Power Conditioning Unit output voltage	: 415 V TPN, 50Hz

5.2 System Description & Power Evacuation

The main intent of grid connected PV solar system shall be to convert solar energy to generate electricity. The electricity generated shall be directly connected to the power system at 415V. The solar system shall be photovoltaic based in which arrays of photovoltaic (PV) modules shall be installed on building roof top under clear sky, shade free, tilted towards south at an optimum inclination. Contractor shall perform the analysis for finalizing the location, direction & inclination angle of the PV arrays.

The PV arrays shall convert solar energy and generate DC electricity, which shall be collected using array junction box and/ or main junction box and finally fed into power conditioning unit (PCU). The PCU shall convert DC power to three phase AC power at 415V voltage and shall be hooked up to 415V power supply system of substation/ building electrical system/ plant electrical system/ grid (Grid/DG/ CPP etc.) after automatic synchronization. In case of solar PV system out of synchronization due to grid/ plant electrical supply failure, or due to low/ high grid voltage, the PV system shall get disconnected from the grid. Once the healthy grid supply is available, PV system shall again automatically synchronize with grid supply and would feed energy/power into electrical system.

5.3 Major Items & Components of the SPV system

The Grid connected Solar Rooftop Photo Voltaic (SPV) system consists of SPV array, Module Mounting Structure, Power conditioning Unit (PCU) having Maximum Power Point Tracker (MPPT) and controls & protections, interconnecting cables and junction boxes etc. PV arrays shall be mounted on suitable structures. Grid Connected SPV system shall be without battery and shall be designed with necessary features to supplement grid power during day time.

Solar PV system shall consist of following equipment/ components as minimum. Any other equipment / component required for completeness & operation of the system shall be provided by contractor:

a) Solar PV Modules/Panels, Crystalline type

b) Grid Connected/ On-grid Power Conditioning Unit with MPPT units

c) Mounting Structures

d) AC Distribution board

e) Junction Boxes

f) Data Acquisition and monitoring system including weather monitoring instruments

g) Cables, Pipes, conduits, accessories, glands, lugs etc.

h) Earthing, Lightning, over voltage & Surge Protection

i) Fuses/ Switches/ Circuit breakers/ Connectors

5.4 Design / Selection Criteria of the System

a) The quantity of solar modules, W_p rating of each solar module, number of PCU and AC output rating of PCU shall be decided by contractor considering the total capacity of the SPV system required as per the Job specification.

b) Contractor shall ensure proper system designing that would include consideration of accurate solar irradiation data, resulting in the correct sizing of equipment for the solar power system and get the same approved from the EIL/ Owner. Proper design and component sizing procedures as per acceptable standards shall be adopted. Contractor shall provide the detailed energy generation calculation (daily/ monthly /yearly) and other analysis reports with the help of internationally accepted software (e.g. PVSyst) during detailed engineering.

c) All PV Modules shall be of same make and rating and shall have identical characteristics.

d) The solar PV modules shall be tilted towards south. The tilt angle shall be fixed based on the availability of maximum annual solar insolation (kWh/m^2-day) at particular tilt based on optimum inclination analysis.

e) Full rated PCU shall be provided i.e. overloading capacity available in the PCU shall not be used to meet the peak rating of power evacuation from PV System. PCU rating shall be finalized considering poorly ventilated non air conditioned room/ outdoor installation as per the job specification.

f) PV Array Configuration

The solar Array shall be configured in multiple no. of sub-arrays, providing optimum DC power to suitable number of sub arrays. Contractor shall furnish the design indicating configuration of PCU and respective sub arrays. While ensuring full compatibility between PV array and PCU, contractor shall consider the following aspects and the calculations shall be submitted for review:

i. The number of PV modules per string in an array shall be decided such that MPPT DC voltage range is not violated under site condition. All strings shall be identical w.r.t. number of modules and their ratings & characteristics. For achieving identical strings, if more number of PV modules are required, the same shall be provided.

ii. The peak-power point voltage and the peak-power point current of any module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case may be.

iii. As far as possible, all PCU shall be of identical ratings. All PCUs shall be of same make. Grid Connected String inverter with MPPT shall be provided. For a solar PV system, the AC combined wattage of all inverters shall not be less than the rated DC capacity of the PV plant at STC. For a solar PV system, smaller rating of multiple inverters can be provided and AC output from all inverters shall be fed to ACDB of that system. One feeder from ACDB shall evacuate power to 415V switchboard in substation/ building electrical system.

iv. The maximum open circuit voltage of the arrays shall not violate the maximum DC voltage that the PCU can accept under minimum site temperature.

v. Contractor shall suitably decide series parallel combination of PV modules, DC voltage for array, DC input voltage of PCU etc. Contractor shall finalize suitable scheme for solar power evacuation ensuring grid connectivity at 415 V. However, string output voltage/ DC array voltage/ PCU input voltage shall be highest possible DC voltage considering the optimum energy generation as per the PCU MPPT range.

vi. The array output shall be well within the input voltage range of the inverter so that inverter works in MPPT range for most of the solar insolation range.

vii. The automatic synchronization facility of solar power and grid power shall be provided at PCU only. PCU shall adjust voltage & frequency levels to suit the grid supply. Synchronization at any other location in the system is not acceptable.

g) The complete solar system layout shall be developed by contractor indicating all modules, mounting structures, PCU, JBs etc. The solar system including mounting structures shall have required walkways at intervals for movement of personnel for operation & maintenance.

6.0 EQUIPMENT SPECIFICATIONS

Equipment and material shall conform to the following specifications as well as site & system conditions defined elsewhere in the enquiry document. The equipment shall be manufactured in accordance with current Indian/ International Standards. In absence of specification for any equipment/ system, the specification shall be developed by contractor and shall be approved by the EIL/ Owner. All similar materials and removable parts shall be uniform and interchangeable with one another.

6.1 Solar Photo Voltaic Modules

a) Solar PV module array shall consist of high efficiency Solar Modules utilizing Crystalline Silicon solar PV cells. Individual Solar module rating shall not be less than 300Wp at standard test conditions. Preference shall be given to bigger Solar PV module ($\geq$ 300 Wp).

b) Crystalline high power cells shall be used in the Solar Photovoltaic module. Solar module shall be laminated using lamination technology with established polymer (EVA) and Tedlar / Polyester laminate. The solar modules shall have suitable encapsulation and sealing arrangements to protect the silicon cells from the environment. The arrangement and the material of encapsulation shall be compatible with the thermal expansion properties of the silicon cells and the module framing arrangement / material. The encapsulation arrangement shall ensure complete moisture proofing during life of the solar modules.

c) All materials used shall be having a proven track record of reliable and stable operation in external outdoor applications.

d) Module rating is considered under standard test conditions (STC), however, solar modules shall be designed to operate and perform in relative humidity up to 100% with temperatures between -10°C & +65°C and withstand gust as per the wind zone of the

location from back side of the panel. The Geological data of site shall be referred for design to get optimum generation.

e) Protective devices against surges at the PV module shall be provided. Low voltage drop bypass diodes shall be provided.

f) The PV modules shall be suitable for highly corrosive atmosphere throughout their lifetime.

g) PV modules must qualify as per relevant IS/IEC standards (test reports/ certificate from IEC/NABL accredited laboratory shall be furnished). Additionally the performance of PV modules at STC conditions must be tested and approved by one of the IEC / NABL Accredited Testing Laboratories including Solar Energy Centre of MNRE. Qualification certificate from IEC/NABL accredited laboratory as per relevant standard for PV modules shall be accompanied with the STC report/ certificate.

h) Solar PV Module design shall conform to following requirement:

i. Toughened, low iron content, impact resistant

ii. High transmissivity front glass.

iii. Anodized Aluminium frame.

iv. Ethyl Vinyl Acetate (EVA) encapsulant.

v. Sealant around laminate.

i) Weatherproof DC rated connector and a cable as a part of the module shall be provided for making connections easier & secure and not allowing for any loose connections.

j) Modules shall be resistant to water, abrasion, hail impact, humidity and other environment factor for the worst site conditions/ situations.

k) Each module shall have low iron tempered glass front for strength and superior light transmission. It shall have tough multi-layered polymer back sheet for environment protection against moisture and provide high voltage electrical insulation. Transmitivity of glass shall not be less than 91%.

l) The fill factor of modules shall not be less than 0.72.

m) The rated output of any module shall have maximum tolerance of ±3%.

n) Photo-electric conversion efficiency of SPV module shall not be less than 15% at STC.

o) Each PV module must have a RF identification tag (RFID). The following information must be mentioned in the RFID used on each module. This can be inside or outside the laminate, but must be able to withstand harsh environmental conditions.

i. Name of the manufacturer of PV Module

ii. Name of the Manufacturer of Solar cells

iii. Month and year of the manufacture (separately for solar cells and module)

iv. Country of origin (separately for solar cells and module)

v. I-V curve for the module

vi. Peak Wattage, Im, Vm and FF for the module

vii. Unique Serial No. and Model No of the module

viii. Date and year of obtaining IEC PV module qualification certificate

ix. Name of the test lab issuing IEC certificate

x. Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

p) The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof cover with captive screws and cable gland entry points or may be of sealed type and shall be IP-65 rated designed for long outdoor operation in harsh environment.

q) I-V curves at STC for modules shall be furnished.

6.2 Power Conditioning Unit

a) Power Conditioning Unit shall convert DC power generated by SPV array into 3 phase 415V, 50 Hz AC power to be connected to grid/ plant electrical system. It also provides necessary protections for grid synchronization and data logging & monitoring. The DC energy produced shall be utilized to maximum and supplied to the DC bus for inverting to AC voltage with the help of power Conditioning Unit using its Maximum Power Point Tracking (MPPT) which shall be part of the PCU. MPPT shall extract maximum energy from solar. MPPT voltage range shall be selected for wider voltage range and MPPT shall be of very high efficiency as per the applicable codes.

i. The PCU shall have protections such as, over current, short circuit, earth fault, over temperature, internal protection arrangement against any sustained fault etc.

ii. The PCU shall be designed for continuous reliable power supply, minimize the risk of short circuit and shall ensure human & operational safety.

iii. The PCU shall have built in metering and data logging arrangement for monitoring plant performance.

iv. The PCU shall be designed to be completely compatible with the SPV array voltage. Minimum open circuit DC voltage suitability for PCU shall be 1000V DC.

v. MPPT controller, inverter and associated control and protection devices etc. shall be integrated into the PCU.

vi. The PCU shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start till the fault is rectified.

b) The PCU shall automatically turn on and turn off successively as the available solar irradiation varies over the day. The PCU shall have all necessary synchronization equipment installed and shall be able to synchronize independently and automatically/ phase lock with grid power supply to attain synchronization.

c) The 3 phase Grid connected PCU shall incorporate latest technological advances to provide highly reliable and efficient energy conversion from DC to AC. The PCU shall incorporate system design which uses multiple power stakes which work in tandem. Both AC & DC lines shall have suitable fuses/ contactors/MCCB to allow safe start up & shut down of the system. Fuses used in the DC circuit should be DC rated. The PCU shall be complete with all protection, metering, alarm, annunciation, indications as required.

d) The power conditioning unit shall be three phase static solid state type with integrated system comprising static inverter, controller, input & output contactors, line filters, EMC filters and protection devices and all other equipment/ accessories required for completeness of the system whether specifically mentioned herein or not, but necessary for completeness and satisfactory performance of the system.

e) The inverter shall be efficient with IGBT based reliable design. The control system shall be of highest reliability based on microprocessor / Digital signal Processor design.

f) The PCU manufacturer shall be responsible for design, engineering and manufacturing of the complete PCU system to fully meet the intent and requirements of this specification and enclosed data sheets. Selection, sizing and suitability of all equipment and components used for PCU system shall be PCU manufacturer's responsibility.

g) All breakers/ contactors shall be adequately rated for continuous rating as well as breaking capacity as applicable. Paralleling of breaker/ switch/ contactor poles to achieve the required current rating is not acceptable. All DC input isolating device shall be double pole type.

h) All electronic power devices including transistors (IGBT), diodes etc. shall be rated under operating conditions for approximately 200% of the maximum current carried by the device. All other electrical components such as transformers, reactors, breakers, contactors, switches, bus bars etc. shall be rated for at least 125% of the maximum required rating. No electronic device shall be subjected to PIV greater than 50% of its rated value.

i) PCU shall have user friendly LED/ LCD display & keypad for system control, programming, monitoring, change set points and for viewing on line parameters such as DC power input, DC input voltage, DC current, AC power output, AC voltage (all the 3 phases and line) and AC current (all the 3 phases and line), cumulative output energy in KWH, power factor, frequency, PCU operating state status, various fault conditions etc.

j) PCU performance parameters:

i. The total harmonic distortion and individual harmonics level shall be less than 3% for both voltage and current harmonics.

ii. DC ripple content shall be less than 3%.

iii. Safety from grid power failure including under-voltage, overvoltage or any other fault conditions.

iv. The efficiency of the PCU shall be minimum 96%. The PCU shall be transformer less design.

v. PCU shall have internal protection arrangement against any sustained fault in the feeder line & against lightning strikes in the feeder line.

vi. PCU shall have required protection arrangement against earth leakage faults.

vii. DC output side shall have suitable DC rated contactor/ MCCB/ other protection devices for protection & isolation. AC output side shall have suitable AC rated 4 pole TPN switch/breaker with protection devices for isolation purposes.

viii. The minimum indications through LEDs/ LCD display shall be as follows:

- Inverter ON
- Grid ON
- Grid/ Inverter under voltage / over voltage
- Inverter over-load
- Inverter over temperature
- Earth fault

k) PCU shall be able to withstand an unbalanced Grid/ Electrical system conforming to relevant IEC/ IS standard.

l) PCU shall have communication facility and all the data related to metering, operating status, faults etc. shall be hooked up to Data monitoring system.

m) PCU Operational Requirements:

i. The PCU inverter shall be designed such that it follows grid voltage & frequency and shall operate without any problem for normal fluctuations of grid voltage & frequency. The PCU shall be suitable for synchronizing with grid supply voltage variation range of +12.5%, -20% and frequency variation range ±3%. PCU inverter shall follow grid frequency up to ±3Hz of the normal output frequency.

ii. The PCU shall be provided with auto wake up feature such that PCU inverter shall be able to wake up when the available power from the PV array is more than the total loss of the inverter system. As the available power from the PV array changes with weather condition, the wake up algorithm shall be adaptive in nature.

iii. The PCU shall be able to synchronize AC output with the grid power supply and shall close output contactor/ breaker when the synchronization parameters (voltage difference, frequency difference and phase angle difference) are complied.

iv. The power control scheme of the PCU shall follow the maximum output from the PV array determined by the level of solar radiation on the DC side and shall employ maximum power point tracking (MPPT) control capable of constantly obtaining the maximum energy from the array according to the quantity of solar radiation and temperature.

v. As the PCU shall be operating in parallel with the grid power supply, it shall be capable of interrupting line-line fault currents and line-to earth fault currents.

vi. The PCU shall have following modes of operation:
- Standby mode – The PCU shall operate in this mode when PV array does not have enough power capacity to maintain PCU inverter losses or PCU has responded to a fault condition and fault condition has been cleared. In this mode PCU shall remain idle, disconnected from PV array as well as from grid. The inverter shall remain in this mode until PV array voltage exceeds wake up value and enter into system wake up test mode.
- Wake up test mode – After PV array voltage exceeds wake up value, the PCU control system shall continuously monitor PV array voltage for certain duration before making transition to power tracking mode. If the PV array voltage drops below wake up value during test duration, PCU shall enter into standby mode.
- Power tracking mode – This shall be main operating mode of the PCU under normal operating condition. In this mode maximum power point tracking algorithm shall be functional which shall extract maximum power from PV array under varied conditions of solar irradiance and temperature.
- Sleep mode – Whenever PCU output power drops below certain threshold limit, PCU enters into sleep mode and wait for certain duration. Within this duration if PCU output power exceeds threshold limit, PCU re-enters into power tracking mode, otherwise PCU goes into standby mode.
- Shutdown mode – The PCU shall operate in this mode whenever fault conditions will be responded. The PCU shall disconnect itself from PV array as well as from grid.

n) PCU Protective functions

i. The PCU shall be provided with anti-islanding control and protection such that in case of grid supply failure, PCU shall stop exporting power to the grid/ power system.

ii. The PCU shall be able to sense the following situations and accordingly shutdown & disconnect itself from the grid as well as from PV array:
- Grid power supply over voltage & under voltage,
- Grid power supply over frequency & under frequency.
- AC over current & earth fault
- Protection against islanding.
- Loss of any phase of the grid power supply.
- DC bus overvoltage & under voltage
- DC bus over current & earth fault
- Device over temperature/ system temperature rise, heat sink over temperature
- Short circuit
- Array earth fault detection

iii. The PCU shall sense reverse polarity of DC connection, provide warning and shall remain in standby mode.

iv. The PCU shall be provided with surge arrester (metal oxide varistor) both at AC and DC side to protect the system from lightning & switching surges.

v. Cooling system shall include adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled PCU, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the PCU panels for these fans. In case, redundant cooling fan is not possible to be mounted, same shall be supplied loose. Fans shall be equipped with monitoring facilities to provide an alarm/ indication in the event of fan failure.

vi. A suitably sized earth bus shall be provided at the bottom of the panels with provision for earth connection at both ends to main earth grid. The minimum size of earth bus shall be 25 x 3 mm² Copper (or equivalent Aluminium). All potential free metallic parts of various equipments shall be earthed suitably to ensure safety.

o) Maximum noise level from PCU at 1 meter distance, under rated load condition with all normal cooling fans shall not exceed 75 dBA.

p) The PCU shall be housed in sheet steel panel. The panel shall be fabricated from structural / CRCA sheet steel. The panel shall be free standing floor mounted or wall mounted type as per job specification/data sheet, fitted with suitable lovers for ventilation and cooling fans as required. Dust tight gaskets shall be provided. The enclosure shall provide minimum IP-31 degree of protection for indoor panel and IP-65 for outdoor panel. Canopy shall be provided for outdoor PCU.

q) The PCU shall be located indoor or outdoor as specified in the job specification/data sheet.

r) The PCU/ inverter should have been tested from the MNRE approved test centers / NABL/ BIS/ IEC accredited testing – calibration laboratories. In case of imported PCU, these should have been approved by international test houses.

s) The PCU shall comply with applicable IEC/ equivalent BIS standards for efficiency measurements and environment test.

6.3 ACDB (AC Distribution Board)

a) The AC power output of all the inverters shall be fed into the ACDBs (one or multiple number of ACDBs as per requirement and job specification/ SLD).

b) ACDB shall be floor mounted or wall mounted type as specified in the job specification/ data sheet and compartmentalized. The minimum IP-31 degree of protection shall be provided for indoor ACDB and IP-65 for outdoor ACDB. Canopy shall be provided for outdoor ACDB.

c) ACDB shall have required number of feeders for connecting with all the inverters in the SPV system plus 10% additional spare feeders (minimum of 1 no. of each type and rating). All inverters of the PV system shall be connected to ACDB of that system i.e., AC power generated from all inverters shall be combined in ACDBs and combined power from each ACDB shall be fed to the substation / building switchboard.

d) All incoming feeders (from PCU) and outgoing feeder (to substation / building switchboard) shall be provided with MCCB. The MCCB shall be microprocessor based with over-current, short circuit & earth fault protection with shunt trip facility. MCCBs shall be 4 pole type.

e) Outgoing feeder feeding the substation / building switchboard shall have analogue ammeter, voltmeter and integrated Digital Multi-function Meter which includes energy

meter. The Digital Multi-function meter including energy meter shall have communication facility and same shall be hooked up to data monitoring system. Digital Multi-function meter along with CT/VT shall be of accuracy class 0.5.

f) Fault level of ACDB shall be same as that of 415V switchboard in substation/ building electrical system at which the power is to be integrated.

g) Continuous current Rating of the ACDB shall be as per maximum installed capacity of the PV system (AC inverter maximum ratings or DC installed power KWp whichever is higher) and 10% higher/ spare rating.

h) The ACDB shall be located indoor or outdoor as specified in the job specification/data sheet

6.4 **Junction Box (AJB/ MJB/ DCJB)**

a) The Junction Boxes (JBs) shall be made of GRP/FRP/Powder coated Aluminum/ cast aluminum alloy / GI enclosure having Ingress Protection class of IP-65 with adequately sized screwed / screw-less terminals inside and also with full dust, water & vermin proof arrangement.

b) The terminals shall be connected to bus-bar arrangement of proper sizes as required. The junction boxes shall have suitable cable entries fitted with cable glands/ lugs/MC4 connectors of appropriate sizes for both incoming and outgoing cables. All wires/cables must be terminated through cable lugs/ suitable PV system DC connectors. Suitable markings shall be provided on the bus-bars for easy identification and cable ferrules shall be fitted at the cable termination points for identification

c) The junction boxes shall be suitable for solar PV system application and also applicable IS/ IEC codes and MNRE recommendations/ requirement.

d) Copper bus bars/terminal blocks housed in the junction box shall be with suitable termination threads conforming to IP65 standard and door/cover with EPDM rubber gasket to prevent water entry. Provision of earthing shall be provided in junction boxes.

e) The Array Junction Box shall have high quality suitable capacity metal oxide varistors (MOVs) / SPDs and suitable Reverse Blocking Diodes. The Array Junction box shall also have suitable surge protection. The Junction Boxes shall have suitable arrangement for the following.

i. Provide arrangement for disconnection for each of the groups.

ii. Combine groups of modules into independent charging sub-arrays that shall be wired into the controller.

iii. Provide a test point for each sub-group for quick fault location

iv. To provide group array isolation.

v. The current carrying ratings of the junction boxes shall be suitable with adequate safety factor to inter connect the solar PV array.

f) As far as possible, JBs shall be placed at 1.5 meters height or above for ease of accessibility.

6.5 **Data Acquisition and Plant Monitoring System**

a) The Data Acquisition & Monitoring System shall cover the complete solar PV system. One set of weather monitoring instruments shall be provided unless otherwise specified. The data monitoring system & data loggers of the PV system shall be suitable for integration with weather monitoring instruments.

b) The data acquisition, monitoring & data logging system shall provide facility for plant monitoring, fault analysis, time & date stamped system data logs for analysis with suitable laptop/ desk top computer and shall allow visualization, monitoring,

commissioning and service of the SPV system. Metering and instrumentation for display of systems parameters and status indication shall be provided. The data monitoring system/ data-logger shall have the provision of interface of complete data through MODBUS TCP/IP protocol with RJ45 port or any other protocol as defined in Job Specification/ datasheet. Data monitoring software for data analysis shall be provided.

c) The data acquisition, monitoring & logging system shall be either web based or interconnected with the owner's substation automation system as defined in the job specification/ data sheet.

d) For web based system, it shall be possible to access the data logger with any standard web browser and relevant software/hardware required shall be supplied by contractor for monitoring & data downloading. In addition to web portal, it shall be possible to retrieve data directly from data acquisition & monitoring system. Complete data of monitoring system as per this specification including all inverters, weather monitoring systems, Digital Multi-function meter in ACDBs etc. shall be accessible and downloadable from the data monitoring software via internet/ web access in laptop / desktop computer with required authentication.

e) For substation automation interconnected system, the SPV data monitoring system/ data-loggers shall be connected to the owner's Data Concentrator / Ethernet Switches or Owner's SCADA or ECS RTU located in the substation as mentioned in the Job Specification/ data sheet. In this regard all necessary provisions shall be considered in the data monitoring & data logger system by contractor. Complete data related to data monitoring system including all inverters, weather monitoring systems, Digital Multi-function meters (including energy meter) in ACDBs etc. shall be available in the substation data concentrator /HMI. Cables for interconnection up to data concentrator/ Ethernet switches shall be provided by the contractor.

f) Weather Monitoring Instruments as per the following shall be provided:

   i. Solar Irradiance: An integrating Pyranometer / Solar cell based irradiation sensor (along with calibration certificate) shall be provided, with the sensor mounted in the plane of the array. Readout shall be integrated with the data logging system.

   ii. Temperature: RTD type thermometer and Temperature probes for recording the Solar panel temperature, module back surface temperature and ambient temperature shall be provided complete with readouts integrated with the data logging system.

   iii. Anemometer: For wind speed measurement, anemometer shall be provided (along with calibration certificate) complete with readouts integrated with the data logging system.

g) The following parameters shall be accessible via the operating interface display in real time for solar power system:

   i. DC power input

   ii. DC Input Voltage

   iii. DC Input Current

   iv. AC Voltage

   v. AC Output current

   vi. AC Output Power

   vii. Power factor

   viii. Time Active

   ix. Time disabled

   x. Time Idle

xi. Power produced

xii. Operating modes

xiii. Inverter status

xiv. Fault indications

xv. Protective function limits i.e. AC Over voltage, AC Under voltage, Over frequency, Under frequency, Earth fault, PV starting voltage, PV stopping voltage etc.

xvi. Data from weather monitoring instruments –Solar irradiance daily & per month based on instantaneous irradiance readings (kWh/m2/month), Daily and monthly average ambient temperature based on instantaneous temperature readings near array field, Module back surface temperature, Wind speed at the level of array plane

xvii. Solar Energy generation data from all Digital Multi-function meter (energy meter) in ACDBs.

h) All major parameters on the digital bus and logging facility (the current values, previous values for up to a month and the average values) shall be available for energy auditing through the internal microprocessor and should be read on the digital front panel.

i) PV array energy production: Digital Multi-function meter shall log the actual values of AC voltage, Current & Energy generated by the PV system. Digital Multi-function meter shall be connected with data logger of the PV system to have interface of complete data through MODBUS TCP/IP protocol with RJ45 port or any other protocol as defined in Job Specification/ datasheet. Guaranteed energy productions values shall be measured in digital Multi-function meter (Energy meter) mounted on ACDBs. Hence, the historical & instantaneous data of Digital Multi-function meter shall be available at data logger & monitoring system.

j) DC String/Array monitoring and AC output monitoring shall be provided as part of the inverter and/or string/array combiner box or separately.

k) String and array DC Voltage, Current and Power, Inverter AC output voltage and current (All 3 phases and lines), AC power (Active, Reactive and Apparent), Power Factor and AC energy (All 3 phases and cumulative) and frequency shall be monitored as a minimum.

l) All instantaneous data shall be shown on the computer screen.

m) Software shall be provided for USB download and analysis of DC and AC parametric data for the system.

n) If specified in the job specification/data sheet, complete SCADA system including server, software etc. for centralized monitoring system shall also be provided for storage, download and analysis of cumulative data of various solar systems and the data of the solar radiation & temperature monitoring system.

o) Simultaneous monitoring of DC and AC electrical voltage, current, power, energy and other data of the system for correlation with solar and environment data shall be provided.

p) The data acquisition & monitoring software shall also be installed by contractor in owner's laptop/desk top computer during testing and commissioning of PV system at site. One set of original software in CDs/DVDs/removable media shall be also provided by contractor which shall be handed over to owner after commissioning of the system.

q) The system data shall be secured from all any kind of breach. All data loggers shall be suitable to be connected with any local laptop for data monitoring and downloading of data shall be possible with a laptop.

6.6 **Cables**

All power, control, signal, communication, LAN, Fibre Optic (FO) cable, DC cables as required for the SPV system shall be provided by the Contractor. Further AC Power and control cables from PCU to ACDB and from ACDB to substation / building Electrical system MV switchboard for power supply hook up shall be provided by Contractor.

a) Cable Design Criteria

i. Sizes of cables between string interconnections, array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum. The cables shall be as per relevant IS codes and shall be insulated with a special grade XLPE/ XLPO compound formulated for outdoor use.

ii. The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 2%.

iii. The total voltage drop on the AC cable segments from the solar inverter to the ACDB shall not exceed 0.5% for PV systems located nearby to the ACDB where ACDB is located in the same building. The total voltage drop on the cable segments from the solar inverter to the ACDB shall not exceed 2.0% for PV systems located away from the ACDB where ACDB is not located in the same building.

iv. Cable sizing document shall be submitted by contractor for review to EIL/ Owner based on the voltage drop, other sizing criteria as per the requirement. The final cable sizes shall be decided during detailed engineering based on the approved cable sizing document. Contractor to ensure that all equipments shall be suitable for termination of the required cable sizes.

b) DC Cables & connectors

i. The voltage grade of the DC cables used shall be suitable for the solar system maximum DC system voltage continuously.

ii. DC cables shall be single core flexible copper conductor type with excellent resistance to heat, cold, water, oil, abrasion, UV-stabilized, halogen free, flame retardant low smoke, low toxicity, XLPE or XLPO insulated and sheathed. Multi-core cables shall not be used.

iii. DC cables shall be suitable for rated DC voltage of 1.5KV and maximum DC voltage of 1.8KV.

iv. The Cable should be so selected that these should be compatible to the full life time of the solar PV panels i.e. 25 years. The inner & outer sheath shall pass UV protection for 25 years.

v. The DC cables from the SPV module array shall run through a UV-stabilized PVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5mm.

vi. Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors and couplers.

vii. Minimum DC cable size shall be 4.0 sq. mm copper.

c) AC Cables

i. MV Power Cables shall conform to EIL standard specification no. 6-51-0051 and datasheet for MV cables.

ii. Control cables shall be copper conductor, twisted pair, overall shielded type and conform to EIL standard specification 6-51-0052. However, Cl. 5.0 of EIL specification 6-51-0052 is not applicable for control cables.

iii. All power cables & control cables for use on medium voltage systems shall be 650/1100V grade, XLPE/ PVC insulated, extruded inner-sheathed, armoured and overall PVC sheathed, FRLS type.

iv. All MV power cables 2.5 sq.mm to 16 sq.mm shall be with copper conductor and above 16 sq.mm shall be with either aluminium or copper conductor. In three phase systems, the size of the neutral wire shall be equal to the size of the phase wires.

6.7 Module/ Array Mounting Structure

a) Unless otherwise specified, mounting structures shall be made of hot dipped galvanized mild steel (MS).

b) The mounting structures shall be designed to sustain wind loading applicable as per the wind zone & also as per wind speed mentioned elsewhere. The entire structure including array shall be earthed to an independent earth pit with redundant paths. Mounting structures shall be with fixed tilt.

c) Each structure shall have angle of inclination as per site conditions to take maximum insolation for annual energy output. The array structure shall be so designed that it will occupy minimum space without sacrificing the SPV panels output and allows easy replacement.

d) Suitable fastening arrangement such as grouting and calming shall be provided to secure the installation against the specific wind speed.

e) Each Panel frame structure shall be so fabricated as to be fixed on the floor of roof top. The height of the frame shall be so decided to avoid shadows from building structure subject to minimum 500 mm above rooftop level unless otherwise specified.

f) The Contractor shall specify installation details of the PV modules and the support structures with appropriate diagrams and drawings. Such details shall include, but not limited to the following;

i. Determination of true south at the site

ii. Array tilt angle to the horizontal, with permitted tolerance

iii. Details with drawings for fixing the modules

iv. Details with drawings of fixing the junction/terminal boxes

v. Structure installation details and drawings

vi. Inter-panel/Inter-row distances with allowed tolerances

vii. Safety precautions to be taken

The array structure shall support SPV modules at a given orientation and shall absorb & transfer the mechanical loads to the rooftop columns properly. While deciding civil foundation & structure required for the SPV system, the load bearing capacity of roof shall be considered by contractor.

7.0 CABLING, EARTHING & LIGHTNING / SURGE PROTECTION

7.1 Cabling System

Cabling system shall conform to the following requirements: -

a) Within building area, the cables shall be laid in GI cable trays. Further in case cable trenches are available in the SPV system cable routes, power and control cables can be laid in cable trenches also.

b) GI cable trays, conduits, pipes, sleeves, cable accessories, cable lugs, ferrules etc. for cable laying shall be provided.

c) Above ground cables shall be well supported on cable trays and suitably protected against mechanical damage.

d) Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer.

e) Signal cables e.g. communication, LAN and data highway cables etc. shall preferably not be laid in the same trench/ tray along with electrical cables. FO cables if any shall be laid in the HDPE pipe conduit.

f) Cable/wires shall be routed in GI cable trays and shall be suitably tagged & marked with ferule or by other means so that the cables are easily identified. On routes where cables are few, cables & conduit pipes can be directly clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm.

g) Top most cable trays and vertical cable trays shall be provided with GI sheet covers.

7.2 Earthing System

a) The earthing for array and power system shall be provided as per provisions of IS -3043 and CEA guidelines. The earthing system shall comprise of equipment earthing connections, main earthing grid along with suitably located earth plates to provide multiple earth connections and earth electrodes in test pits. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.

b) Each Array structure of the SPV shall be earthed. The entire structure including array shall be earthed to an independent earth pit with redundant paths.

c) The system neutral, current & potential transformer secondary neutral, metallic non-current carrying parts of all electrical equipment i.e. PV arrays, mounting structures, JBs, PCU, ACDB and cable shields & armour shall be earthed.

d) The complete earthing system shall be mechanically & electrically connected to provide independent return to earth. All the electrical equipment operating above 250 V shall have two separate and distinct connections to earth grid.

e) All non-current carrying metal parts shall be earthed with two separate and distinct earth conductors to the nearest earth grid. All earth connections shall be visible for inspection.

f) The resistance values of the earthing system shall not exceed 1 ohm.

7.3 Lightning & Over Voltage/ Surge Protection

a) The SPV system shall be provided with lightning and over voltage/ surge protection connected to earth pits. The source of over voltage can be due to lightning / atmospheric disturbance and/or switching surge. The main aim of over voltage protection shall be to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system components. The entire space occupying the SPV array shall be suitably protected against lightning by deploying required number of lightning arrestors. Necessary concrete foundation for holding the lightning conductor in position shall be provided after giving due consideration to maximum wind speed and maintenance requirement at site.

b) The Lightning conductor shall be earthed through flats and connected to earth pits as per applicable Indian Standards. Each Lightning arrestor shall be fitted with individual earth pit as required.

c) Contractor shall ensure adequate lightning protection to provide an acceptable degree of protection as per IS/ IEC for the complete system including array. For lightning protection, the value of 5 ohms as earth resistance shall be ensured.

d) The protection against induced high voltages shall be provided by the use of Metal oxide varistors (MOVs) with suitable earthing such that induced transients find an alternate route to earth.

e) The lightning protection of Solar PV system shall also comply to the requirement of NBC 2016.

f) Air Terminals may be installed at physical distance from PV mounting structures or mounted directly on the PV module structure at strategic locations to bring the complete area under zone of protection. The height of vertical air terminals shall be calculated such that there is no or minimum influence of shadow on the PV modules (as per NBC 2016). The quantities of vertical air terminals shall be determined such as to bring the entire PV installation under protection zone.

g) Surge Protection

The internal surge protection shall consist of three MOV type surge arrestors connected from +ve and –ve terminals to earth (via Y arrangement) suitable for higher withstand of the continuous PV-DC voltage during earth fault condition.

8.0 SHOP INSPECTION & TESTING

a) All electrical equipment including PV modules, PCU, JBs, data logging system, cables, material etc. shall be thoroughly inspected and tested at the manufacturer's works in accordance with approved inspection & test plans. Contractor shall prepare and furnish the inspection & test plans for EIL/owner approval. The type test certificates for the equipment shall be available; in case of non-availability of type test certificates, fresh testing of the equipment in accordance with applicable codes & standards shall be done. All routine & acceptance test as per the applicable standards shall be conducted on the equipment.

b) EIL/ Owner may witness all factory tests. EIL/ Owner shall have entry and access at any time to all parts of manufacturer's facilities associated with manufacturing and testing of the system.

c) Contractor shall invite EIL/ Owner well in advance of the date at which the system is ready for testing.

d) Before dispatch of equipment from manufacturers work, Contractor shall prepare inspection report for individual equipment and same shall be submitted along with test certificates for EIL/Owner review and release note.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', Owner's particulars, Purchase order number etc., shall be clearly marked on the package together with other details as per Purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature. In order to prevent movement of equipment within the crates, proper packing supports shall be provided. A set of instruction manuals for erection, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover and supplied along with the shipment.

10.0 FIELD INSPECTION, TESTING & COMMISSIONING

a) Site inspection, testing and commissioning of electrical installation shall be carried out as per EIL Standard Specification no. 6-51-0087.

b) All the equipment installed by the Contractor shall be tested and commissioned.

c) Any work not conforming to the execution drawings, specifications or codes shall be rejected forthwith and the Contractor shall carry out the rectification.

d) The Contractor shall carry out all the field tests as enumerated in the technical specification & technical documents which may be furnished to him during execution of the work.

e) Before the SPV system is made live, the Contractor shall carry out suitable tests to establish to the satisfaction of Engineer-in-Charge/Owner that the installation of equipment, wiring and connections have been correctly done and are in good working condition and that it will operate as intended.

f) All field tests shall be conducted in the presence of Owner/Engineer-in-Charge or his authorized representative unless he waives this requirement in writing. All testing equipment necessary to carry out the tests at site shall be arranged by the Contractor. The tests shall be recorded on approved Performa and certified records of the tests shall be submitted to Owner/Engineer-in-Charge.

g) After the completion of all tests and rectification of all defects pointed out during final inspection, system start-up trial would be commenced. Any defects noticed during the start-up trial relating to the equipment supplied and work carried out by the Contractor, will be rectified by the Contractor.

10.2 **Site Acceptance Test (SAT)**

a) Contractor shall prepare SAT documentation covering power distribution system in the plant & system functional testing and submit it for EIL/Owner review and approval. Site Acceptance Test shall be done based on the stipulation in the approved SAT document. Once the test is successfully performed, the temporary acceptance of the system shall be given. Only then the system would be ready for test run.

b) Contractor shall offer fully functional system for SAT when he has successfully commissioned all equipment, carried out all pre SAT and submitted the reports.

11.0 WARRANTY

11.1 The mechanical structures, electrical works & equipments including power conditioners/ inverters/ maximum power point tracker units/ distribution boards/ digital meters/ switchgear etc. and overall workmanship of the grid connected solar photovoltaic plant shall be warranted against any manufacturing/ design/ installation defects during the warranty period.

11.2 Contractor shall be fully responsible in respect of proper design, manufacture, quality workmanship and operation of all the equipment, accessories etc. supplied by the Contractor for the warranty period.

11.3 It shall be obligatory on the part of Contractor to modify and/or replace any equipment/component free of cost in case any malfunction is revealed even during on line operation after taking over within the warranty period.

11.4 **Performance Warranty:**

The predicted electrical degradation of power generated not exceeding 20% of the minimum rated power over the 25 year period and not more than 10% after ten years period of the full rated original output.

उच्च वोल्टेज इंडक्शन मोटरों के लिए विनिर्देश

SPECIFICATION FOR HIGH VOLTAGE INDUCTION MOTORS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor / Approved by	Standards Bureau Chairman
6	26 12 18	REVISED AND ISSUED AS STANDARD SPECIFICATION	RKR	VKJ	BRB	RKT
5	20 11 13	REVISED AND ISSUED AS STANDARD SPECIFICATION	SA	BRB	UAP/JMS	SC
4	26 09 07	REVISED AND ISSUED AS STANDARD SPECIFICATION	SD	BRB	JMS	VC
3	09 04 02	REVISED AND RE-ISSUED	UG	AAN	VPS	SKG
2	01 02 97	REVISED AND ISSUED AS STANDARD SPECIFICATION	AAN	VPS	SG	AS

Abbreviations:

BIS	Bureau of Indian Standard
BS	British Standards
CEA	Central Electricity authority
CIMFR	Central Institute of Mines and Fuel Research
CT	Current Transformer
DOL	Direct On Line
EIL	Engineers India Limited
FM	Factory Mutual
FRP	Fiberglass Reinforced Plastic
IEC	International Electro-technical Commission
IEEE	Institute of Electrical & Electronics Engineers
IS	Indian Standard
JEC	Japanese Electro-technical Committee
LCIE	Laboratoire Central des Industries Electriques
LRWT	Locked Rotor Withstand Time
NEMA	National Electrical Manufacturers Association
OEM	Original Equipment manufacturer
PESO	Petroleum & Explosives safety organisation
PO	Purchase Order
PVC	Poly Vinyl Chloride
p.u.	per unit
RPM	Revolutions per Minute
r.m.s	Root Mean Square
TPIA	Third party Inspection Agency
TETV	Totally enclosed Tube Ventilated
UL	Underwriter's Laboratories
VDE	Verband Deutscher Elektrotechniker
VFD	Variable Frequency drive

CONTENTS

1.0 SCOPE

This specification covers the design, manufacture, testing, packing and supply of high voltage squirrel cage induction motors.

2.0 CODES AND STANDARDS

2.1 The squirrel cage induction motors and their components shall comply with the latest editions of following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified:

IS - 5	Colours for ready mixed paints and enamels
IS - 1271	Electrical insulation - Thermal evaluation & Designation
IS - 2071	Methods of high voltage testing
IS - 2253	Designation for type & construction and mounting arrangement of rotating electrical machines
IS - 2968	Dimensions of slide rails for electrical motors
IS - 4029	Guide for testing of three phase induction motors
IS - 4889	Method of determination of efficiency of rotating electrical machines
IS - 6362	Designation of methods of cooling of rotating electrical machines
IS - 7816	Guide for testing insulation resistance of rotating machines
IS - 8223	Dimensions and output series for rotating electrical machines
IS – 8789	Values of performance characteristics for three phase induction motors
IS - 12065	Permissible limits of noise level for rotating Electrical Machines
IS - 12075	Mechanical vibration of Rotating Electrical Machines with shaft heights 56 mm and higher measurement, evaluation and limits of vibration severity
IS - 13529	Guide on effects of unbalanced voltages on the performance of three phase induction motors
IS - 13555	Guide for selection and application of three phase induction motors for different types of driven equipments
IS - 14222	Impulse voltage withstands levels of rotating electrical machines with form-wound stator coils
IS - 14568	Dimension and output series for rotating electrical machines, frame numbers 355 to 1000 and flange numbers 1180 to 2360
IS / IEC60079-0	Electrical apparatus for explosive gas atmospheres (General Requirements)
IS/IEC60079-1	Equipment protection by Flame proof enclosures "d".
IS/IEC60079-2	Explosive protection by pressurized enclosure "p"
IS/IEC60079-7	Explosive atmospheres-Equipment protection by increased safety –"e"
IS/IEC60079-15	Explosive atmospheres-Equipment protection by type of protection "n"
IS/ IEC: 60529	Degree of protection provided by enclosures (IP Code)
IS/IEC-60034-1	Rotating Electrical machines Rating & Performance.
IS/IEC-60034-5	Degrees of protection provided by enclosure for rotating electrical machinery.

IS/IEC 60034-8: Terminat marking and direction of rotation for rotating electrical machinery.

IEEE-386 : Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V

2.2 In case of imported motors, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian Standards.

2.3 The motors shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case Indian Standards are not available, standards issued by IEC/BS/VDE/IEEE/JEC/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents, the most stringent one shall prevail. However, owner's decision in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 OPERATING CONDITIONS

4.1 Ambient Conditions

Motors shall be suitable for operating satisfactorily in humid and corrosive atmospheres found in refineries, fertilizer, petrochemical and metallurgical plants. Service conditions shall be as specified in the motor data sheet. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000 meters above mean sea level shall be taken into consideration.

4.2 Frequency and Voltage variations.

Unless otherwise agreed, motors shall be designed for continuous operation at rated output under the following conditions:

a) The terminal voltage differing from its rated value by not more than ± 6 %
b) The frequency differing from its rated value by not more than ± 3 %
c) Any combination of (a) and (b)

4.3 Starting

a) Motors shall be designed for direct on line starting or other method of starting as specified in datasheet.

b) Motors shall be designed for re-acceleration with full load after a momentary loss of voltage, not exceeding 0.2 seconds, with the possibility of application of 100% of the rated voltage when the residual voltage has dropped down to 50% and is in phase opposition to the applied voltage.

c) Motors shall be designed to allow the minimum number of starts on full load indicated in Table below:-

Min. Number of starts	Up to 1000 KW	Above 1000 KW
No. of consecutive start-ups with initial temperature of the motor at ambient level (cold.)	3	2
No. of consecutive start-ups with initial temperature of the motor at full load operating level (hot)	2	1

d) Unless otherwise specified, the locked rotor withstand time under hot condition at 100% voltage (time t_E for increased safety i.e. Ex e motor) shall be minimum 5 seconds more than the starting time at 100 % voltage, under specified load conditions.

4.4 Unless otherwise stated in the motor data sheet, motors shall be suitable for starting at 80% of the rated voltage against the torque speed characteristics of the driven equipment.

a) Starting torque and minimum torque of the motor shall be compatible with the speed torque characteristics of the driven equipment under specified starting and operating conditions.

b) For heavy duty drives such as blowers, crushers, compressors etc., high starting torque motors shall be provided.

This shall be checked against the speed torque characteristics of the load and the thermal withstand characteristics of the motors.

4.5 The pull out torque at rated voltage shall be not less than 175 percent of the rated load torque with no negative tolerance. In case of motors driving equipments with pulsating loads (e.g. reciprocating compressors), the minimum value of the pull out torque at 80% of rated voltage shall be more than the peak value of the pulsating torque and the current pulsation shall be limited to 40%.

Unless otherwise agreed, the pull out torque shall not exceed 300% of the rated load torque.

4.6 Direction of rotation

Motors shall preferably be suitable for either direction of rotation. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. Any alteration required for obtaining a change in the direction of rotation such as reversal of the fan, must be clearly specified. Motors which are suitable for only one direction of rotation shall have this direction of rotation clearly indicated on the motor together with the phase sequence of the terminals associated with this rotation in indelible marking. Motors suitable for bi-directional rotation shall be provided with a double headed arrow. Directional arrow should be manufactured from corrosion resistant material.

Normally, clockwise rotation is desired as observed from the driving (coupling) end, when the terminals ABC are connected to a supply giving a terminal phase sequence in the order ABC. Counter clockwise rotation of the motor shall be obtained by connecting the supply to terminals so that the phase sequence corresponds to the reversed alphabetical sequence of the terminal letters. Ample space shall be provided at the terminal box for interchanging external leads C and A for this purpose.

5.0 PERFORMANCE

5.1 Motors shall be rated for continuous duty (S_1), unless otherwise specified.

5.2 Motors shall have adequate torque to accelerate the load from zero to full speed under the specified starting and operating conditions.

5.3 Starting current shall be 500% subject to IS/IEC tolerance for motors up to 1000 kW. For motors above 1000 kW, it shall be as agreed with purchaser for each case.

5.4 In particular cases, when the starting current is to be limited, care shall be taken such that the design values of torque meets the load requirement while at the same time complying with clause 4.3 above of this specification.

5.5 In particular cases, when the starting with reduced voltage is specified, care shall be taken such that the design values of torque meets the load requirement while at the same time complying with clause 4.4 and 4.5 above of this specification.

5.6 Motors fed by variable frequency drive shall additionally meet the following requirements:

5.6.1 The motors shall be suitable for the current wave forms produced by the power supply including harmonics generated by the drive.

5.6.2 The motors shall be designed to operate continuously at any speed over the range (10–100%) of rated speed or as specified in data sheet. The characteristics shall be based on the application – in terms of constant torque / variable torque as per the driven equipment. Additional cooling fan shall be provided if required to limit the temperature rise to specified limits.

5.6.3 The motors shall withstand torque pulsation resulting from harmonics generated by the solid state power supply.

5.6.4 The motors required to be transferred to DOL bypass mode shall be rated for specified variations in line voltage and frequency.

6.0 CONSTRUCTION DETAILS

6.1 Windings

6.1.1 Motors shall be provided with class-F insulation. The permissible temperature rise above the specified ambient temperature shall be limited to those specified in the applicable Indian Standards for class-B insulation.

6.1.2 The windings, along with the stator, shall be tropicalised and shall be vacuum impregnated (resin poor type).
Winding shall be adequately braced to prevent any relative movement during operation. In this respect, special care shall be taken for the stator windings of direct-on-line starting squirrel cage motors. Insulation shall be provided between coils of different phases which lie together.

6.1.3 Core laminations must be capable of withstanding burnout for rewind at 350°C without damage or loosening.

In case of motors driving equipment with pulsating loads, special attention shall be paid to the joints of rotor bars and end rings to avoid premature failures due to induced fatigue stresses.

For Ex n and Ex e motors, the conductor insulation must be carried right up to the terminal clamp.

6.1.4 Motors shall be designed to withstand impulse voltages specified in applicable Indian Standards/relevant IEC. The wave shape shall be as per IS/relevant IEC.

6.1.5 Windings of motors shall be star connected. For VFD fed motors, the main winding connected in 'Delta' can also be considered acceptable subject to motor manufacturer having adequate proven track record.

6.2 Terminals, terminal boxes and cable entries

6.2.1 The ends of the winding shall be brought out into a terminal box. The terminations shall be by means of clamp type or bushings with adequately sized bolted terminals. Line terminals shall be properly insulated from the frame with material resistant to tracking.

6.2.2 The terminal box shall be located on the right hand side viewed from the driving (coupling) end. Unless otherwise specified, the terminal box shall be suitable for side cable entry. The size of the cable end boxes shall be large enough to provide a minimum distance of 600 mm between cable gland plate and terminal lug.

6.2.3 The neutral point of the star windings shall also be brought out to a separate terminal box. This shall house the current transformers for differential protection of motors wherever required and shall be located on the opposite side of main terminal box.

6.2.4 The main and neutral terminal box shall be of fabricated sheet steel. The main terminal box shall be phase segregated type, unless otherwise agreed. However for Non sparking motors phase insulated type terminal box is also acceptable.

Motors can have elastimold phase insulated terminals in a common box. Ex d type (flame proof) motors can have phase insulated terminal box of Exd rating whereas Ex p type (pressurized) motors can have phase insulated terminal box of Ex d/Ex p rating.

Ex d (Flameproof) motors with non phase segregated & non phase insulated flameproof terminal box duly tested at independent test laboratory can be considered acceptable subject to motor manufacturer having adequate proven track record.

6.2.5 The terminal box must be of robust construction, with necessary clearance, creepage distances between live parts and between live parts to earth considering air insulation and without any compound filling.

6.2.6 The terminal box shall be provided with pressure relief flaps/devices for increased safety i.e. Ex e motors, non-sparking i.e. Ex n motors and safe area motors, as per manufacturer's standard.

6.2.7 The terminal box shall be capable of withstanding the fault current for a period of 0.2 seconds specified in the motor data sheet. For phase insulated elastimould terminations, the short time current rating and duration shall be as per IEEE:386-2006.

6.2.8 Appropriate phase markings as per IS/IEC shall be provided inside the terminal box. The markings shall be non-removable and indelible.

6.2.9 The terminal box shall be provided with suitably sized entries for suitable cable glands corresponding to the size of the specified cables. For termination of multi run of power cables, more than one terminal box is not acceptable.

Equipment and accessories provided shall conform to the hazardous area classification and the environmental conditions as specified in the motor data sheet.

6.2.10 An adequately sized earth terminal shall be provided for cable armour termination. It is essential that all metal parts (mounting rail and cable glands) are bonded and connected to the earth system. Bonding straps are also required across joints on non-active parts.

6.2.11 Separate terminal boxes shall be provided for space heaters, resistance temperature detectors and vibration probes.

6.2.12 Main and neutral terminal box covers must be provided with handles to facilitate easy removal. Terminal boxes covers having weight up to 5kg can be accepted without handles.

6.3 Motor casing and type of enclosure

6.3.1 All Motors shall be suitable for installation directly outdoor and must have degree of protection corresponding to IP-55 as per IS.

6.3.2 All internal and external metallic parts, which can come into contact with cooling air (Piping, air supply and discharge conduits, protective grills air deflectors, filters and supports etc.) shall be of corrosion resistant material or appropriately treated to resist corrosive agents which may be present in the atmosphere. Screws and bolts shall be of rust proof material or protected against corrosion.

6.3.3 Effective equipotential bonding straps to guard against the occurrence of sparks due to presence of circulating currents shall be provided in type Ex n, Ex e and Ex p motors.

6.4 Bearing and lubrication

6.4.1 Motors shall have grease lubricated ball or roller type bearings or of the manufacturer's standard type. However, 2 pole motors above 750 kW rating shall be provided with sleeve bearings as a minimum, except for motors intended to be installed in hazardous area having gas group IIC. Sleeve bearings when provided shall be of proven design.

6.4.2 The bearings shall be chosen to give a minimum L- 10 rating life of 5 yrs. (40,000 hrs) at rated operating conditions.

(The L -10 rating life is the number of hours at constant speed that 90 % of a group of identical bearings will complete or exceed before the first evidence of the failure).

6.4.3 Where bearing supports are attached to the motor casing, adequate bracing shall be provided on these supports to reduce vibrations and ensure long life of the bearings. Bearings shall be adequate to absorb axial thrust in either direction produced by the motor itself or due to shaft expansion.

6.4.4 Motor bearings exposed to high temperatures (e.g. motors for hot oil/boiler feed pumps) shall have adequate provisions for cooling of bearings.

6.4.5 Vertical motors shall be provided with angular contact/thrust bearings suitable for the load imposed by the driven equipment.

6.4.6 Motors shall be designed to permit removing/replacement of bearings.

6.4.7 **Grease lubricated bearings**

Bearings shall be capable of grease injection from outside without removal of covers. The bearing boxes shall be provided with labyrinth seals, to prevent loss of grease or entry of dust or moisture. When grease nipples are provided, these shall be associated, where

necessary, with appropriately located relief devices, which ensure passage of grease through the bearings.
The motors shall have facility for on-line greasing.

6.4.8 **Sleeve bearings**

Sleeve type bearings shall be fitted with oil rings for continuous lubrication. The oil reservoirs shall have a form suitable for allowing settling of any solids or residual particles contained in the oil.

The covers shall be provided with suitable openings for adding and draining oil, together with an overflow plug and level indication. Oil sight glass provided for checking the oil level can also be considered acceptable in place of overflow plug/level indicator subject to motor manufacturer having proven track record. The shaft shall have perfect seals so as to prevent entry of dust or moisture.

6.4.9 **Forced lubrication bearings**

The oil lubrication system shall be independent of the driven machine. Common lubrication system for the driven equipment and the motor can be accepted provided it is separate from the seal oil system. The common lubrication system shall be provided with suitable degassing equipments to extract gas reducing the probability of gas entering the motor.

In the independent lubrication system, oil supply shall be guaranteed by one of the following methods:

- With a mechanical pump co-axial with the motor and supplemented by a separate electric motor driven pump for initial lubrication during start up and stopping operations.

- With a separate electric motor driven pump. In this case the lubricating system shall consist of two identical motor driven pumps, one running and one acting as standby.

In addition to the pumps, the lubrication system shall be supplied complete with the following as a minimum:

a) An oil cooler of shell and tube type with tubes of inhibited admiralty brass. Internal coolers shall not be accepted. To prevent the oil from being contaminated, if the cooler fails, the oil side operating pressure shall be higher than the water side operating pressure.

b) An austenitic stainless steel oil reservoir with the following characteristic :

- The capacity to avoid frequent filling, to provide adequate allowance for system rundown and to provide a retention time of at least 3 minutes to settle.
- Provision to eliminate air and minimize flotation of foreign matter to the pump suction.
- Fill connections, reflex type level indicators and breathers suitable for outdoor use.
- Sloped bottoms and connections for complete drainage.
- Clean out openings as large as is practicable.
- A bypass line that returns below the oil level to eliminate aeration and static electricity.

- A thermostat with two electrical contacts for alarm & tripping in case of high oil temperature.

c) A supply and return system.

d) A duplex full flow filter with replaceable elements and filtration of 25 µm nominal or finer as recommended by the bearing manufacturer. Filter cartridge material shall be corrosion resistant. Metal mesh or sintered metal filter elements shall not be acceptable. The filter shall not be equipped with a relief valve or an automatic bypass.

e) The motor driven auxiliary pumps shall be provided with suction stainer and an automatic/manual control system arranged to start automatically on low oil pressure and with manual shutdown only.

f) Sight flow indicators in each bearing drain line.

g) Temperature gauges (with thermowells) in the reservoir, after the oil cooler and each bearing drain line.

h) Low oil pressure alarm and shutdown switches.

i) A pressure gauge (valved for removal) for each pressure level and a pressure differential indicator to measure filter pressure drop.

j) Thermostatically controlled electric immersion heater with a sheath of austenitic stainless steel for heating the charge capacity of oil before start-up in cold weather. The heating device shall have sufficient capacity to heat the oil in the reservoir from the specified minimum site ambient temperature to the start-up temperature, as required by the manufacturer, within 12 hours. The watt density of heater shall not exceed 2.33 watts per sq. mm.

k) The oil pumps shall have steel casings unless they are enclosed in a reservoir. All other oil containing pressure components shall be of steel.

A control panel shall be provided for operation & control of the lubrication system. The control panel shall include fuses, electrical contactors and thermal relays for the protection and operation of the motor driven pumps, push-buttons, auxiliary relays and timer relays for the automatic and manual starting up and shutting down of the oil pump.

Equipment and accessories provided shall conform to the hazardous area and the environmental conditions specified in the motor data sheet.

Armoured cables suitable for high temperature duty shall be used for external electrical connections between the control panel and the lubrication system.

6.4.10 Bearing Insulation-Shaft Voltage

Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV r.m.s. for roller and ball bearings and 400 mV r.m.s. for sleeve bearings. If the shaft voltage exceed these values, the non-driving end bearing shall be insulated from the motor frame to avoid circulating currents.

The insulated bearing end shield or pedestal shall bear a prominent warning and manufacturer shall provide detailed drawings showing insulation arrangement.

6.5 Cooling System

All motors shall preferably be self-ventilated. Motors with higher outputs having manufacturer's standard designs using forced ventilation cooling or closed circuit cooling employing external coolants may also be considered.

6.5.1 Self Ventilated Motors

All motors shall be fan cooled. The fans shall be of corrosion resistant material and appropriately protected. For fertilizer plants, brass or bronze are not permitted materials. The material of fan for motors to be used in hazardous areas shall be anti-static and non-sparking type.

Motors for installation in dusty atmospheres or in the presence of sand, fuels or other suspended solid particles in the air shall be fitted with filters for the cooling air. The filters shall be easily accessible for inspection and removable for cleaning and re-use. The material of the filters and supports trays shall be rust proof or protected against oxidation or corrosion.

6.5.2 Motors with forced ventilation

Motors with forced ventilation shall be equipped with two motor driven fans each capable of supplying the full quantity of cooling air required by the motor at full load.

Where air cooler design permits provision of one fan only; the second fan shall be supplied loose. Cooler design shall allow easy replacement of fan in such case.

The ventilating system shall include the flanges for the air intake and the mating flanges for the discharge ducts. An airflow indicator as described in paragraph 7.3 (a) shall also be provided.

Motors and fans used for forced ventilation shall conform to the hazardous area classification and environmental conditions specified in the motor data sheet.

6.5.3 Motors with closed circuit cooling with water to air heat exchangers

The material of the heat exchangers shall be corrosion resistant (e.g. cupro-nickel alloy, muntz metal, admiralty brass) and suitable for the type of water used. The heat exchangers shall be designed for minimum water pressure of 5 kg / cm ^{2} and with head losses not greater than 0.5 kg / cm ^{2}, unless otherwise agreed.

The heat exchangers shall be arranged by the side(s) of the motor, if possible. Screens shall be provided to protect the motor windings from water leaks or leakage in the tubes. Suitable drains shall be fitted for draining water in case of leakage. The cooling system shall include the trip and alarm devices mentioned in paragraph 7.3 (b). Heat exchangers for identical motors shall be interchangeable.

6.5.4 Motors with closed circuit cooling with air to air heat exchangers

The heat exchanger tubes shall be of stainless steel or extruded aluminum. All exposed surfaces of the heat exchanger shall be treated for anti-corrosion procedure with suitable anti corrosion paint. Motors shall be safeguarded against corrosion by immersion in varnish followed by baking.

Joints between the heat exchanger and the main body of the motor shall be sealed by weather-proof gaskets.

6.6 Rotor

The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration level and a long service life to the bearings. The accepted values of vibrations for a motor at rated voltage and speed shall not exceed those given in the IS. The shaft ends shall be provided with suitably threaded hole or holes to facilitate the assembly or removal of couplings and bearing races.

6.7 Shaft extension

Motors shall be provided with a single, bare shaft extension with key way and key. Motor shaft shall be sized to withstand dynamic torque equal to 10 times the rated design torque.

6.8 Lifting hooks

All motors shall be provided with lifting facility (i.e. hooks etc.) of adequate capacity.

For motors provided with heat exchangers, lifting facility shall also be provided for the heat exchanger.

6.9 Earth terminals

Two earth terminals shall be provided on the frame of each motor at diametrically opposite points. Minimum size of the stud shall be 12 mm. Necessary nuts and spring washers shall be provided for earth connection. These earth terminals shall be in addition to the earth terminals provided in the terminal box for earthing of the armour.

7.0 CONTROL, ALARM AND TRIP DEVICES

All electrical contacts for the devices described below (e.g. at sections 7.3 & 7.4) shall have a current carrying capacity not lower than 5 A and a minimum interrupting capacity of 1 A at 220 V DC or 5 A at 240 V AC.

The contacts shall be located in explosion proof or totally sealed housing according to the type of motor enclosure. The cable ends shall be brought together to the terminal box. Any external connections between the housing containing the relay contacts and the terminal box shall be carried out by insulated copper wires in steel conduits or by PVC insulated, armoured, copper conductor cables with cable entries through double compression type cable glands.

7.1 Measurement of winding temperature

Motors with outputs greater than 750 KW or those provided with filters for cooling air irrespective of output shall be provided with platinum resistance temperature measuring devices of 100 ohms resistance at 0°C and a temperature co-efficient of 3.85×10^{-3} located in suitable positions to measure the winding temperature. A minimum of three (one per phase) detectors shall be provided between the coil sides to measure the winding temperature and three (one per phase), preferably at the base of the slots, to measure core temperature, each placed 120° apart. If RTD's at the base slot are not possible to be provided based on motor manufacturer specific design, 12 no's RTD's shall be provided

between the coil side, to measure winding temperature. TETV motors may not be provided with core temperature detectors.

A separate terminal box shall be provided for the temperature detectors for hook up with a remote located control / monitoring unit.

7.2 Measurement of bearing temperature

Motors with self-lubricated bearing shall be provided with :

a) Two dial type and gas filled capillary type, indicating dial thermometers for checking of bearing temperatures.
b) For motors with output greater than 750 KW, a resistance type of temperature measuring device shall be provided for bearings with connections terminating in the common terminal box for winding temperature detectors.

7.3 Measurement of cooling medium for heat exchangers

Motors with forced ventilation and those with air water heat exchangers shall be provided with:

a) An airflow circulation indicator with electrical trip contacts that operate if the flow of cooling air is interrupted or is inadequate. If airflow indicator is not provided based on motor manufacturer specific design constraint, provision for alarm/trip of the motor shall be provided based on RTD.
b) A cooling water flow circulation indicator with electrical trip contacts, which close if the flow of cooling water is interrupted or is inadequate. The indicator shall be located on the discharge piping of the heat exchanger.

7.4 Pressurization Control Panel

All pressurized motors (Type Ex p) shall be provided with a control panel for controlling the initial purging and pressurization of the motor. The pressurization control panel shall be mounted on the motor itself and shall be suitable for the hazardous area classification specified in the motor data sheet. Purged control panel shall be powered through external supply to be made available by purchaser. Battery operated purge controller is not acceptable.

The panel shall be complete with but not limited to the following items :

- Timers
- Push buttons for purging/pressurization. (Manual push button shall override the auto selection parameters)
- Solenoid valves/dampers
- Indicating lamps for purging ON, purging OVER, pressurization ON & pressurization OVER etc.
- Claps regulator to compensate the pressure dip.
- Minimum & intermediate pressure sensor
- Pressure switches and flow switches with alarm and trip contacts.
- Low pressure alarm & trip contacts
- Intermediate pressure & pressurization completed contacts
- Purging started & purging completed contacts
- Power interlock/fail contact

8.0 MISCELLANEOUS ACCESSORIES

8.1 Current transformers

Unless otherwise specified, motors rated 1500 KW and above shall have differential protection and shall be equipped with current transformers suitably designed for installation in the neutral terminal box.

Unless otherwise specified, the CTs shall be supplied along with the motor and mounted in the terminal box, which shall be suitable for housing the CTs and providing the necessary connections. CT terminals shall be brought out to a separate auxiliary terminal box. Voltage rating of CT shall be same as voltage rating of motor, however window type CT with voltage rating up to 1100 V can be considered acceptable.

These transformers shall have a secondary current of 1 A, and the characteristics of the CTs (V_k, R_{CT} and I_m) shall be finalized at detailed engineering stage in consultation with the purchaser. CT ratio shall be as indicated in the motor data sheet.

8.2 Anti condensation heaters

All motors shall be provided with 240 V anti-condensation heaters, sized and located so as to prevent condensation of moisture during shut down periods. The heaters shall remain 'ON' when the motor is not in service and shall not cause damage to the windings.

Motors with heaters installed in hazardous atmospheres (Zone-1 or Zone-2), shall conform to the provisions of applicable IS/IEC standards and temperature classification specified in the motor data sheet.

The heater leads shall be brought out to a separate terminal box of the same specification and grade of protection as the main power terminal box.

A warning label with indelible red inscription shall be provided on the motor to indicate that the heater supply shall be isolated before carrying out any work on the motor.

8.3 Special tools and spanners

Motors with special features (e.g. motors with single bearing, explosion proof and increased safety motors etc.) shall be provided with a set of spanners and special tools, required for dismantling and maintenance of the motor.

8.4 Motors shall be supplied complete with double compression Nickel plated brass (or Aluminum, if specifically required) cable glands, crimp type tinned Cu cable lugs for all power, space heater and auxiliary cables (for the specified cable sizes) and first filling of lube oil for forced lubricated bearings.

8.5 Auxiliary motors, if any, shall be as per relevant Indian / International standards and shall be suitable for the hazardous classification as specified in the motor data sheet.

8.6 Name plates

A stainless steel name plate manufactured from series 300 stainless steel and having information as per IS shall be provided on each motor. In addition to the motor rating plate, a separate number plate for motor tag number shall be fixed in a readily visible position. This number shall be as per the motor data sheets.

Additional information as stipulated in applicable Standards shall be included in the name plate for motors meant for use in hazardous atmospheres.

9.0 NOISE LEVEL

The permissible noise level shall not exceed the stipulations laid down in IS.

10.0 MOTOR VIBRATION

Motor vibrations at bearing housing shall be within the limits of IS, unless otherwise specified for the driven equipment. Limits of shaft vibration for motors with sleeve bearings shall be as per IEC-60034-14.
Two and four pole motors having sleeve bearings with forced oil lubrication shall be provided with proximity probes to measure the shaft vibration adjacent and relative to the bearings.

11.0 CRITICAL SPEEDS

The first actual critical speed of stiff rotors shall not be lower than 125% of the synchronous speed. For flexible rotors, this shall be between 60% and 80% of the synchronous speed. The second actual synchronous speed shall be above 125% of the synchronous speed.

12.0 PAINTING

All metal surfaces shall undergo manufacturer's standard cleaning /painting cycle. After preparation of the under surface, the equipment shall be painted with two coats of epoxy based final paint. Color shade of final paint shall be 632 of IS: 5/ RAL-7035. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then these shall be greased.

13.0 INSPECTION, TESTING AND ACCEPTANCE

13.1 During fabrication, the equipment shall be subjected to inspection by EIL / Owner or by an agency authorised by the Owner, if specified / agreed in Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine / acceptance tests shall be carried out at manufacturer's works under his care and expense.

13.2 Type test certificates from CIMFR or equivalent test house, applicable PESO/ DGMS approval certificates, BIS license and original drawings referred in type test certificates shall be shown to the inspection agency on demand during inspection. The certificates and BIS license must be valid at the time of dispatch.

13.3 Test certificates of bought out components shall be shown to the inspection agency on demand during inspection.

13.4 For VFD fed motors, all tests as specified in VFD specification shall be followed

13.5 All equipments shall be subjected to various routine / acceptance tests as per Inspection & Test plan no. 6-81-1031.

14.0 CERTIFICATION

The motors and associated equipment shall have test certificates issued by recognised independent test house (CIMFR/ CPRI/ ERTL/ Baseefa/ LCIE/ UL/ FM or equivalent). All indigenous motors shall conform to Indian standards and shall be certified by Indian testing agencies. All motors (indigenous & imported) shall also have valid statutory approvals e.g. PESO, DGMS etc. as applicable for the specified location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

15.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to finish. Crates/cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'PO Nos.' etc. shall be clearly marked on the package together with other details as per purchaser order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature, unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

मोटर सोफ्ट स्टार्टर के लिए विनिर्देश

SPECIFICATION
FOR
SOFT STARTERS
FOR
MOTORS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
1	20.10.20	REVISED & ISSUED AS STANDARD SPECIFICATION	MKM	HK	SA	SM
0	15.12.15	ISSUED AS STANDARD SPECIFICATION	RG	HK	BRB	SC

Abbreviations:

AC	:	Alternating Current
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mining and Fuel Research (formerly CMRI)
CRCA	:	Cold Rolled Cold Annealed
CW	:	Cooling Water
DC	:	Direct Current
DCS	:	Distributed Control System
DOL	:	Direct On Line
ECS	:	Electrical Control System
EM	:	Electromagnetic
FLC	:	Full Load Current
HV	:	High Voltage
IEC	:	International Electro technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IEGT	:	Injection Enhanced Gate Transistors
IGBT	:	Insulated Gate Bipolar Transistor
IGCT	:	Insulated Gate Commutated Transistor
I/O	:	Input/Output
IP	:	Ingress Protection
IS	:	Indian Standard
LED	:	Light Emitting Diode
mA	:	Milliampere
MCB	:	Miniature Circuit Breaker
MTBF	:	Mean Time Between Failure
MTTR	:	Mean Time to Repair
NEMA	:	National Electrical Manufacturer's Association
PLC	:	Programmable Logic Controller
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
SGCT	:	Silicon Gate Commutated Transistor
THD	:	Total Harmonic Distortion
V_{BO}	:	Break Over Voltage
VDE	:	Verband Deutscher Electrotechniker

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CONTENTS

1.0 SCOPE

1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Soft Starters for AC Motors.

1.2 Soft starter shall be 3-phase, solid state, reduced voltage (V/F controlled or Voltage controlled as specified in data sheet) type motor controller for controlling & ensuring smooth starting of motors. Soft starter shall be provided with microprocessor based control to soft start and stop the motor. Soft starters shall have ability to limit the starting current to the specified limits as specified in data sheet. Soft starter shall have either anti-parallel technology or V/F controlled type as defined in data sheet.

The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. This shall include but not be limited to inverter/converter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the latest editions of the following standards unless specified otherwise:

IS:4411	Code of designation of semi-conducting devices
IS:5001	Guide for preparation of drawings of semiconductor devices & Integrated Circuits
IS:5469	Code of practice for the use of semiconductor Junction Devices
IS:8789	Values of Performance characteristics for Three Phase induction motor
IS: 12615	Line Operated Three Phase A.C. Motors (IE CODE) - Efficiency Classes and Performance Specification
IS:14901	Semi-conductor devices- Discrete devices & Integrated Circuits
IS: 15880	Three Phase Cage Induction motors when fed from IGBT Converters- Application Guide

IEC 60068-2-60 Environmental testing: Tests -Flowing mixed gas corrosion test

IS/IEC 60079 Explosive atmospheres

IEC: 60146 Semiconductor Convertors general requirements and line commutated convertors.

IEC 60721-3-3 Classification of environmental conditions: Classification of groups of environmental parameters and their severities - Stationary use at weather protected locations

IS/IEC: 60947 Low Voltage Switchgear and Control gear

IEC 61378-1 Converter transformers - Part 1: Transformers for industrial applications

IEC 61378-3 Converter transformers - Part 3: Application guide

IS/IEC 61439-0 Low-Voltage Switchgear and Controlgear Assemblies- Guidance to Specifying Assemblies

IS/IEC 61439-1 Low-voltage switchgear and control gear assemblies- General Rules

IS/IEC 61439-2 Low Voltage Switch Gear and Controlgear Assemblies- Power Switch Gear and Control Gear Assemblies

IEC 61800-2 Adjustable speed electrical power drive systems: General requirements - Rating specifications for low voltage adjustable speed A.C. power drive Systems

IEC 61800-3 Adjustable speed electrical power drive systems: EMC requirements and specific test methods

IEC 61800-4 Adjustable speed electrical power drive systems: General requirements – Rating specifications for a.c. power drive systems above 1000 Va.c. and not exceeding 35 kV.

IEC 61800-5 Adjustable speed electrical power drive systems: Safety requirements – Electrical, Thermal, Energy and Functional.

IEC TS 61800-8 Adjustable speed electrical power drive systems: Specification of voltage on the power interface

IS/IEC 62271: Part 1 High-Voltage Switchgear and Controlgear: Common Specifications

IS/IEC 62271: Part 102 High-Voltage Switchgear and Controlgear: Alternating Current Disconnectors and Earthing Switches

IEC TS 60034-25 Rotating Electrical machines, AC electrical machines used in power drive systems – Application guide.

IEEE:519 Recommended Practices and requirements for Harmonics Control in Electrical Power Systems

ANI/ ISA-S71.04 Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants

ASTM B845 Standard Guide for Mixed Flowing Gas (MFG) Tests for Electrical Contacts

EN-50178 Electronic Equipment for use in Power Installation

2.2 In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents, the most stringent one shall prevail. However, owner's decision in this regard shall be final and binding.

3.0 SITE CONDITIONS

3.1 The soft starter system shall be designed to operate under specified site conditions as mentioned in the data sheets. If not specifically mentioned therein, a design ambient temperature of $40^{O}C$ and an altitude not exceeding 1000 metres above mean sea level shall be considered. For ambient temperature above $40^{O}C$, suitable de-rating factor shall be considered by vendor while selection of current rating.

3.2 The soft starter shall be installed indoors in a non-hazardous area, in non-air-conditioned / pressurized room, as specified in data sheet. Transformer installation (outdoor/ indoor) shall be as indicated in datasheet. Motor shall be installed outdoors in safe or hazardous area as specified in datasheet.

3.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

4.0 GENERAL REQUIREMENTS

4.1 The offered equipment shall be brand new with state of art technology and a proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.4 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection / sizing of offered soft starter system. The vendor shall be responsible for design, engineering and manufacturing of the complete system to fully meet the intent and requirements of this specification and attached data sheets.

4.5 Soft Starter panels shall be sourced from the OEM. Panels from system groups / channel partners shall not be accepted.

5.0 TECHNICAL REQUIREMENT

5.1 Performance Requirement:

5.1.1 The system shall be energy efficient, designed as standard product and shall provide very high reliability, low vibration / wear & noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.2 Soft Starters shall have a compact, solid-state, three-phase Electronic controllers consisting of a set of thyristors/IGBT/IGCT/IEGT/SGCT in all three phases.

5.1.3 By-pass shall be provided for normal running of motor after soft start-up.

5.1.4 The sequence logic for control, start up and stoppage, shifting to bypass of soft starter shall be built up as per the operating philosophy of the load.

5.1.5 In the soft start mode, the motor voltage shall be gradually increased with step less control of voltage through phase control of the switching devices with acceleration ramp time. The following modes of operation shall be provided in the controller as a minimum:

- Soft Start mode with selectable Kick start.
- Current Limit start mode with selectable Kick start.
- Soft stop

If soft starter fails, it shall be possible to run the motor with bypass in circuit with full voltage.

5.1.6 The rated operating voltage of the soft starter shall be as specified in data sheet. The control voltage shall be 240 V AC, 50 Hz, single phase unless specified otherwise in data sheet.

5.1.7 Separate parameter setting shall be possible such as staring voltage/current, ramp up etc.

5.1.8 The starting voltage shall be adjustable from 40% to 100% with stepless control.

5.1.9 Adjustable ramp up time for soft starting shall be provided, suitable for driven load characteristic.

5.1.10 Soft Starter shall be able to adjust the starting current from 1.0 to 3.0 times the rated current of the motor as specified in job specification/datasheet.

5.1.11 Reset / restarting option after overload tripping shall be settable in Manual / Automatic mode It shall have built-in protection, diagnostic features, as well as the facility to communicate with various network protocols.

5.1.12 The soft start system shall be designed to deliver the motor input current (FLC) and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of ±10% and frequency variation of +3%. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit. Necessary design in the Soft Starter shall be considered to avoid / minimise drop in the output voltage of Soft Starter.

Soft Starter sizing calculation shall be submitted by vendor for review/approval by Owner/EIL.

5.1.13 All electrical components such as transformers, switches, contactors, reactors, bus bars etc. shall be rated 125% of the maximum required rating. All electronic devices including thyristors, transistors, diodes, IGBT, IGCT, IEGT, SGCT (as applicable) etc. shall be rated under operating conditions for approximately 200% of the maximum current carried by the device.

5.1.14 The soft starter controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.15 For MV V/F based soft Starter, the dv/dt limits & Vpeak shall be as per IEC-61800-2 & 60034-25 and same shall be also considered in the design of the motor.

5.1.16 For HV V/F based soft starter, the voltage stress of the motor winding insulation system shall be as per IEC-61800-4 & 60034-25 & same shall be considered in the design of motor. The vendor shall ensure that in all practical conditions of operation, the voltage stress level does not exceed the insulation system voltage stress capability as per IEC-61800-4. Vendor is, therefore, responsible for specifying the voltage stress level (i.e. transient peak voltage values, peak rise time, repetition rate, etc) at the motor terminals, taking into account possible voltage reflection depending on the topology of the converter, cable type and length, etc.

5.1.17 Harmonics at the supply side of the soft starter system shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519.

5.1.18 Maximum noise level from the soft starter system at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.

5.1.19 Un-shielded cable shall be used for connection between soft starter & motor. Length between soft starter & motor shall be considered as per data sheet & vendor shall supply the output filter accordingly.

5.1.20 Soft starter shall be designed to achieve the rated speed in minimal time possible which includes Soft Starter Charging Time. Magnetisation Time, Motor ramp-up Time.

5.2 Control Requirement

5.2.1 The system shall be suitable for number of starts as per attached EIL specification / Data sheet.

5.2.2 The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.3 Soft starter shall be provided with synchronizing equipments and PT at input and/or output side as specified.

5.3 Panel Construction

5.3.1 Upstream breaker 'ON/OFF/TRIP' indications and upstream breaker closing and trip push buttons shall be provided on the front door.

5.3.2 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Alternatively, for DC link capacitor, DC capacitor charged LED status shall be provided on front side of inverter cell. Shrouding shall be provided on all HV open live parts in the drive. Further, suitable warning label shall also be provided on the panel. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.3 The drive shall be suitably housed in sheet steel panels and shall be fabricated using Galvanised steel or any other material complying with EMC requirements. The sheet steel used for the panel shall be of minimum 2 mm thickness except the doors & covers which will be of minimum 1.5mm thickness. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of protection as min. IP-31 & type test report shall be submitted for the same. The maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.4 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm^2 and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 300 mm for upto 1100V system and 600mm for above 1100V system (unless specified otherwise) clear from bottom of the cable gland plate. All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single compression type for indoor equipment unless specified otherwise.

5.3.5 The soft starter system panel(s) shall have isolated compartments as follows:

- Main power bus and ground bus compartment
- Power cell compartment
- Low voltage compartment

5.3.6 Bus bars shall be of electrolytic copper/aluminum, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.

5.3.7 All the switches, component and accessories which are essential for normal and emergency operation shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, where provided, shall be switchboard type, back connected & of size 96x96mm. Scale shall have red mark indicating maximum permissible operating rating.

5.3.8 Each panel shall be provided with LED type illuminating lamp with MCB & door limit switch for lamp control. 6/15A, 240V power socket with switch shall be provided. Each panel shall have space heater with MCB & variable setting thermostat. Dual pole MCB shall be provided for isolation and protection of utility components.

5.3.9 Copper earth bus of min. 30x6 sq.mm. upto short circuit withstand capacity of 31.5kA and 50x6 sq.mm. for a short circuit withstand capacity above 31.5kA shall be provided in the panel with provision for connection to owner's plant earth grid. All the non-metallic components/parts shall be connected to the main earth bus bar. Separate earth bus bar and stud for electronic control system if required shall be provided.

5.3.10 All panels shall be of same height so as to form a uniform line-up to give good aesthetic appearance.

5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring

inside the panel shall be done with BIS approved /equivalent agency approved for imported cables. PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm^2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm^2 size for control fuse rating above 16 A for electrical circuits and 0.5mm^2 for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system i.e. control electronic equipments and power electronic equipments shall be used.

5.3.13 Low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment. Metal or glass polyester barriers shall be provided between the low voltage compartment and the power cell and/or main power bus compartment. Personnel shall have access to the low voltage compartment, with the controller energized, without being exposed to any High voltage.

5.3.14 For V/F based soft starter, DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.

5.3.15 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.

5.3.16 Acrylic type transparent insulating material shall be used for covering live components.

5.3.17 Soft start system keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.

5.3.18 The soft starter panel shall be naturally cooled. Cooling system shall have adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. Necessary starters shall be provided within the panels for the Ventilation fans. For fan cooled soft starters, redundant ventilating fans (N+1) shall be provided. In case redundant cooling fan is not possible to be mounted in the panel, same shall be supplied loose.

5.3.19 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively.

5.3.20 Conformal coating shall be done for all PCB, electronic equipments as per min. Class 3C2 (Harsh environment) of IEC 60721-3-3. Alternatively, it shall comply with ANSI/ ISA S71.04 class G3 or IEC 60068-2-60 for mixed flow gas test or ASTM B845. Supporting documents shall be provided for the same.

5.3.21 Spare terminals of all the devices viz. relay, transducers, Digital/Analog I/O Boards etc. shall be wired upto panel terminal strip.

5.3.22 Panel including insulator supports, conductors etc. shall be designed to withstand specified short circuit currents for a period of min. 1 sec. Short circuit type test report along with bus-bar sizing calculations shall be submitted by vendor.

5.3.23 Necessary Earth switch/Earth truck shall be provided for the Soft starter HV switchgears as specified in job specification/datasheet by the vendor.

5.4 Equipment/ Component Specification

5.4.1 **Converter Transformer**

a. The converter transformer shall be dry type or oil filled type as specified in the data sheet. In case of the dry type transformer, it shall be mounted in the soft starter panel unless specified otherwise in the datasheet. Offered transformer shall be as per enclosed EIL Specifications/data sheet & shall comply to IEC 61378-1.

b. Converter transformer shall be sized for both fundamental KVA and additional KVA on account of system voltage variation & harmonic current. Suitable correction factor shall be considered for higher loss value at rated, non-sinusoidal convertor load for thermal sizing of transformer taking into account loss & efficiency of complete converter installation.

c. Drive out put transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

d. The impedances of converter input transformers with more than one secondary windings for 12/18/24/36/54 pulse systems shall be selected to ensure equal load/current sharing between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

e. Drive out put transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

f. Converter transformer shall have shielded isolation between HV and LV winding to neutralize effect of third and its multiple harmonics, softening of high-frequency noise from the input side by the natural inductance of the transformer and provide an electrostatic shield between the primary and the secondary windings to avoid transfer of surge/impulse voltages passing through inter-winding capacitance.

g. Incoming and outgoing terminals of converter transformers shall be mounted in separate terminal boxes. HV Terminal boxes shall be designed to withstand rated short circuit current for 0.2 Sec. Terminal box shall be complete with support for clamping for outgoing and incoming cables. Head room available between cable gland plate and terminal lugs shall not be less than 600mm for Voltage ratings upto 11 kV.

h. Surge Arrestor shall be provided at primary side of input transformer to protect against HV Surges.

5.4.2 **Power Converter for V/F based soft Starter**

a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.

b. Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.

c. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.

d. All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.

e. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.

f. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

g. Offered system shall also take into account the distance between Drive panel and motor and system shall include all material and accessories such as filter to make system suitable for a distance of 350m unless otherwise specified in the data sheet.

h. Soft starter shall have integral thermal sensor to trip and disengage the soft starter on heat sink over temperature.

5.4.3 **DC Link Reactor (as applicable).**

a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.

b. Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel.

c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.4.4 **Output Filter**

Soft starter output current waveform shall be inherently sinusoidal with harmonic limits as specified in this specification. Output filter shall be provided, if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance-free and self-healing type.

5.4.5 **Bypass Feature**

a. Bypass feature along with motor protection relay and output side isolator/breaker shall be provided by purchaser for input voltage 3.3kV & above whereas for input voltage lower than the 3.3kV, same shall be provided by vendor unless otherwise specified in the datasheet. All necessary interlocks as required for safe and reliable operation of soft start system along with bypass feeder and output side isolator/breaker considered by Purchaser shall be provided in the soft start system.

b. In case, bypass feature is provided by vendor, same shall be in separate compartment and switching scheme shall be such that in case soft starter system mal-operation, the motor could be taken on bypass control manually, while the soft starter could be attended independently. Suitable interlock shall be provided such that bypass mode and soft start mode shall not operate simultaneously.

c. Soft start panel with bypass feature shall also include MCB for motor space heater, auxiliary power supply if required for local panel, panel space heater etc. in the bypass section and same shall be included and mounted in an easily accessible location.

d. All numerical relays provided in the MV/HV switchgears/bypass switchgear panel shall be suitable for communication via IEC 61850 through dual redundant FO link for data integration with ECS/SAS. Ethernet switches as required shall be provided by vendor.

e. Soft Starter panel shall include synchronizing equipment for synchronization of Soft starter output and bypass supply. Indication shall be provided for "Sync Check OK".

5.5 Protection, Control, Metering, Indication and Annunciation

5.5.1 The soft starter system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment including cooling system of main motor.

5.5.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

5.5.3 **Operator Control Panel**

a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Increase/Decrease, menu

navigation and protection and measurement parameter selection, etc. For parameterization & adjusting parameter, LAPTOP is also acceptable.

b. All parameter names, fault messages, warnings and other information shall be displayed in complete english words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.

c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.

d. Drive System control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.

e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

f. Operating procedure of the soft starter system showing sequential operation of various components shall be provided by the vendor.

5.5.4 **Protective Features**

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

i. Incoming line surge protection

ii. Under / Over voltage protection

iii. Phase loss protection.

iv. Programmable over current protection and under load protection.

v. Inverter Fault.

vi. Over frequency/Over speed of motor

vii. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).

viii. Over temperature tripping of equipment by sensing temperature of heat sink .

ix. Specific motor protection like no. of consecutive starts beyond acceptable limit, long start time, locked rotor including motor winding, bearing temperatures, over-current, overload, negative phase sequence and earth fault protections etc.

x. System earth fault protection.

xi. Shorted SCR.

xii. Prompt for modified / alteration in parameters setting

xiii. Additional protection, if any for the drive system

5.5.5 **Control**

The following controls shall be provided as a part of the Operator Control Panel or through separate switches. Provision shall be provided for interfacing with field/ control room at soft start as well as by-pass mode.

i. Start/Stop

ii. Auto/Manual /Test mode

v. Local/Remote

vi. Emergency stop

vii. Start/Stop for bypass starter (where specified)

viii. Trip-Remote Breaker

5.5.6 **Indications**

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not include but not limited to the following indications.

i. Motor running through Starter

ii. Motor running on by-pass (DOL)

iii. Starter in stop mode

iv. Inverter Fault

v. Rectifier fault

vi. Starter ready to start

vii. AC mains ON

viii. Motor over speed

ix. Rectifier output 'ON'

x. Motor zero speed

xi. Remote breaker trip

xii. Motor stopped

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm.

Potential free contacts shall be wired in terminal strip separately for remote indications in DCS system.

5.5.7 **Metering**

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

i. Output voltage

ii. Output current-soft start mode/ Bypass mode

iii Output frequency

iv Drive thermal state / Transformer RTD display

v. Motor speed

vi. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

vii. Necessary current inputs (CT/Transducers) to Local Control Station (LCS) shall be provided in the soft starter by the vendor.

5.5.8 **Audio-visual Annunciations**

a. The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the complete system, cables, DC Reactor and the Converter. Convertor transformer etc.

b. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

c. Audio-visual window annunciations shall be provided on the front of the panel. All annunciations as required for normal and satisfactorily operation of the drive system shall be included as per vendor standards. These annunciations can be part of operator console panel or separately mounted type.

d. Vendor shall include audio-visual alarm as required for normal operation and maintenance of the system but not be limited to the following.

i. Rectifier fuse failure/Drive fault

ii. Main AC failure

iii. Inverter fuse failure/Drive fault

iv. Inverter overload

v. Inverter high temperature/Drive fault

vi. Cooling system failure

vii. Motor failed to start/Drive fault

viii. Transformer failure (if applicable)

ix. Motor temperature high

x. Harmonic filters monitoring

xi. Convertor Temperature High

All drive internal faults will be annunciated as drive fault.

Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminal block for owner's use for remote alarm and monitoring.

5.6 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.7 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to soft starter module, space heater supply for Motor (as applicable for Bypass feature), panel space heater, auxiliary power supply for transformers, cubicle LED lamps, LED indicating lamps, digital meters etc. shall be 240 volts single phase AC supply provided by purchaser.

All control circuit shall operate at maximum voltage of 240V AC or 220V DC unless otherwise specified in the datasheet.

One No. 110V DC /110V AC/ 230V AC UPS Supply for each panel shall be provided by Owner for control logic. Power supply at any other voltage shall be derived by vendor. Conversion of this 110V DC / 110V AC / 230V AC supply to any other voltage level or to AC/DC power supply shall be take care by vendor by providing suitable converter/inverter module inside panel.

240V AC space heater supply for panel and motor space heater shall be provided from external source by Owner.

Vendor shall include supply of all control transformers, protective devices, associated accessories etc. and any other control supply voltage required for the system shall be derived by the vendor from the power supply made available by purchaser.

5.8 Reliability Features

The expected lifetime of the soft starter shall be min. 20 years. The system including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

The controller design shall incorporate the following reliability features:

- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted.
- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

5.9 Software

PC based software for start-up & commissioning of soft starter shall be provided. The software shall allow the user to perform the following:

- Setting of soft starter parameters
- Copying of parameter sets to and from a soft starter
- Document/print out set up
- Servicing & fault analysis set up

One CD-ROM of such software shall also be supplied along with soft starter panel.

5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

- Modular construction
- All components shall be easily accessible.
- Printed circuit boards shall be plug connected.
- Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.2 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the soft starter shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that

only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an Inspector of EIL/ Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 All Routine & Type Tests shall be conducted as per the approved ITP. However, combined test for soft starter and motor at vendor's works shall be carried out if specified in the datasheet. For HV Converter transformer, same shall be offered for test & inspection as per EIL Std. ITP 6-81-1044 in compliance to IEC 61378-1 at manufacturer's works.

6.4 Additional tests on switchgears and transformers shall be carried out based on the requirement defined in the EIL's specification of respective equipment.

6.5 String Test with driven equipment

If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

7.0 CERTIFICATION

The motors and associated soft starter system equipment shall have test certificates issued by recognized independent test house (CIMFR/ BASEEFA/ LCIE/UL/FM or equivalent) as applicable.

8.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

एम.वी. वैरीएबल फ्रीक्वेन्सी ड्राईव सिस्टम के लिए विनिर्देश

SPECIFICATION FOR MV VARIABLE FREQUENCY DRIVE SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	06.11.19	REVISED AND ISSUED AS STANDARD SPECIFICATION	MKM	HK	SA	RKT
2	20.08.14	REVISED AND ISSUED AS STANDARD SPECIFICATION	MK/SA	HK	BRB	SC
1	24.04.09	REVISED AND ISSUED AS STANDARD SPECIFICATION	AM	SG	JMS	ND
0	24.09.02	ISSUED AS STANDARD SPECIFICATION	RM	AAN	VPS	GRR

Abbreviations:

AC	:	Alternating Current
AFE	:	Active Front End
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CBCT	:	Core Balance Current Transformer
CEA	:	Central Electricity Authority
CFL	:	Compact Fluorescent Lamp
CRCA	:	Cold Rolled Cold Annealed
DC	:	Direct Current
DCS	:	Distributed Control System
DOL	:	Direct On Line
ELR	:	Earth Leakage Relay
EM	:	Electromagnetic
EMC	:	Electromagnetic Compatibility
FLC	:	Full Load Current
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IGBT	:	Insulated Gate Bipolar Transistor
IO	:	Input/Output
IP	:	Ingress Protection
IS	:	Indian Standard
LCS	:	Local Control Station
LCP	:	Local Control Panel
LED	:	Light Emitting Diode
MCB	:	Miniature Circuit Breaker
MCCB	:	Moulded Case Circuit Breaker
MTBF	:	Mean Time Between Failure
NEMA	:	National Electrical Manufacturer's Association
PCC	:	Point of Common Coupling
PLC	:	Programmable Logic Controller
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
r.m.s	:	Root Mean Square
THD	:	Total Harmonic Distortion
VDE	:	Verband Deutscher Electrotechniker
VFD	:	Variable Frequency Drive

Electrical Standards Committee

Convener : Ms. Sumita Anand

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Mr. M.K.Sahu
Ms. ANP Singh
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Ms. Shalini Verma
Mr. Raman Sood
Ms. Shirali Aggarwal
Mr. Rajesh Sinha (Inspection)
Ms. N.P. Guha (Projects)

CONTENTS

1.0 SCOPE

The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Medium Voltage, AC Variable Frequency Drive (VFD) System. The VFD system shall be complete with Squirrel Cage Induction motor as specified in data sheet, Converter, Converter input transformer(if required), DC link/AC line reactor with associated auxiliaries, filters(if required) and field mounted local motor control panel. Separate dedicated panel(s) shall be provided for each VFD system.

The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets.

This specification applies to drives connected to line voltage up to 1000 V, AC.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the latest editions of the following standards unless specified otherwise:

IS: 4411 Code of designation of semi-conducting devices

IS: 5001 Guide for preparation of drawings of semiconductor devices and Integrated Circuits

IS: 5469 Code of practice for the use of semiconductor Junction Devices

IS: 8789 Values of Performance characteristics for Three Phase induction motor

IS: 12615 Line Operated Three Phase a.c. Motors (IE CODE)- Efficiency Classes and Performance Specification

IS: 14901 Semi-conductor devices- Discrete devices & Integrated Circuits

IS: 15880 Three Phase Cage Induction motors when fed from IGBT Converters- Application Guide

IS 16724 / IEC 60079-14 Explosive Atmospheres — Electrical Installations Design, Selection and Erection

IEC 60068-2-60 Environmental testing: Tests -Flowing mixed gas corrosion test

IS/IEC 60079-0 Explosive atmospheres: Equipment - General requirements

IS/IEC: 60947 Low Voltage Switchgear and Control gear

IEC: 60146 Semiconductor Convertors general requirements and line commutated convertors.

IEC 60721-3-3 Classification of environmental conditions: Classification of groups of environmental parameters and their severities - Stationary use at weather protected locations

IEC 61378-1 Converter transformers - Part 1: Transformers for industrial applications

IEC 61378-3 Converter transformers - Part 3: Application guide

IS/IEC 61439-0 Low-Voltage Switchgear and Controlgear Assemblies- Guidance to Specifying Assemblies

IS/IEC 61439-1 Low-voltage switchgear and control gear assemblies- General Rules

IS/IEC 61439-2 Low Voltage Switch Gear and Controlgear Assemblies- Power Switch Gear and Control Gear Assemblies

IEC 61800-2 Adjustable speed electrical power drive systems: General requirements - Rating specifications for low voltage adjustable speed A.C. power drive Systems

IEC 61800-3 Adjustable speed electrical power drive systems: EMC requirements and specific test methods

IEC 61800-5 Adjustable speed electrical power drive systems: Safety requirements - Electrical, Thermal, Energy and Functional.

IEC 61800-8 Adjustable speed electrical power drive systems: Specification of voltage on the power interface

IEC TS 60034-25 Rotating Electrical machines, AC electrical machines used in power drive systems – Application guide.

IEEE:519 Recommended Practices and requirements for Harmonics Control in Electrical Power Systems

ANI/ ISA-S71.04 Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants

ASTM B845 Standard Guide for Mixed Flowing Gas (MFG) Tests for Electrical Contacts

2.2 In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents, the most stringent one shall prevail. However, owner's decision in this regard shall be final and binding.

3.0 SITE CONDITIONS

3.1 The AC drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 40^{o}C and an altitude not exceeding 1000 metres above mean sea level shall be considered.

3.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurised room, as specified in data sheet.

3.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

4.0 GENERAL REQUIREMENTS

4.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/ spares to enable the end user to place order for spares and services.

4.4 The vendor shall be responsible for design, engineering and manufacturing of the complete VFD system to fully meet the intent and requirements of this specification and attached data sheets.

4.5 VFD panels shall be sourced from the OEM of VFDs. VFD Panels from system groups / channel partners shall not be accepted.

5.0 TECHNICAL REQUIREMENTS

5.1 Performance Requirement

5.1.1 The system shall be energy efficient, and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.2 The VFD system shall be designed to deliver the motor input current (FLC) and torque for the complete speed torque characteristics of the load. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit. Necessary design in the VFD shall be considered to avoid / minimise drop in the output voltage of VFD. VFD sizing shall be done taking care of following:

- Input supply variation of +/-10% and frequency variation of +/- 3%.
- Steady state voltage drop across the AC drive including associated choke and internal / external filters on input and output side.
- Steady state voltage drops of 3% across cable from VFD to motor.

VFD sizing calculation shall be submitted by vendor for review/approval by Owner/EIL. Sizing for choke / filters shall be also provided for review / approval by Owner.

5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as specified in the data sheet:

a) Variable torque changing as a function of speed i.e. Speed squared
b) Constant torque over a specific speed range
c) Constant power over a specific speed range where the torque decreases when speed increases
d) Any other as specified in data sheet

5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 1.100 unless otherwise specified with speed set accuracy of +1% of rated maximum speed and steady state regulation of ±0.5% of rated speed.

5.1.6 The dv/dt limits & V_{peak} shall be as per IEC-61800-2 & 60034-25 & same shall be considered in the design of motor.

5.1.7 Harmonics shall be restricted within maximum allowable levels of current and voltage distortion as per recommendation of latest edition of IEEE519. To verify compliance to IEEE519 at switchboard level the necessary data related to switchboard like min. short circuit current (kA) , Load current , other linear and non linear loads connected to the switchboard and the working / standby configuration of the connected loads shall be provided by owner. Using the above required data the harmonics shall be analyzed and suitable mitigation solution shall be provided by vendor level by providing suitable filters in VFD, 6/12 pulse VFD, AFE VFD etc.

5.1.8 The controller output overload capacity shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.

5.1.9 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in set point within a time limit up to 60 seconds.

5.1.10 The integrator action of the set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustment by the distributed control system shall be considered as 10 seconds.

5.1.11 Drive shall trip in case the speed exceeds 105% of the maximum operational speed and / or reduces to 95% of the minimum operational speed for more than 10 seconds.

5.1.12 Maximum noise level from the drive at 1 meter distance, under rated load with all normal cooling fans operating shall not exceed 75 dB(A).

5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start-up adjustments and troubleshooting.

5.1.14 VFD shall be provided with Auto-Reacceleration feature with facility of enabling/disabling this feature at site.

5.1.15 Vendor to provide suitable voltmeter at VFD output side (after filter) so that final output voltage at VFD end i.e. after taking into account voltage drop within VFD is available.

5.1.16 VFD System shall be designed to comply with EMC requirements as per IEC 61800-3 for conductive and radiated emission. Type test report for EMC compliance for VFD Panel shall be submitted by vendor. For longer cable lengths, requisite mitigation measures including providing suitable filters in VFD panels shall be provided by vendor to comply with EMC requirements. Design and construction of VFD shall also comply to safety requirements specified in IEC 61800-5.

5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips upto 20% of nominal (e.g. in case of a large motor start up connected to the same bus as VFD), shall not cause the control system to stop functioning and shall not trip the drive system.

5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of re-synchronizing onto running motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached standard specification for Medium Voltage Induction Motors.

5.2.5 The power controller shall be regulated to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed regulated corresponding to 4-20 mA or 0-10 V reference input signal. Upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

a) With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated / Digital potentiometer shall be provided as a speed set point device.

b) With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.

c) Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, operator shall be able to start and speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above. (For local control station, also refer Cl. 5.5.7 below).

5.2.8 The required provision for the interface with PLC/DCS (located at remote control room) including the details of communication module and data transfer facility, I/O details shall be furnished. The communication interface shall be via serial communication link with industry standard open protocol i.e. MODBUS/Data Highway Plus/IEC-61850/ RS-485 etc. and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with owner's system (software) shall be provided.

5.2.9 Temperature controller in VFD shall receive signal from thermistor provided in the motor. Contact of the same from temperature controller shall be used in Start Permissive.

5.3 Panel Construction

5.3.1 The panel shall include suitable isolating device (i.e. Circuit breaker/MCCB/ Switch fuse) for main supply, contactors, semi conducting power devices (Diodes / IGBT) modules with

protective devices, reactors, filters, output isolating device (for VFD with By-pass), control circuit, control accessories, indication and annunciation etc.

5.3.2 Main isolating device shall function as a manual disconnect and shall be an AC thermal-magnetic circuit breaker or a fused switch with dual element fuse to trip automatically on fault currents, as specified in data sheet. Devices shall be lockable in the open position and shall have a minimum interrupting capacity as specified in data sheet. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.

5.3.3 The drive shall be suitably housed in sheet steel panels and shall be fabricated using Galvanised steel or any other material complying with EMC requirements & unpainted from inside. The sheet steel used for the panel shall be of minimum 2 mm thickness except the doors & covers which will be of minimum 1.5mm thickness. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of protection as min. IP-41 & type test report shall be submitted for the same. The maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.4 Bolted undrilled gland plate shall be provided at bottom with single compression type cable gland. Clamp type terminals shall be used for connection of all wires up to 10 mm^2 and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum clearance between gland plate to cable termination point for power cable termination shall be 300mm clear.

5.3.5 Bus bars shall be of electrolytic copper/aluminium, colour coded. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided. The type/material of construction for all name plates shall be preferably anodized aluminum or 3-ply (Black-White-Black) lamicoid sheets. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

5.3.6 All the power and control switches shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, wherever provided, shall be switch board type, back connected, 96x96mm size. Scale shall have red mark indicating maximum permissible operating rating. All components mounted on DIN RAIL shall be provided with end clamps except for components mounted firmly on base plates using screws.

5.3.7 Each panel shall be provided with LED type illuminating lamp with MCB & door limit switch for lamp control. 5/15A, 240V power socket with switch shall be provided. Each panel shall have space heater with variable setting thermostat. Dual pole MCB shall be provided for isolation and protection of utility components.

5.3.8 Copper earth bus of min. 30X6 mm size shall be provided at the bottom of the panel extending outside the panel on both sides. All the non-metallic components/parts shall be connected to the main earth bus bar. In case a separate earth bus for electronic control system is required, the same shall be indicated in the drawings.

5.3.9 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.

5.3.10 All the control wiring shall be enclosed in plastic channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, flame retardant, low smoke, copper conductor wire. 1.5 mm^2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm^2 size for control fuse rating above 16 A for electrical circuits and 0.5 mm^2 for electronic circuits.

5.3.11 All electronic modules and components shall be accessible from front of panel only. Modular plug-in/draw-out assemblies for both the system control electronic equipment and power electronic equipments shall be used.

5.3.12 Suitable removable type hooks shall be provided for lifting the panel.

5.3.13 Conformal coating shall be done for all PCB, electronic equipments as per min. Class 3C2 (Harsh environment) of IEC 60721-3-3. Alternatively, it shall comply with ANSI/ ISA S71.04 class G3 or IEC 60068-2-60 for mixed flow gas test or ASTM B845.

5.3.14 Spare terminals of all the devices viz. relays, transducers, Digital/Analog I/O Boards etc. shall be wired upto panel terminal strip.

5.3.15 VFD Panel including insulator supports, conductors etc. shall be designed to withstand specified short circuit currents for a period of min. 1 sec. Short circuit type test report alongwith busbar sizing calculations shall be submitted by vendor. For small rated VFD protected with incoming SFU/MCCB feeders having fault current limiting features, prospective short circuit current shall be considered.

5.4 Cooling

Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the VFD panels for these fans. In case redundant cooling fan is not possible to be mounted, same shall be supplied loose.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the attached standard specification for Medium Voltage Induction Motor, in addition to the following requirements:

a) The motor shall be converter grade motor suitable for operation with a solid state power supply consisting of an adjustable frequency inverter for speed control and shall comply to IS 16724, IEC-60034-25 and relevant part of IS/IEC-60079.

b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c) The motor shall be designed to operate continuously at any speed over the range (1-100%) of rated speed or as specified in data sheet.

d) Motor shall be provided with thermistor type temperature detector.

e) The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.

f) Motor shall be designed suitable to deliver the torque required for complete speed torque characteristics of the load considering the voltage available at the motor terminals after taking into account supply voltage tolerances, voltage drop within VFD panel and voltage drop within cable as specified in cl. no. 5.1.2.

g) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in line voltage, frequency and starting current limitations as specified in data sheet.

h) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid state power supply.

i) The motor insulation shall be designed to accept the applied voltage wave form, within the V_{peak} and dv/dt limits as per IEC-61800-2 and 60034-25.

j) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

k) Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning. Insulated bearing (Non Drive End) shall be provided irrespective of motor frame size.

l) Motor for hazardous area application shall have valid type test certificate issued by recognized independent test house certifying that motor is suitable for converter duty application. Corresponding statutory approval (e.g. PESO/DGMC etc.) as applicable for the specified location shall also be furnished for the hazardous area motor.

5.5.2 **Converter Transformer (As applicable)**

The converter transformer shall be suitable for use with the variable frequency drive system and shall comply to IEC 61378-1. The impedances of transformers with two secondary windings for 12 pulse systems shall be selected to ensure equal load/current sharing between the two secondary windings, the converters and the motor windings under all operational conditions including starting and restarting. The transformer shall be provided with ± 5% off circuit taps in steps of ± 2.5%.

5.5.3 **Power Converter**

a) The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter.

b) Normally, for all output short circuits, the inverter shall interrupt the current before any semi-conductor fuse blows. For internal short circuits, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuseless design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

c) All power converter devices shall include co-ordination by peak voltage protecting snubber networks and di/dt and dv/dt networks.

d) The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range.

e) All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.

f) The power converter circuit shall be designed so that motor can be powered at its full name plate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.

g) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.

h) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

i) All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I^2t particulars of the power controller devices and the fuses shall be properly co-ordinated for the selection of fuses.

5.5.4 **DC Link / AC line Reactor**

a) Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit. AC line reactors, if provided as per standard vendor design, shall be suitable for harmonic suppression and fault current limitation.

b) The reactor shall be dry type, air cooled or fan cooled type located within the panel. In case of fan cooled type, operation of fans shall be monitored.

c) Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.5 **Output Filter**

VFD output current waveform shall be inherently sinusoidal at all speeds. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds after a loss of AC voltage.

The VFD system shall inherently protect motor from high voltage dv/dt stress & Vpeak , independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.6 **Bypass Feature**

5.5.6.1 Output contactor or Load Break Switch shall be provided for isolation between the output of the controller and the motor for VFD systems with Bypass feature.

5.5.6.2 Bypass feature shall be provided, if specified in the data sheet along with VFD-Bypass selector switch. Accordingly Bypass feature with Bypass starter shall meet the following requirements, unless otherwise specified in the data sheet:-

- Bypass starter shall comprise of switch-fuse, contactor, bimetal relay meeting the requirements of Type-2 coordination as per IS/IEC-60947. CBCT and ELR shall be provided for motors rated above 22kW & upto 55kW unless otherwise specified in the data sheet. Heavy duty starters shall be provided with saturable type current transformer operated overload relay only, which shall be suitable for motor starting time of 15-60 seconds. For motors rated above 55kW, ACB/MCCB and motor protection relay (Numerical Relay) along with necessary metering shall be provided. The communication protocol of Numerical relay shall be IEC-61850 unless specified otherwise.

- Bypass starter shall be in separate compartment and it shall be possible to isolate and maintain the VFD while drive motor runs in Bypass mode. Three contactors/ breakers shall be used for this purpose, one contactor in the bypass and two contactors across the drive, such that in case of drive mal-operation, the motor could be taken on bypass control, while the drive could be attended by opening its contactors. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.7 **Local Control Station**

The local control station shall conform to the attached standard specification(s).

Meters in the local control station for motors rated above 5.5kW shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current unless specified otherwise. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. Local-off-Remote selector switch shall be provided in the LCS for selection of control from Local (i.e. LCS in Field) and Remote (i.e. from VFD panel / DCS / PLC).

Vendor to ensure that suitably sized canopy shall be provide by vendor for outdoor LCS which will cover LCS from all 3 sides and protect the LCS from rain water in all directions.

Auxiliary AC power supply for LCP/LCS shall be derived by vendor.

LCS shall be provided with 20% spare terminals.

5.6 Protection, Control, Metering and Indication / Annunciation

5.6.1 The manufacturer shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor based system.

5.6.3 **Operator Control Panel**

Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for Run/Stop, Local/Remote, Increase/Decrease, menu navigation and parameter select/save. All parameter names, fault messages, warnings and other information shall be displayed in Complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics.

5.6.4 **Protective Features**

The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:

i) Incoming line surge protection
ii) Under / Over voltage protection
iii) Phase loss, phase reversal protection
iv) Programmable Over current protection
v) Inverter Fault protection
vi) Over frequency /Over speed protection of motor

vii) Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm. Suitable sensors as required for same shall be provided)
viii) Over temperature protection of equipment
ix) Complete motor protection
x) System Earth fault Protection

5.6.5 **Alarms**

The system shall incorporate protection alarms, required for various fault conditions, for the Drive motor, Supply cables, Converter Transformer, DC Reactor and the Converter. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

5.6.6 **Controls**

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

i) Start/Stop
ii) Speed control (Raise/lower)
iii) Forward/Reverse
iv) Auto/Manual mode
v) Emergency stop
vi) Start/stop for by pass starter
vii) Trip-Remote upstream feeder

5.6.7 **Indications**

The following indications shall be provided as a part of the Operator Control panel.

i) Motor running
ii) Motor stopped
iii) VFD System Fault
iv) System ready to start
v) AC mains ON
vi) Motor over speed
vii) Drive 'ON'
viii) Motor zero speed
ix) Remote breaker trip

Potential free contacts of items i) - iv) shall be wired separately for indications in DCS system.

5.6.8 **Metering**

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

i) Input AC voltage
ii) Input AC frequency
iii) Input AC Current
iv) Output voltage
v) Output current VFD / Bypass
vi) Output frequency
vii) Drive thermal state
viii) Motor speed
ix) Motor energy meter
x) Run hour meter

Necessary dual type transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS under both VFD and Bypass mode of operation.

5.6.9 **Annunciations**

Potential free contacts shall be provided for following annunciations and shall be wired up to terminal block for owner's use for remote monitoring:

i) Rectifier fuse failure/Drive fault
ii) Main AC failure
iii) Inverter fuse failure/Drive fault
iv) Inverter overload
v) Inverter high temperature/Drive fault
vi) Failure of panel cooling system
vii) Motor failed to start/Drive fault

All drive internal faults will be annunciated as drive fault.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available for a period of minimum 4 days (96 hours) after a shut down even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.8 Control Circuit

Control supply for devices external to VFD module i.e contactors control, indicating lamps, digital meters (Ammeter, Voltmeter, Speedometer) etc. shall operate on 240 V control supply derived from single-phase control supply transformer, with switch-fuse provided in primary and MCB in secondary, located inside the drive controller.

One No. 110V DC /110V AC/ 230V AC UPS Supply for each VFD panel shall be provided by owner for VFD control logic. Power supply at any other voltage shall be derived by vendor. Conversion of this 110V DC / 110V AC / 230V AC supply to any other voltage level or to AC/DC power supply shall be take care by vendor by providing suitable converter/inverter module inside VFD panel.

240V AC space heater supply for panel and motor space heater shall be provided from external source by owner.

5.9 Reliability Features

i) The expected life time of the VFD shall be minimum 20 years. The VFD including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

ii) The controller design shall incorporate the following reliability features:

- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted

- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

5.10 Maintenance Features

The controller design shall incorporate the following maintenance features:

- Modular construction
- Printed circuit boards shall be plug connected.
- All components shall be easily accessible from the front of the enclosure.
- Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.2 After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be RAL-7032, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the VFD shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of EIL/ Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 Complete VFD system (as defined in Cl.1.0 above) shall be offered for test & inspection as per EIL Std. ITP 6-81-1038. In case of HV Converter transformer used as input transformer for MV Drive, same shall be offered for test & inspection as per EIL Std. ITP 6-81-1044 in compliance to IEC 61378-1 at manufacturer's works. In case combined testing requirement is mentioned in PR/Data sheet, testing shall be carried out on Complete VFD with Job motor as per EIL Std. ITP 6-81-1038. For hazardous area application, requirements specified in cl. no. 5.5.1.l) above shall also be complied.

6.4. String Test with Driven Equipment

If a string test with driven equipment is required, this will be mentioned in the data sheet of the driven equipment.

7.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight',

'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

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SPECIFICATION FOR LV & MV OIL FILLED TRANSFORMERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	09.08.2024	REVISED & REISSUED AS STANDARD SPECIFICATION	MKM	VT	HK	MN
6	05.04.2018	REVISED & REISSUED AS STANDARD SPECIFICATION	MKM/DA	HK	BRB	RN
5	08.04.2011	REVISED & REISSUED AS STANDARD SPECIFICATION	MK	SA	UAP	DM
4	27.02.2009	REVISED & REISSUED AS STANDARD SPECIFICATION	SA	NS	JMS	VC
3	10.02.2004	REVISED & REISSUED AS STANDARD SPECIFICATION	NPG	RR	VPS	MG

Abbreviations:

AC	:	Alternating Current
BEE	:	Bureau of Energy Efficiency
BS	:	British Standards
BIS	:	Bureau of Indian Standards
BDV	:	Breakdown Voltage
CBIP	:	Central Board of Irrigation & Power
CEA	:	Central Electricity Authority
CT	:	Current Transformer
DC	:	Direct Current
ECS	:	Electrical Control System
FEC	:	Fire Extinguishing Cubicle
FRLS	:	Flame Retardant Low Smoke
FO	:	Fibre Optic
GI	:	Galvanised Iron
GSM	:	Global System for Mobile Communication
HMI	:	Human Machine Interface
HV	:	High Voltage
IEC	:	International Electro Technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standards
KNAF	:	(Non-Mineral) Oil Natural Air Forced
KNAN	:	(Non-Mineral) Oil Natural Air Natural
KV	:	Kilo Volt
KVA	:	Kilo Volt Ampere
LED	:	Light-emitting diode
LIU	:	Light Interface Unit
LV	:	Low Voltage
MR	:	Material Requisition
MSL	:	Mean Sea Level
MV	:	Medium Voltage
NABL	:	National Accreditation Board for Testing and Calibration Laboratories
NEMA	:	National Electrical Manufacturers Association
NGR	:	Neutral Grounding Resistor
NIFPES	:	Nitrogen Injection Fire Prevention and Extinguishing System
NO	:	Normally Opened
ODV	:	Oil Drain Valve
OEM	:	Original Equipment Manufacturer
OLTC	:	On Load Tap Changer
ONAF	:	Oil Natural Air Forced
ONAN	:	Oil Natural Air Natural
OTI	:	Oil Temperature Indicator
PESO	:	Petroleum and Safety Explosives Organisation
PLC	:	Programmable Logic Controller
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
PRV	:	Pressure Release Valve
RPRR	:	Rapid Pressure Rise Relay
RTCC	:	Remote Tap Changer Control
SCADA	:	Supervisory Control and data Acquisition
SMS	:	Short Message Service
SS	:	Stainless Steel

TCIV	:	Transformer Conservator Isolation Valve
TPN	:	Three Phases and Neutral
VDE	:	Verband Der Electrotechnik, Elecktronik und Information Stechnik
WTI	:	Winding Temperature Indicator
XLPE	:	Cross Linked Polyethylene

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Mr. Rajesh Sinha (PDD)
Mr G Suresh (Inspection)

CONTENTS

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of MV (>1kV upto 33kV) & LV (upto 1000V) oil filled power/distribution transformers along with nitrogen injection fire protection system (if specified in MR/ Tender specification).

2.0 CODES AND STANDARDS

The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS.

IS:5	:	Colours for Ready Mixed Paints and Enamels
IS:335	:	New Insulating oils - Specification
IS:1180-1	:	Outdoor type oil immersed distribution transformers up to and including 2500 kVA, 33kV – Mineral Oil Immersed
IS:1180-3	:	Outdoor/indoor type liquid immersed distribution transformers up to and including 2500 KVA, 33 kV – Natural/ Synthetic organic ester liquid immersed
IS:1271	:	Electrical insulation - Thermal evaluation and designation
IS:1747	:	Nitrogen Compressed gas and Liquid-Specification
IS:2026 (Various Parts)	:	Power transformers
IS:2312	:	Specification for propeller type AC ventilating fans
IS:2705	:	Current transformers
IS:3024	:	Grain Oriented Electrical Steel Sheet and Strip
IS:3347	:	Dimensions for porcelain Transformer Bushings
IS:3401	:	Silica Gel Specification
IS:3624	:	Specification for pressure and vacuum gauges
IS:3637	:	Specification for gas - Operated relays
IS:3639	:	Specification for fittings and accessories for power transformers
IS:4253 Part-2	:	Cork composition sheets - Specification: Part 2 cork and rubber
IS:4201	:	Application guide for Current Transformer
IS:7098 Part-1	:	Specification for crosslinked polyethylene insulated pvc sheathed cables: Part 1 for working voltages up to and including 1100 volts
IS:8468	:	Tap - Changers Part 1 Performance Requirements and Test Methods
IS:8478	:	Application guide for On-load tap changers
IS:11149	:	Specification for rubber gaskets
IS 13503	:	Classification of insulating liquids
IS:16081	:	Insulating Liquids — Specification for unused synthetic organic esters for electrical purposes
IS:16227	:	Instrument Transformers
IEC 60076 (Various parts)	:	Power transformers
IEC 60214	:	Tap-changers
IEC 60296	:	Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment
IEC 60599	:	Mineral oil-filled electrical equipment in service - Guidance on the interpretation of dissolved and free gases analysis

IEC:61869	:	Instrument Transformers
IEC:62535	:	Insulating liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil
IS/IEC:60137	:	Insulated Bushings for Alternating Voltages above 1000 V
IS/IEC 60273	:	Characteristic of Indoor and Outdoor Post Insulators for Systems with Nominal Voltages Greater than 1000 V
IS/IEC:60529	:	Degree of protection provided by enclosures (IP Code)
IS/IEC:60947	:	LV switchgear and control gear.
IS/IEC 61850	:	Communication Networks and Systems for Power Utility Automation
IEEE C37.91	:	IEEE Guide for Protective Relay Applications to Power Transformers
IEEE C57.104	:	IEEE Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers
CBIP GP-317	:	CBIP Manual on Transformer
GOI Order	:	Latest Gazette of India Notification
NEMA TR-1	:	Transformers, Regulators and Reactors

2.1. In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.2. The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

2.3. In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.4. In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However, Owner/ EIL decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1. The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2. Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3. Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1. Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres. The transformer shall be designed to operate under site conditions as specified in data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000m above MSL shall be considered.

5.0 CONSTRUCTION

5.1. Transformer tank shall be of welded sheet steel construction and provided with gasketed steel cover plates. Base shall be suitably reinforced to prevent any distortion during lifting. Base channels shall be provided with skids and pulling eyes to facilitate handling.

5.2. Transformer shall be double wound, core type with high grade cold rolled non-aging grain oriented low loss, high permeability silicon steel laminations (M-4 or better grade) perfectly insulated and clamped to minimise vibration and noise. Care shall be taken to insulate core-fastening bolts to reduce losses and avoid hot spots. All parts of magnetic circuit shall be bonded to earth system.

5.3. Power/ Distribution Transformers shall have conventional type of windings. However, distribution transformer with Foil type LV windings are also acceptable. Windings shall be of copper and shall be designed to withstand the applicable thermal and dynamic short circuit stresses.

5.4. All covers and seals shall be oil and airtight and shall not be affected by mineral or synthetic oil action. Detachable radiators (tank mounted) equipped with air vent, drain plug and lifting lugs shall be provided with shut-off valves for transformer rated more than or equal to 500kVA to permit removal of any radiator unit without emptying the tank. Radiators shall be securely braced to prevent undue vibration.

5.5. All fasteners and bolts etc. shall be galvanised. All surfaces to be painted shall be thoroughly cleaned, de-scaled, made free from rust and transformer shall be epoxy painted.

5.6. Different non-current carrying parts of transformers shall be connected by copper flexible for earth continuity purpose.

5.7. Transformer shall be supplied with first filling of oil and 10% extra oil in non-returnable drums. Oil shall conform to IS-335 (Mineral Oil)/ 16081 (Synthetic Ester Oil) as specified in MR/tender.

5.8. Distribution transformer rated upto 2500 kVA shall comply with latest IS-1180 (Part-1)/ IS-1180 (Part-3) (including amendments) and latest Gazette of India Notifications. Accordingly, efficiency of transformer at 50% and 100% load shall be considered with total losses at 50% and 100% loading not exceeding maximum losses values specified in Table-6 of IS-1180 (Part-1)/ IS-1180 (Part-3): (including amendments) for Energy Efficiency Level 3/ Table-3 of GOI Notification dt. 08 Dec 2023, BEE Star Rating 3 (including latest GOI Notifications). Higher energy efficiency levels/ star ratings shall be provided, if specified in MR/ Tender.

5.9. The transformer shall bear standard mark of the Bureau of Indian Standards in line with Gazette of India notifications. Copy of the license obtained from Bureau of Indian Standards shall be furnished by vendor in compliance with IS-1180 (Part-1)/ IS-1180 (Part-3). Further, energy efficiency labelling for distribution transformer shall be also provided as per Bureau of Energy Efficiency (BEE).

5.10. Temperature rise limits shall be limited to limits of Temperature rise specified in Gazette of India notifications/ IS-1180 (Part-1)/ IS-1180 (Part-3).

5.11. The guaranteed minimum value of efficiency shall be demonstrated during inspection.

6.0 TERMINALS AND MARSHALLING BOX

6.1. Windings shall be brought out and terminated on outdoor bushings, cable boxes or bus-duct chamber, which will be located as specified in MR/ Tender.

6.2. When outdoor bushings are specified, these shall be supplied complete with terminal connectors suitable for the specified conductor size.

6.3. Cable box shall be supplied with cable lugs and glands.

6.3.1. For HV XLPE Cables and MV XLPE Power/control cables, double compression nickel plated brass cable glands and crimped type tinned copper cable lugs shall be supplied. Gland plate shall be removable type. For single core cables, gland plate shall be of non-magnetic material. HV cable box shall be suitable for termination of specified size of XLPE insulated cable. The head-room available between cable gland plate and terminals shall not be less than 600mm for cable upto 11 kV, and 900 mm for 22 kV and 33 kV cables. Cable box and disconnecting chamber shall be air insulated.

6.3.2. Cable box shall be weatherproof to minimum IP-55. For fixed portion of cable box, inspection cover with lifting handle shall be provided.

6.3.3. Primary cable box (where applicable) shall be able to withstand specified primary system fault level for 0.20 second.

6.4. Terminal chamber for bus-duct termination shall have a gasketed cover plate bolted to it and shall be weatherproof to IP-55. A separate inspection cover with lifting handle shall be provided to facilitate connection and inspection.

6.5. Marshalling box shall be weatherproof and vermin proof with minimum IP-55 degree of protection. All protective devices and neutral CTs shall be wired by means of XLPE insulated copper conductor armoured cables (As per IS 7098-Part 1), FRLS type upto the marshalling box. Terminals shall be clamp type. Removable gland plate with double compression type glands shall be provided. Lamp with switch & socket shall be provided in the marshalling box. Preferably, marshalling box shall be located on the front side of transformer unless authorised by purchaser. Marshalling box for the distribution transformer shall be mounted on the transformer. Marshalling box for power transformer shall be mounted on transformer/ wall mounted/ pedestal mounted as agreed by purchaser.

6.6. For transformers having provisions for terminating TPN bus duct on the 433V side, neutral of the star connected secondary winding shall be brought out to a secondary terminal chamber. CT(s) shall be mounted (if specified) on the neutral terminal with CT secondary wired up to the marshalling box.

6.7. A separate neutral bushing shall be provided for neutral earthing of transformers. The neutral CT(s) shall be mounted as below: -.

a) CT for 51G shall be located in the earth path after bifurcation of neutral.
b) CT for 64 R can be located before bifurcation of neutral.

Supporting arrangement for GI strip/cable as applicable shall be provided for connection of neutral bushing to earth/NGR.

6.8. All contacts including 'spare contacts' and 'contacts for Owner's interface' shall be duly wired & terminated at the terminal block.

7.0 COOLING

7.1. Type of cooling shall be in accordance with MR/ Tender.

7.2. Forced air-cooling system shall have a weather proof IP-55 control panel to be installed on the body of the transformer, complete with cooler controls and cable glands necessary for Purchaser's external cable connections. Contacts shall be provided for remote indication/alarm for following operating conditions:

a) Auto/manual selection
b) Winding over temp.
c) Fans ON (for each fan separately) & Fans tripped (for each fan separately).

Cooling fans shall be complete with mounting/supporting structure. These shall be suitably sized to limit the temperature rise of the transformer to specified values with continuous maximum loading of ONAF/KNAF rating and at maximum specified ambient temperatures. One standby fan per 50% cooler bank shall be provided.

In Auto mode, all fans including redundant fans shall be running. In manual mode, provision shall be made for starting each fan independently.

8.0 TAPPINGS & CONTROL

8.1. These shall be provided on high voltage side and connected to off circuit or on-load tap changing gear as specified in MR/ Tender. Under conditions of external short circuit, the tap changing equipment shall be capable of carrying the same current as the windings.

8.2. **Off circuit tap changing gear:**

Off circuit tap changing gear shall have an external operating handle mounted on the transformer side and shall meet the following requirements:

a) Positive snap-action contact changing
b) The mechanism shall be such that it is impossible for the contacts to be set in a position whereby the windings remain open-circuited or partly short-circuited.
c) Mechanical stops at the ends shall be provided to prevent overrun.
d) The driving rod through cover or tank wall shall be properly sealed against oil leakage under all service conditions.

The handle shall be metallic and adequately sized in order to allow operation without the need of tools and shall be located in a directly accessible position.

The handle shall be provided with padlock facilities to lock the tap changer in the desired position.

Tap positions shall be clearly marked in line with the data given on the rating plate.

8.3. **On Load Tap Changer**

8.3.1. High speed on load tap changing gear with number of steps as specified on MR/ Tender shall be provided and mounted on the transformer. The OLTC gear shall have diverter resistance and the current diverting contacts shall be housed in a separate oil chamber segregated from the main tank of the transformer. The contacts shall be accessible for inspection and their tips shall be replaceable.

OLTC oil chamber shall have oil filling, drain and sampling facility. It shall be provided with oil level indicator, connection orifices, valves and silica gel breather. Pressure relief device with trip contact and oil surge relay with trip contact shall be provided for OLTC.

8.3.2. OLTC shall be provided with local and remote controls.

8.3.2.1. **Local Control**

a) Manual-Mechanical Control

The cranking device for operation of the OLTC gear shall be removable type and located at a height not exceeding 1500mm above ground level for easy operation. The mechanism shall be complete with normal accessories including at least the following: -

i. A mechanical tap position indicator (Rated tap voltages shall be marked on the diagram plate).
ii. A mechanical operation counter.
iii. Mechanical stops to prevent over cranking of the mechanism beyond extreme tap positions.

b) Electrical Control

Control circuit shall incorporate the following:

i. Local/remote manual electrical operation.
ii. Device to ensure a positive and full completion of tap change once it is initiated even if here is loss of power.
iii. An interlock to cut-off electrical control automatically upon recourse being taken to manual mechanical control in emergency.
iv. Electrical interlock to cut-off a counter impulse for a reverse tap change, being initiated during a progressive tap change and until the mechanism comes to rest and resets circuits for a fresh operation.
v. All auxiliaries and devices for electrical control of OLTC gear shall be housed in a weather-proof cabinet mounted on the transformer and shall include:
   - Local tap position indicator
   - 5-digit operation counter
   - Cubicle lighting
   - Thermostatically controlled space heater.
   - Miniature circuit breaker with magnetic and thermal overload devices for controlling the incoming supply to the OLTC motor.
   - Padlocking arrangement for the hinged cabinet door.
   - Removable plate with cable glands.
   - Inside tag with control scheme indelibly marked.

8.3.2.2. **Remote Tap Changer Control Panel**

a) Remote Tap Changer control panel shall comprise of the following:

- Individual/parallel control on Master follower sequence selector switch.
- Raise/lower control switch.

- Potentiometer type tap position indicator.
- Out of step relay.
- Time delay relay.
- Indicating lamp for out of step.
- Out of step buzzer.
- Indicating lamp for tap changer supply available.
- Indicating lamp for tap change in progress.
- Voltage Sensing Relay (If specified)

b) RTCC panel shall be dust & vermin proof, floor mounting, and free-standing type. The enclosure shall be cold rolled sheet of 2.0 mm thickness. All doors and opening shall be provided with neoprene gaskets. RTCC can be offered in conventional or digital configuration unless a specific type of RTCC is mentioned elsewhere in the MR/ Tender.

8.3.3. OLTC, wherever called for, shall be suitable for bi-directional power flow.

9.0 ACCESSORIES

9.1. The following accessories shall be provided as a minimum:

a) Rating Plate
b) Terminal marking Plate
c) Two earthing terminals
d) De-hydrating breather
e) Conservator
f) Air release Device (for transformers with conservator)
g) Oil filling hole with cover
h) Oil Level indicator with alarm contact
i) Thermometer pocket
j) Oil temperature indicator with alarm & trip contacts
k) Winding temperature indicator with alarm & trip contacts (for transformers of rating 500 KVA and above)
l) 4-20mA transducers for OTI & WTI (For Transformers rated above 1000kVA)
m) Pressure relief valve shall be provided (with trip contact)
n) Sampling valve
o) Conservator drain valve
p) Top oil filter valve
q) Drain cum bottom filter valve
r) Double float Buchholz relay
s) Separate neutral bushing outside terminal box with connector assembly
t) Inspection cover
u) Terminal box
v) Marshalling box
w) Lifting lugs
x) Jacking lugs
y) Cross channels with towing lugs
z) HV and LV bushings

9.2. Conservator shall be complete with oil filling plug and cap, oil drain valve, oil level gauge in addition to magnetic oil level gauge. A flexible oil resistance air bag shall be provided for conservator for transformer rated above 2500kVA unless specified otherwise in MR/ Tender. Air bag shall be designed to withstand repeated expansion and contraction due to changes in oil level.

9.3. Separate buchholz relay shall be provided for main tank and OLTC chamber. This shall be double float type for the main tank with separate normally open trip and alarm contacts. For the OLTC chamber the relay shall be of single float type or oil surge relay with one trip contact. Isolating valve shall be provided on either side of the relay and distance piece shall be supplied.

9.4. Size of valves for drain, filter and sampling shall be as per table below.

Transformer rating (kVA)	Size of drain valve (mm)	Size of filter valve mm	Size of sampling valve Mm
Upto 1600	25	25	15
>1600 to 10000	50	25	15
>10000 to 25000	80	50	15
>25000 to 50000	100	50	15
>50000	100	50	15

9.5. ECS Interface signals as listed below shall be provided if specified in the data sheet / projects specifications.

a) Selector switch status (OLTC/RTCC/Remote Control mode)
b) Master / Follower status
c) Auto/Manual mode status
d) Tap changer out of step status
e) Tap changer stuck status
f) Tap changer status signal (Digital) for each step
g) Control Supply failure for RTCC Panel / OLTC
h) Raise/Lower Control from ECS

10.0 NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM (NIFPES)

Nitrogen Injection Fire Prevention and Extinguishing System (NIFPES) provided by the manufacturer/ vendor shall be complete in all respects. The scope shall cover design, supply, installation, connections, testing & commissioning. The scope also includes provision of heat/ fire detectors (sensors), required pipes, cable connections etc. All other components meant for activation and successful operation of the NIFPES shall be provided by the manufacturer/vendor.

10.1. Nitrogen Injection Fire Prevention and Extinguishing System (NIFPES) shall be designed to prevent the fire from taking place in the transformer and possible explosion of transformer tank due to internal faults/ arcing. In case of fire inside the transformer tank, the NIFPES shall be capable of extinguishing the fire, minimizing the damage to the transformer and thus avoiding the spread of fire.

10.2. NIFPES system shall work on the principle of drain and stir of transformer oil. On activation of NIFPES, it shall isolate conservator tank oil from the oil in the main transformer tank, drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, and inject nitrogen gas from the bottom side of the tank through the inlet valves to create stirring action and reduce the temperature of oil to prevent/ extinguish the fire. On the operation of NIFPES, the quantity

of oil removed from the tank shall be such that adequate amount of oil shall remain in the transformer to cover the active part of the transformer i.e. the core-coil assembly. The NIFPES shall be designed in such a way that heat/ fire detection period upon commencement of incident will be maximum 10 second and fire extinguishing period on commencement of Nitrogen injection shall be 30 second (maximum).

10.3. The detection properties of the detector/ sensor shall be site configurable.

10.4. Electrical isolation of transformer shall be an essential pre-condition for activation of NIFPES system.

10.5. **Operation controls**

The system operation shall be automatic and will be activated when the pre-set conditions of activation of the system are attained/triggered. Maximum time period for extinction of fire from commencement of nitrogen injection into the transformer shall be 30 seconds. In addition to automatic operation, remote operation from the control room/remote centre/local control in the fire extinguishing cubicle (FEC) shall also be provided. System shall operate in the following situations:

10.5.1. **System Activation in Fire Prevention Mode**

To prevent fire and explosion in the transformer including that from internal fault, signals from the following shall be used to activate the NIFPES:

a) Operation of either of the protective relays i.e. differential or restricted earth fault REF) or over current;

AND

b) Operation of either protective relays [Buchholz Relay or Pressure Relief Valve (PRV)] or the signal from Rapid Pressure Rise Relay (RPRR)

AND

c) Operation / Feedback of tripping of associated circuit breakers

Transformer shall be electrically isolated after which only the NIFPES shall operate. In case of some problem in main protection, the NIFPES shall derive the operation signal from the backup protection.

However, the exact logic for system activation shall be finalized during detailed engineering.

10.5.2. **System Activation in Fire Detection Mode**

In case of fire detection mode, signals from the following shall be used to activate the NIFPES:

a) Fire/heat detectors/sensors

AND

b) Operation of either of the protective relays [Buchholz relay or Pressure Relief Valve (PRV) or Rapid Pressure Rise Relay (RPRR)]

AND

c) Operation / Feedback of tripping of associated circuit breakers

Transformer shall be electrically isolated after which only the NIFPES shall operate. In case of some problem in main protection the NIFPES shall derive the operation signals from the backup protection system.

However, the exact logic for system activation in fire detection mode shall be finalized during detailed engineering.

10.5.3. If the fire detection is not associated with any other fault, the system activation shall be manual. Manual operation switch with a proper cover to avoid inadvertent operation of the switch, shall be provided in the control room / remote center and in FEC. Interlock shall be provided so that manual operation shall work only when the transformer is completely electrically isolated. NIFPES shall operate once the circuit breakers are isolated and feedback signal for isolation of breakers is received on NIFPES panel. The manual operation of NIFPES shall override the automatic operational mode and the operator shall ensure the complete isolation of the transformer before activation of the NIFPES.

10.5.4. The NIFPES manufacturer should provide the warning information on the Control Box and Fire Extinguishing Cubicle (FEC) that *"Ensure that HV, IV and LV breakers are open before operating in Manual Mode"* both in Hindi and English and the local language as prevalent.

10.5.5. The logic for OLTC and Cable box protection shall be on similar lines as that of transformer main tank in case if separate provisions are being provided by transformer OEM.

10.6. **Operation of System**

On receiving activation signal, the system shall:

a) Open the quick opening drain valve of transformer to drain its top layer oil (pre-determined quantity);
b) Shut off the transformer conservator isolation valve (TCIV) to prevent flow of oil from the conservator tank to the main transformer tank; and
c) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated. There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

The system shall be designed in such a manner that Nitrogen purging shall commence only after ensuring that the oil draining has commenced.

10.7. **Technical Particulars**

10.7.1. The vendor/manufacturer shall be responsible for design of the complete system and shall submit the drawings and design calculations for the number of Heat (Fire) detectors (sensors), sizing of drain pipe, Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc and get approval from the user. The facility shall be provided to test the system by operation of valves [Nitrogen injection valve, TCIV and Oil Drain Valve (ODV)] when the transformer is in service, without actually draining the oil and injecting Nitrogen in real time operation by obtaining the feedback from valve. The Nitrogen injection scheme shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/leakage of valve.

10.7.2. The oil drain mechanism may or may not be a part of the fire extinguishing cubicle.

10.7.3. Owner shall provide two distinct station auxiliary DC/AC supplies for control power supply purposes. The system shall work on station DC/AC supply with voltage variation as per relevant standards. The control box of fire prevention and extinguishing system shall have facility to receive these DC/AC supplies for auto changeover of supply. It shall be the Vendor's/NIFPES supplier's responsibility to further distribute power to the required locations. In case auxiliary DC/AC power supply requirement is different than station auxiliary DC/AC supply, then all necessary converters shall be provided by the Vendor.

10.7.4. Following minimum indications and alarms shall be provided in the control cubicle in the control room:

a) DC supply 'ON'
b) AC supply 'ON'
c) Total System Healthy
d) DC supply fail
e) AC supply fail
f) System out of Service
g) Differential relay trip
h) PRV trip/RPRR trip
i) Buchholz Relay trip
j) Master Relay trip [(HV, IV and LV (Tertiary Voltage)]
k) Restricted Earth Fault (E/F) Relay Trip
l) Overcurrent Relay Trip
m) Nitrogen cylinder pressure low
n) Fire alarm
o) Heat/Fire detector/Sensor faulty Signal
p) Heat/Fire Detector/Sensor alarm/signal
q) Nitrogen injection Valve open
r) Nitrogen injection Valve close
s) Nitrogen injection Valve leakage
t) Oil drain Valve open
u) Oil drain Valve Close
v) Leakage in Oil drain valve
w) TCIV Open
x) TCIV Closed
y) Cable fault signal for interconnecting cable for transformer trip signals
z) Auto operation failed
aa) NIFPES system in Auto Mode
bb) NIFPES system in Manual Mode
cc) NIFPES system in Test / Maintenance mode

Another indicator which supplier/user consider necessary shall also be provided.

10.7.5. The following push buttons shall be provided as a minimum:

a) Mode Selection Switch, Auto/Manual/ (test/Off)
b) Lamp test push buttons
c) System reset push button

d) Detector reset push button, if applicable.
e) Manual extinction push-button for manual operation of the system
f) Hooter reset push button

10.7.6. Apart from the above list Nitrogen cylinder pressure indication manometer with sufficient number of adjustable 'Normally Opened (NO)' contacts shall also be provided in FEC. In case of fire in the transformer and fulfilling the conditions of defined logic for NIFPES operation for fire extinguishing mode and fire prevention mode alarm (Audio & Visual) will be generated in control room.

10.8. **Technical Data Sheet:**

The following are the technical requirements of the NIFPES:

Sl. No.	Item	Requirements
1.	Fire detection period on commencement of fire	Maximum 10 seconds
2.	Fire Extinction period on commencement of Nitrogen injection	Maximum 30 seconds
3.	Fire detectors'/ sensors' "heat sensing" temperature	120 ^{0}C temperature of the transformer oil minus 5 ^{0}C with tolerance of +/- 2^{0}C.
4.	Power source for: a) Control Box b) Fire extinguishing cubicle	 110/220 V DC (+10% & -15%) / 230 V AC 110/220 V DC (+10% & -15%) / 230 V AC
5.	Nitrogen Cylinder and Valve (PESO approved)	As per IS:7285 (Part 2) and IS:3224 (latest) BIS Mark
6.	Degree of protection of (a) FEC Heat (fire) detector / sensor and Signal / Junction box (if any)	(a) IP 65 IP 65
7.	Steel Sheet of FEC, Control Box and Signal Box	Steel sheet shall be as per grade CR2 of IS: 513, Part-1. Thickness of Steel Sheet of FEC and Control Box and Signal Box shall be 3.0 mm minimum
8.	Colour of all panels and Nitrogen Injection pipes	Shade 538 of IS: 5
9.	Heat (fire) detector / sensor	OEM shall furnish technical details
10.	Minimum distance of FEC from the Transformer	FEC should be at a safe distance from Transformer (preferably 5-7 meters). Firewall (minimum 2 hrs fire withstand capacity) will be provided around FEC with the height 600 mm from the top of FEC to protect it from fire of the transformer.
11.	For conservator valve of flow-based mechanism, flow rate for closing of flow-based conservator isolation valve	60 Ltrs. / minute.

In case the pressure in the nitrogen cylinder somehow exceeds the rated pressure, there should be the provision for extracting the excess nitrogen to attain the safe pressure in the nitrogen cylinder.

10.9. **Details of Supply of System/Equipment and Other Related Activities:**

Nitrogen injection fire protection system shall broadly consist of the following components/ devices. However, all other components that are necessary for fast, reliable, complete, and effective working of the fire protection system shall deemed to be included in the scope of supply.

10.9.1. Fire extinguishing cubicle with base frame and containing at least the following:

a) Nitrogen gas cylinder and cylinder valve having the Petroleum and Explosive Safety Organization (PESO) certificates of sufficient capacity.
b) Pressure regulator with indicators for nitrogen pressure of the cylinder and actual injection pressure through nitrogen cylinder and manometer with sufficient number of adjustable 'Normally Open (NO)' contacts.
c) Oil Drain Assembly including oil drain valve and its equipment for operation, oil drain pipe extension of suitable size for connecting pipes to Oil Storage Tank, along with level switch for detecting leakage in oil drain valve;
d) Mechanical release device for oil drain and nitrogen gas release;
e) Limit switches for monitoring of the systems;
f) Panel lighting;
g) Flanges on top of the panel for connecting oil drain in case of oil drain mechanism is part of fire extinguishing cubicle and nitrogen injection pipes for transformer;
h) Fire Extinguishing Cubicle (FEC) shall have proper illumination.
i) The heater with thermostat shall be provided in the FEC. Heater should be operated as per the setting of thermostat.
j) One set of mandatory spares as applicable.

In case if oil drain mechanism is not a part of FEC – the related items shall be as per the Original Equipment Manufacturer (OEM) design, however functional requirements have to be met with.

10.9.2. The FEC shall be provided with canopy / shed to be protected from 3 sides to avoid water ingress and protect the FEC from direct sunlight and radiant heat. The canopy / shed shall be designed to cover almost more than half of the FEC height from top.

10.9.3. Control box/cubicle to be installed in the control room of the substation for monitoring the NIFPES operation, automatic control, and remote operation, with alarms, indications, switches, push buttons, audio signal etc. Control Box/Cubicle should be microprocessor based /PLC based compatible to be interfaced with Owner's/ Purchaser's Supervisory Control and data Acquisition (SCADA) system in the Substation / Switchyard.

10.9.4. The required number of heat/ fire detectors / sensors to be located at strategic locations and to be finalized during detailed engineering. Diagonal / adjacent distance between two heat/fire detectors / sensors shall not exceed more than 800 mm. heat/fire detector / sensor shall be IP 65 approved. All the control / power cables between the NIFPES panel and the transformer, from the control room to FEC, from the Control and Relay Panel to the Control Box / cubicle, Control Box / cubicle to DC / AC supply Source, Signal / junction box to FEC or any additional junction box placed near FEC shall be Fire Survival Cable type up to the thermal limit (in case of fire and or explosion). Fire survival cables shall be suitable to withstand a temperature of 750 °C. Further, Technical Data sheet and applicable valid type test report as per applicable latest IS shall be submitted to the user during detailed engineering.

10.9.5. Transformer Conservator Isolation Valve to isolate the conservator oil from the main tank oil is to be provided by the NIFPES supplier. This valve shall be located in the piping between the conservator and the Buchholz relay.

10.10. **SCADA compatibility**

10.10.1. The NIFPES shall be provided with IEC 61850 / RS 485 / TCP IP compatible port or using suitable converters for integration with user's SCADA system. Integration to SCADA system will be done as per contract outlined by owner, however necessary support shall be provided by NIFPES OEM.

10.10.2. For transformers rating of 25 MVA and above – the control panel of NIFPES shall be HMI (Human Machine Interface) based SCADA system having facility to store and take print out of the events and history of all the alarms & faults occurred into the NIFPES system. The data retention capacity shall be of minimum 6 months.

10.10.3. The HMI screen size shall be of minimum 12" or above as per manufacturer standard. The HMI shall display the graphical representation of the system along with dynamic status of all the valves.

10.10.4. The system shall also be designed keeping in view for addition of GSM modem & card for future so as to send SMS alerts to minimum of 5 personnel.

10.10.5. The ethernet switch, patch cord, Light Interface Unit (LIU) and Fibre Optic (FO) cable are not included in the present scope.

10.11. **Drain Oil Storage Tank**

10.11.1. A drain oil storage tank for each transformer shall be provided at suitable location.

10.11.2. The oil storage tank shall have non-corrosive, waterproof, epoxy coated, mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPES.

10.11.3. The total capacity of storage tank shall be more than 12% of transformer tank oil to avoid over flowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. All the pipes and physical connections from transformer to storage tank shall be in the scope of NIFPES OEM / Vendor.

11.0 ONLINE INSULATING OIL DRYING SYSTEM

11.1. If specified in MR/ tender specification, transformer shall be provided with a cartridge type on line insulating oil drying system of adequate rating with proven field performance. It shall be designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition.

11.2. There shall be molecular sponge device for moisture absorption in easily replaceable cartridges. It shall display the moisture content in oil (PPM) and temperature of the inlet and outlet oil from the drying system. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge.

11.3. The system shall be housed in IP-55 metallic enclosure of grade SS 304. Oil flow to the equipment shall be controlled through pump of suitable capacity with oil flow indicator for visual monitoring of flow. It shall be an integrated system comprising of filters, cartridges, sampling valves, sensors and protection devices, as required for completeness of the system suitable for operating at oil temperature up to 105°C, unless specified otherwise. All components shall be capable of withstanding the applicable thermal and dynamic stress.

11.4. Drying system, if transported without oil, shall be suitable for withstanding vacuum to ensure that no air/ contamination is trapped during commissioning. In case, it is transported with oil, the oil shall conform to specifications for unused transformer oil. Oil sample shall be tested before installation to avoid contamination of main tank oil.

11.5. The equipment shall be capable of transferring data to substation automation system through FO port on IEC 61850 protocol. Potential free contacts for system trip/ off for relaying shall be provided.

12.0 NOISE LEVEL

Audible Noise level shall not exceed the limits specified in NEMA TR-1/ CBIP manual.

13.0 INSPECTION AND TESTING

13.1. Owner's representative shall be given free access in the works from time to time for stage wise inspection and progress reporting. Four weeks advance notice shall be given to witness the final routine test as per relevant IS and other tests as agreed upon. These tests shall be performed on the complete assembly at manufacturer's works. Test certificates duly signed by owner's representative shall be issued as part of final document.

13.2. Routine tests and special tests as listed below shall be carried out on all transformers:

a) GA along with verification of all accessories
b) Dimensional & electrical clearance
c) Rating plate details
d) Terminal/ tapping markings
e) Earthing arrangement
f) Measurement of winding resistance
g) Measurement of voltage ratio and check of voltage vector relationship
h) Measurement of impedance voltage and load loss
i) Measurement of no- load loss and current
j) Induced over voltage withstand test
k) Separate-source voltage withstand test (HV Test)
l) Measurement of insulation resistance before and after HV test
m) Noise level check
n) Magnetic Balance test
o) Dielectric test
p) BDV on transformer oil
q) Tests on OLTC/ control panel (if applicable)
r) Measurement of power taken by fans & oil pumps (on sample basis on one transformer)

13.3. **Additional Tests:**

For transformers rated upto 2.5 MVA rating, oil leakage test, vacuum test and pressure test values shall be as specified in IS-1180-1/ IS-1180-3. For transformers rated > 2500 kVA following shall be considered:

13.3.1. Oil leakage Test - All tanks and oil filled compartments shall be tested for oil tightness by being completely filled with air/oil of a viscosity not greater than that of insulating oil at an ambient temperature and subjected to a pressure equal to the normal pressure plus 35 kN/m2 measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air, during which time no leakage shall occur.

13.3.2. Vacuum Test - One transformer tank of each size shall be subjected to the specified vacuum as in Table-1 below. The tanks designed for vacuum of 760mm of mercury shall be tested at a maximum internal pressure of 3.33 kN/m^2 (25mm of Hg) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in Table-2 below without affecting the performance of the transformer.

Table – 1

Highest System Voltage	MVA Rating	Vacuum Gauge pressure kN/m2	mm of Hg
Upto 36 kV	above 2.5 & upto 20	68.0	500
	Above 20	100.64	760

Table – 2

Horizontal length of flat plate (in mm)	Permanent deflection (in mm)
Upto and including 750	5
751 to 1250	6.5
1251 to 1750	8
1751 to 2000	9
2001 to 2250	11
2251 to 2500	12.5
2501 to 3000	16
Above 3000	19

13.3.3. Pressure Test - One transformer tank of each size shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/m2 whichever is lower measured at the base of the tank and will be maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified in Table-2.

13.3.4. One transformer of each rating shall be subjected to heat run test, if specified in MR/ Tender.

13.3.5. Impulse test, if specified in MR/ Tender, shall be carried out on all three limbs of the transformer.

13.3.6. Transformer shall be subjected to short circuit test, if specified in MR/ Tender.

13.3.7. All the instruments, meters, etc. used for testing shall be duly calibrated at NABL laboratory and necessary calibration certificate shall be made available during inspection.

13.3.8. Type test report of the heat/fire Detector/Sensors shall be submitted to Owner/ EIL along with the design/drawing documents.

14.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers, P.O. number etc.

Transformer tank shall be filled with oil/ pure dry nitrogen/ air depending upon the transport weight limitations or as specified in MR/ tender specifications. Dry air should be preferred due to safety of personnel entering transformer. If nitrogen is used, the information shall be stencilled on tank prominently. External gas cylinders should be provided to make up any gas leakage during transit and storage. Pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

शुष्क किस्म के लाईटिंग ट्रांसफॉर्मर के लिए विनिर्देश

SPECIFICATION FOR DRY TYPE LIGHTING TRANSFORMER

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.11.2022	REVISED AND REISSUED AS STANDARD SPECIFICATION	MKM	HK	MKS	SM
5	03.04.2017	REVISED AND REISSUED AS STANDARD SPECIFICATION	NT	SA	BRB	RN
4	08.04.2011	REVISED AND ISSUED AS STANDARD SPECIFICATION	MK	SA	UAP	DM
3	25.04.2008	REVISED AND ISSUED AS STANDARD SPECIFICATION	SA	NS	JMS	VC
2	25.03.03	REVISED AND ISSUED AS STANDARD SPECIFICATION	NPG	RR	VPS	SKG

Abbreviations:

AN	:	Air Natural
BIS	:	Bureau of Indian Standards
BS	:	British Standards
CEA	:	Central Electricity Authority
CRCA	:	Cold Rolled Cold Annealed
IEC	:	International Electro technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
KVA	:	Kilo Volt Amperes
MSL	:	Mean Sea Level
MV	:	Medium Voltage
NEMA	:	National Electrical Manufacturers Association
PO	:	Purchase Order
PVC	:	Polyvinyl Chloride
SWG	:	Standard Wire Gauge
VDE	:	Verband Der Electrotechnik, Elecktronik und Information Stechnik

Electrical Standards Committee

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Mr. Vijay Kumar
Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of cast resin / resin impregnated dry type lighting transformers suitable for indoor location.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS.

IS: 5	:	Colours for ready mixed paints and enamels
IS: 1271	:	Electrical Insulation-thermal evaluation and designation.
IS: 2026: Part 11 / IEC: 60076-11	:	Dry Type Transformer
IS: 2705: Part I	:	Current transformers - General requirements
IS: 10028	:	Code of practice for selection, installation and maintenance of transformers.
IS/ IEC: 60529	:	Degree of protection provided by enclosures (IP Code)
ECBC 2017	:	Energy Conservation Building Code

2.2 In case of imported equipments standards of the country of origin shall be applicable provided these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However Owner's / EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 All the offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the user of equipment and EIL, before phasing out the product/ spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres found in Refineries, Petrochemical and Fertilizer plants or as specified in the material requisition / tender. The transformer shall be designed to operate under site conditions as specified in data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000m above MSL shall be considered.

5.0 CONSTRUCTION

5.1 The transformer shall be dry type, AN cooled suitable for indoor installation. Transformer shall be conventionally housed in a freestanding panel type enclosure of welded sheet steel frames with expanded metal screens of suitable size or louvres backed by wire-mesh. Transformer and the enclosure shall be suitably reinforced to prevent distortion during handling.

For panel mounted transformer, if specified in datasheet, the panel shall be floor mounted type suitable for installation in substation and shall not have any wheels / rollers. The panel shall be provided with integral base frame which shall be suitable for tack welding.

The frame of vertical panels of panel mounted transformer shall be fabricated using pressed and cold rolled sheet steel. The sheet steel used for panel shall be of minimum 2mm (14SWG) CRCA except the doors and covers that may be made of 1.6mm (16SWG) CRCA. Wherever required, stiffeners shall be provided to increase mechanical strength of large size doors and covers.

5.2 After preparation of the under surface, the vertical panels of panel mounted transformer shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL-7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.
All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

5.3 The transformer shall be double wound core type with non-ageing, cold rolled grain oriented silicon steel insulated laminations with high magnetic permeability and clamped to minimise vibrations and noise. Core lamination shall be free of burrs and shall be stacked without Air gaps. Core fastening bolts shall be insulated to reduce losses and to avoid hot spots. All parts of the magnetic circuit shall be effectively connected to the earth system.

5.4 The winding shall be of copper and shall be designed for full load current and to withstand the thermal and electromagnetic stresses arising due to the through fault current. The current carrying winding joints shall be electrically brazed. Foil type windings are not acceptable.

5.5 Voltage ratio of lighting transformer shall be as mentioned in Datasheet/Material Requisition/Tender.

5.6 Vector group of transformer shall be as mentioned in Datasheet/Material Requisition/Tender. The windings shall be provided with class 'F' insulation for lighting transformers upto 100 KVA and class 'H' insulation for rating more than 100 KVA.

5.7 Conventional Lighting Transformer shall have minimum degree of protection as IP-23. The enclosure of panel mounted transformer shall be dust and Vermin-Proof and shall provide a degree of protection not less than IP-41. In case of conventional transformer, Marshalling box and cable termination box shall have degree of protection not less than IP-55.

5.8 Different non current carrying parts of the transformers shall be connected by copper flexibles for earth continuity purpose.

5.9 All doors and movable parts of panel mounted transformer shall be earthed, using flexible copper connections, to the fixed frame of the panel. The panel mounted transformer shall be provided with two earthing studs with lugs on the external surface of the enclosures suitable for termination of GI strip / earthing cable.

5.10 All the fasteners and bolts shall be galvanized. All surfaces to be painted shall be thoroughly cleaned, descaled, made free from rust and shall be epoxy painted.

5.11 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on panel mounted transformer. 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.

5.12 Dry type transformer shall be energy efficient with permissible maximum losses at 50% and 100% loading not exceeding the values as defined in Energy Conservation Building Code (ECBC) - 2017.

6.0 TERMINALS

6.1 Windings shall be brought out and terminated in cable boxes for conventional lighting transformer.

6.2 Cable boxes shall be supplied with cable lugs and glands. For MV XLPE power/control cables single compression cable glands and crimped type tinned copper cable lugs shall be supplied. Gland plate shall be removable type. For single core cables, gland plate shall be of non-magnetic material.

6.3 In case of panel mounted transformer, panel shall be provided with bottom cable entries for connecting both primary and secondary windings of transformer installed inside panel. Thus a separate cable termination box is not required. Primary and secondary cable termination arrangement inside panel shall be oriented accordingly for routing and termination of Owner's cables inside panel.

6.4 A separate neutral terminal on the secondary side shall be provided for neutral earthing of the transformers. The neutral terminal shall be complete with connector block assembly for easy termination of GI earth strip / cable.

7.0 ACCESSORIES

Tappings shall be provided on the Primary side. Tap changer shall be off-circuit rotary type or tap links type. Under conditions of external short circuit, the tap changing equipment shall be capable of carrying the same current as the winding. Tap changer regulation range shall be +5% / -7.5% with each step of 2.5%. Tap changing mechanism shall be easily accessible and it shall be possible to change the taps without opening the main transformer enclosure.

Base channels shall be provided with skids and pulling eyes to facilitate handling. Tag plate shall be provided. In case of panel type transformer, suitable removable type eye bolts /lifting hooks shall be provided on the panel to facilitate lifting and handling of the panel. These eyebolts /lifting hooks when removed shall not leave any opening in the panel.

Temperature monitoring system shall be supplied with temperature sensors fitted in each limb. Temperature monitoring system shall initiate alarm and trip for winding over temperature. Alarm and trip temperatures value shall be site settable. The monitoring system shall also have an indicating device.

240V SPN supply at one point shall be provided by purchaser at transformer panel. All the further distribution from this point shall be done by vendor.

ON/OFF Indication Lamps mounted on the door and LED lamp controlled through a door limit switch shall be provided for illumination inside the panel for panel mounted type transformer.\

8.0 NOISE LEVEL

Audible noise level for lighting transformers shall not exceed the limits specified as below:

KVA	Average sound level in decibels (At 30 cm from transformer)
0-50	50
51-150	55
151-300	58
301-500	60

9.0 INSPECTION AND TESTING

9.1 During fabrication, the transformer shall be subject inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

9.2 For testing requirements, refer Inspection & Test Plan doc. no. 6-81-1042. Prior notice of minimum 4 weeks shall b given to EIL/Owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. All testing shall be carried out at manufacturer's works under his care and expense.

9.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1042.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers, P.O. number etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

शुष्क किस्म के डिस्ट्रीब्यूशन ट्रांसफार्मर के लिए विनिर्देश

SPECIFICATION FOR DRY TYPE DISTRIBUTION TRANSFORMERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	10.12.21	REVISED AND REISSUED AS STANDARD SPECIFICATION	MKM	HK	PG	SM
5	23.11.16	REVISED AND REISSUED AS STANDARD SPECIFICATION	NT	SA	BRB	RN
4	11.04.11	REVISED AND REISSUED AS STANDARD SPECIFICATION	MK	SA	UAP	DM
3	21.03.11	REVISED AND REISSUED AS STANDARD SPECIFICATION	NT	SA	UAP	DM
2	20.09.05	REVISED AND REISSUED AS STANDARD SPECIFICATION	ND	AKT	AAN	VJN

Abbreviations:

BIS	:	Bureau of Indian Standards
CEA	:	Central Electricity Authority
CT	:	Current Transformer
EIL	:	Engineers India Limited
GI	:	Galvanised Iron
HV	:	High Voltage
IEC	:	International Electrotechnical Commission
IP	:	Ingress Protection
IS	:	Indian Standard
KVA	:	Kilo Volt Amperes
MSL	:	Mean Sea Level
MV	:	Medium Voltage
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
XLPE	:	Cross Linked Poly Ethylene
51G	:	Back up Earth Fault Protection Relay
64R	:	Restricted Earth Fault Protection Relay

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Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of cast resin / resin impregnated dry type distribution transformers.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified.

IS: 1271	:	Electrical Insulation-thermal evaluation and designation
IS: 2026, Part 11	:	Power Transformer - Dry-Type Transformer
IS: 2705, Part 1	:	Current transformers - General requirements
IS: 10028	:	Code of practice for selection, installation and maintenance of transformers
IS: 11171	:	Dry type power transformers
IS: 16227 / IEC: 61869	:	Instrument transformers
IS/IEC: 60529	:	Degrees of Protection Provided by Enclosures (IP Code)

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of the CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However Owner's / EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres found in refineries, Petrochemical and Fertiliser Plants or as specified in the Material Requisition / Tender. The transformer shall be designed to operate under site conditions as specified in data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000 m above MSL shall be considered.

5.0 CONSTRUCTION

5.1 The transformers shall have core type construction. The core shall be assembled out of low-loss, nonageing, high permeability cold rolled grain oriented steel laminations.

5.2 The windings shall be of high-grade electrolytic copper. The insulation system for cast resin transformers shall comprise of windings cast under vacuum, free of voids in a homogenous uniform laminate of epoxy resin/ polyester resin. The totally assembled core and coil assembly, for resin impregnated transformers, shall be vacuum pressure impregnated to effectively make it impermeable to moisture, dirt, salt, air and other industrial contaminants.

5.3 The entire core assembly shall be covered with a resin-based lacquer for corrosion protection.

5.4 Lifting lugs shall be provided for core and winding assemblies.

5.5 The HV and MV windings shall have class 'F' or better insulation. The temperature rise of windings under continuous full load shall not exceed the maximum allowable temperature for the appropriate class of insulation as per IS 11171/ IS 2026-11, above the design temperature specified in the data sheet.

5.6 The insulation material used shall be non-hygroscopic, non- inflammable and self-extinguishing if ignited by direct flame or arc. No toxic or harmful gases shall form during heating and /or burning. The insulation materials shall be sufficiently resistant to ageing.

5.7 The transformers shall be capable of withstanding the thermal and mechanical effects of a dead short circuit on any or all winding terminals with full voltage maintained on other windings as per IS. The transformers shall sustain a symmetrical short circuit on secondary terminals for 2 seconds without damage or impairment.

5.8 Each limb shall have two solid state winding temperature monitoring elements to initiate an alarm and trip for winding over temperature.

5.9 The transformers for Indoor & outdoor location shall have minimum degree of protection as IP 23 & IP 43 respectively. However the marshalling box, cable termination box, bus-duct termination chamber etc. shall have a degree of protection not less than IP-55.

5.10 All fasteners and bolts shall be galvanised.

5.11 The transformers shall be spray-painted or powder coated with epoxy paint. Colour shade of final paint shall be as specified in the data sheet.

5.12 The transformer shall be provided with a rating plate of weatherproof material, fixed in a visible position mentioning Tag Number and Transformer details as per IS 11171/ IS 2026-11.

6.0 TERMINAL AND MARSHALLING BOX

6.1 Windings shall be brought out on suitable nickel-plated copper terminals for cable termination. HV side termination shall be from the bottom. Suitable disconnection chambers shall be provided to permit the transformer to be removed without disconnecting the cable termination. The MV side termination shall be by bus-duct or cable as defined in datasheet / job specification.

6.2 The high voltage and medium voltage cable termination arrangement shall be complete with cable box and bolted type undrilled cable gland plates. Non-magnetic gland plate shall be provided for single core cables.

6.3 Primary cable box shall be able to withstand specified primary system fault level for 0.2 secs.

6.4 Terminal chamber for busduct termination shall have a gasketed cover plate, bolted to it. Separate inspection covers shall be provided to facilitate connection and inspection.

6.5 All protection, alarm and indication devices and neutral CTs shall be wired by means of PVC/ XLPE insulated cables upto the marshalling box. There shall be two gland plates, one for internal wiring to the marshalling box from various devices which shall be glanded and pre-wired, while the second gland plate shall be removable and undrilled for glanding outgoing cables.

6.6 One neutral terminal inside the cable box/ MV bus-duct connection chamber and a separate neutral terminal outside shall be provided for earthing of transformer winding neutral on the secondary side. The neutral terminal shall be complete with connector block assembly for easy termination of GI earth strip/cable.

6.7 The neutral CT shall be mounted as below:-

a) CT for 51G shall be located in the earth path after bifurcation of neutral.
b) CT for 64 R can be located before bifurcation of neutral.

6.8 Two earthing terminals shall be provided on the transformer frame for transformer body earthing. Suitable lifting arrangement shall be provided in the transformer frame. The transformer shall be supported on flat rollers.

6.9 Phase identification markings shall be provided for the terminals in HV and MV side terminal boxes.

7.0 COOLING

Type of Cooling shall be in accordance with the datasheet.

8.0 TAPPINGS AND CONTROLS

Primary off-circuit rotary type tap changer shall be provided and shall have a range as specified in the data sheet. Tap changing arrangement through links is not acceptable. Under conditions of external short circuit, the tap changing device shall be capable of carrying the same current as the windings.

9.0 ACCESSORIES

9.1 Accessories as specified on data sheet shall be included in the scope of supply. All protective, alarm and indicating devices shall have minimum 1 no. potential free contact each for alarm and trip. All transformers must be provided with at least the following:

- Bi-directional flat rollers
- Rating and terminal marking plate
- Marshalling box
- Lifting hooks and jacking pads, towing holes
- Earthing terminals
- Neutral CT (as per data sheet)
- Off-circuit tap changer
- Temperature monitoring system (For rating 500 KVA & above)

9.2 Temperature monitoring system shall be supplied with temperature sensors fitted in each limb. Temperature monitoring system shall initiate alarm and trip for winding over temperature. Alarm and trip temperatures shall be site settable. The monitoring system shall also have an indicating device.

10.0 NOISE LEVEL

The average audible sound level for the transformers at a distance of 30 cm shall be as below:

KVA	AVERAGE SOUND LEVEL (DECIBEL)
0-50	50
51-150	55
151-300	58
301-500	60
501-700	62
701-1000	64
1001-1500	65
1501-2000	66
2001-3000	68
3001-4000	70
4001-5000	71

11.0 INSPECTION AND TESTING

11.1 During fabrication, the transformer shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

11.2 For testing requirements, refer Inspection & Test Plan doc. no. 6-81-1044. Prior notice of minimum 4 weeks shall be given to EIL/ Owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. All testing shall be carried out at manufacturer's works under his care and expense.

11.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1044.

12.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains and high ambient temperature. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be supplied duly enclosed in a waterproof cover along with the shipment.

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SPECIFICATION FOR STATIONARY NICKEL CADMIUM BATTERIES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	19.08.2021	REVISED AND ISSUED AS STANDARD SPECIFICATION	SS	RS	PG	SM
3	14.07.2016	REVISED AND ISSUED AS STANDARD SPECIFICATION	PB/MHR	RS	BRB	RN
2	11.04.2011	REVISED AND ISSUED AS STANDARD SPECIFICATION	CS	PG	UAP	DM
1	27.08.2007	REVISED AND ISSUED AS STANDARD SPECIFICATION	AP	NS	JMS	VC

Abbreviations:

AC	Alternating current
Ah	Ampere hour
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
DC	Direct current
EIL	Engineers India Limited
IEC	International Electrotechnical Commission
IS	Indian Standard
MSL	Mean Sea Level
PO	Purchase Order
PVC	Polyvinyl Chloride
UPS	Uninterrupted Power Supply
V	Volt

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Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the design, Manufacture, testing and supply requirements of stationary vented type Nickel Cadmium cell/batteries for DC power system /AC UPS system application.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS:

IS-10918 Specification for Vented type Nickel Cadmium batteries

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

2.5 In case of any conflict between various referred standards/ specifications/ datasheets and statutory regulations, the most stringent requirement shall prevail and Owner's/ EIL's decision in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/ spares to enable the end user to place order for spares and services.

4.0 SITE CONDITIONS

Stationary Nickel Cadmium cell/battery shall be suitable for operating satisfactorily in humid and corrosive atmosphere found in refineries, petrochemical and gas processing plants, metallurgical plants and other industrial plants. Service conditions shall be as specified in the data sheets/job specification. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000m above MSL shall be considered, with a minimum temperature of 10°C for battery sizing.

5.0 TECHNICAL REQUIREMENTS

5.1 The Nickel Cadmium cell/battery shall be suitable for float duty operation with a constant voltage permanently applied to its terminals which is sufficient to maintain it in a state close to full charge and shall be designed to supply load in the event of normal power supply failure. Type of plate construction for batteries shall be as per the data sheet.

5.2 The standard rated ampere hour capacity of the cell/ battery shall be at a reference temperature of 27°C, constant current discharge at 5 hours rate (C5) and an end cell voltage of 1.0 V/cell.

5.3 Ampere hour of the battery shall be selected based on the following criteria:
a. Minimum site ambient temperature of 10°C
b. Discharge duty cycle
c. End cell voltage
d. Ageing factor of 0.8
e. Capacity rating factor

5.4 Number of cells and end cell voltage shall be decided by the vendor on the basis of maximum permissible voltage to the load when batteries are float charged while feeding the load and minimum DC system voltage. However, the minimum number of cells and end cell voltage shall be as per the data sheet.

5.5 The battery shall be suitable for being quick charged to fully charged condition from fully discharged condition within 10 hours.

5.6 Battery assembly shall be supplied empty, dry and uncharged. Packed unused liquid electrolyte with 10% extra shall be delivered with the battery in suitable non returnable sealed containers.

5.7 Each cell/battery shall have a separate container of 1.2V (nominal voltage). The cell container shall be of high strength alkali resistant material and designed to withstand mechanical stresses, shocks and vibrations. The cell container shall be translucent/ transparent and shall have minimum & maximum levels markings.

5.8 The terminal posts shall be of nickel plated steel. The terminals shall be suitable for short circuit current and specified discharge current without damage to the cell as a result of terminal heating.

5.9 Stationary Nickel Cadmium cells/battery shall be designed to withstand the mechanical stresses encountered during normal transportation and handling.

5.10 Flame arrestor with venting device and cap shall be mounted on the cell so that all the vented gases diffuse through the arrestor to the outside environment. The construction of the arrestor shall be such that hydrogen burning on the external surface of the arrestor shall not propagate back into the cell to cause explosion.

5.11 The following information shall be permanently marked on the cell.
- Nominal voltage
- Name of manufacturer/model reference
- Rated capacity in ampere hours (Ah) with End Cell Voltage
- Voltage for float operation at 27°C with tolerance of ±1%
- Month and year of manufacture
- Polarity Marking

5.12 Each set of battery shall be supplied with all the accessories, including, but not limited to the following:
a. Battery stand in formation as per data sheet. Mild steel stand pretreated and epoxy painted epoxy powder coated / PVC coated.
b. Inter cell, inter row and inter bank connectors and end take offs. These shall be of nickel plated copper/flexible insulated copper cable/completely insulated solid copper connectors.
c. Cell insulator as applicable.
d. Stand insulator.
e. Cell number plates/permanent stickers, Lugs for cable termination, as required.
f. Other accessories and their quantity as per data sheet.

6.0 PERFORMANCE

Nickel Cadmium batteries shall have been type tested to meet the performance requirements for each design and Ah rating of cells as per Indian Standard referred in clause 2.1 above.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 Batteries shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

7.2 For Testing requirements, refer Inspection & Test Plan for Stationary Nickel cadmium battery (Standard no. 6-81-1047). EIL / Owner's inspector shall be given free access in the works from time to time for stage wise inspection and progress reporting. Prior notice of minimum 4 weeks shall be given to EIL/Owner for witnessing the final tests of battery. Tests shall be carried out at manufacturer's works under his care and expense.

7.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1047.

7.4 Battery load test shall also be performed at site after installation as part of commissioning.

8.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to finish. Crates/cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

छोटे एम.वी. वैरीएबल फ्रीक्वेन्सी ड्राईव सिस्टम के लिए विनिर्देश

SPECIFICATION FOR SMALL MV VARIABLE FREQUENCY DRIVE SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	06 11 19	REVISED AND ISSUED AS STANDARD SPECIFICATION	MKM	HK	SA	RKT
1	20 08 14	REVISED AND ISSUED AS STANDARD SPECIFICATION	MK/SA	HK	BRB	SC
0	24 04 09	ISSUED AS STANDARD SPECIFICATION	AM	SG	JMS	ND

Abbreviations:

AC	:	Alternating Current
AFE	:	Active Front End
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CBCT	:	Core Balance Current Transformer
CEA	:	Central Electricity Authority
CFL	:	Compact Fluorescent Lamp
CRCA	:	Cold Rolled Cold Annealed
DC	:	Direct Current
DCS	:	Distributed Control System
DOL	:	Direct On Line
ELR	:	Earth Leakage Relay
EM	:	Electromagnetic
EMC	:	Electromagnetic Compatibility
FLC	:	Full Load Current
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IGBT	:	Insulated Gate Bipolar Transistor
I/O	:	Input/Output
IP	:	Ingress Protection
IS	:	Indian Standard
LCS	:	Local Control Station
LCP	:	Local Control Panel
LED	:	Light Emitting Diode
MCB	:	Miniature Circuit Breaker
MCCB	:	Moulded Case Circuit Breaker
MTBF	:	Mean Time Between Failure
NEMA	:	National Electrical Manufacturer's Association
PCC	:	Point of Common Coupling
PLC	:	Programmable Logic Controller
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
r.m.s	:	Root Mean Square
THD	:	Total Harmonic Distortion
VDE	:	Verband Deutscher Electrotechniker
VFD	:	Variable Frequency Drive

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Ms. Shalini Verma
Mr. Raman Sood
Ms. Shirali Aggarwal
Mr. Rajesh Sinha (Inspection)
Ms. N.P. Guha (Projects)

CONTENTS

1.0 SCOPE

The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Medium Voltage, AC Variable Frequency Drive (VFD) System for small ratings of air coolers and non critical applications (typically upto 55kW motor ratings). The VFD system shall be complete with Squirrel Cage Induction motor as specified in data sheet, Converter, DC link/AC line reactor with associated auxiliaries, filters(if required) and field mounted local motor control panel.

The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets.

This specification applies to drives connected to line voltage up to 1000 V, AC.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the latest editions of the following standards unless specified otherwise:

IS: 4411 Code of designation of semi-conducting devices

IS: 5001 Guide for preparation of drawings of semiconductor devices and Integrated Circuits

IS: 5469 Code of practice for the use of semiconductor Junction Devices

IS: 8789 Values of Performance characteristics for Three Phase induction motor

IS: 12615 Line Operated Three Phase a.c. Motors (IE CODE) - Efficiency Classes and Performance Specification

IS: 14901 Semi-conductor devices- Discrete devices & Integrated Circuits

IS: 15880 Three Phase Cage Induction motors when fed from IGBT Converters- Application Guide

IS 16724 / IEC 60079-14 Explosive Atmospheres — Electrical Installations Design, Selection and Erection

IEC 60068-2-60 Environmental testing: Tests -Flowing mixed gas corrosion test

IS/IEC 60079-0 Explosive atmospheres: Equipment - General requirements

IS/IEC: 60947 Low Voltage Switchgear and Controlgear

IEC: 60146 Semiconductor Convertors general requirements and line commutated convertors.

IEC 60721-3-3 Classification of environmental conditions: Classification of groups of environmental parameters and their severities - Stationary use at weather protected locations

IS/IEC 61439-0 Low-Voltage Switchgear and Controlgear Assemblies- Guidance to Specifying Assemblies

IS/IEC 61439-1 Low-voltage switchgear and control gear assemblies- General Rules

IS/IEC 61439-2 Low Voltage Switch Gear and Controlgear Assemblies- Power Switch Gear and Control Gear Assemblies

IEC 61800-2 Adjustable speed electrical power drive systems: General requirements - Rating specifications for low voltage adjustable speed A.C. power drive Systems

IEC 61800-3 Adjustable speed electrical power drive systems: EMC requirements and specific test methods

IEC 61800-5 Adjustable speed electrical power drive systems: Safety requirements - Electrical, Thermal, Energy and Functional.

IEC 61800-8 Adjustable speed electrical power drive systems: Specification of voltage on the power interface

IEC TS 60034-25 Rotating Electrical machines, AC electrical machines used in power drive systems – Application guide.

IEEE:519 Recommended Practices and requirements for Harmonics Control in Electrical Power Systems

ANI/ ISA-S71.04 Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants

ASTM B845 Standard Guide for Mixed Flowing Gas (MFG) Tests for Electrical Contacts

2.2 In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents, the most stringent one shall prevail. However, owner's decision in this regard shall be final and binding.

3.0 SITE CONDITIONS

3.1 The AC drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of $40^{\circ}C$ and an altitude not exceeding 1000 metres above mean sea level shall be considered.

3.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurised room, as specified in data sheet.

3.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

4.0 GENERAL REQUIREMENTS

4.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/ spares to enable the end user to place order for spares and services.

4.4 The vendor shall be responsible for design, engineering and manufacturing of the complete VFD system to fully meet the intent and requirements of this specification and attached data sheets.

4.5 VFD panels shall be sourced from the OEM of VFDs. VFD Panels from system groups / channel partners shall not be accepted.

5.0 TECHNICAL REQUIREMENTS

5.1 Performance Requirement

5.1.1 The system shall be energy efficient, and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.2 The VFD system shall be designed to deliver the motor input current (FLC) and torque for the complete speed torque characteristics of the load. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit. Necessary design in the VFD shall be considered to avoid / minimise drop in the output voltage of VFD. VFD sizing shall be done taking care of following:

- Input supply variation of +/-10% and frequency variation of +/- 3%.
- Steady state voltage drop across the AC drive including associated choke and internal / external filters on input & output side.
- Steady state voltage drops of 3% across cable from VFD to motor.

VFD sizing calculation shall be submitted by vendor for review/approval by Owner/EIL. Sizing for choke / filters shall be also provided for review / approval by Owner.

5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as specified in the data sheet:

a) Variable torque changing as a function of speed i.e. Speed squared
b) Constant torque over a specific speed range
c) Constant power over a specific speed range where the torque decreases when speed increases
d) Any other as specified in data sheet

5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 1:100 unless otherwise specified with speed set accuracy of ±1% of rated maximum speed and steady state regulation of ±0.5% of rated speed.

5.1.6 The dv/dt limits & V_{peak} shall be as per IEC-61800-2 & 60034-25 & same shall be considered in the design of motor.

5.1.7 The controller output overload capacity shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.

5.1.8 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in set point within a time limit up to 60 seconds.

5.1.9 The integrator action of the set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustment by the distributed control system shall be considered as 10 seconds.

5.1.10 Drive shall trip in case the speed exceeds 105% of the maximum operational speed and / or reduces to 95% of the minimum operational speed for more than 10 seconds.

5.1.11 Maximum noise level from the drive at 1 meter distance, under rated load with all normal cooling fans operating shall not exceed 75 dB(A).

5.1.12 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start-up adjustments and troubleshooting.

5.1.13 Harmonics shall be restricted within maximum allowable levels of current and voltage distortion as per recommendation of latest edition of IEEE519. To verify compliance to IEEE519 at switchboard level the necessary data related to switchboard like min. short circuit current (kA) , Load current , other linear and non linear loads connected to the switchboard and the working / standby configuration of the connected loads shall be provided by owner. Using the above required data the harmonics shall be analyzed and suitable mitigation solution shall be provided by vendor by providing suitable filters in VFD, 6/12 pulse VFD, AFE VFD etc.

5.1.14 VFD shall be provided with Auto-Reacceleration feature with facility of enabling/disabling this feature at site.

5.1.15 Vendor to provide suitable voltmeter at VFD output side (after filter) so that final output voltage at VFD end i.e. after taking into account voltage drop within VFD is available.

5.1.16 VFD System shall be designed to comply with EMC requirements as per IEC 61800-3 for conductive and radiated emission. Type test report for EMC compliance for VFD Panel shall be submitted by vendor. For longer cable lengths, requisite mitigation measures including providing suitable filters in VFD panels shall be provided by vendor to comply with EMC requirements. Design and construction of VFD shall also comply to safety requirements specified in IEC 61800-5.

5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips upto 20% of nominal (e.g. in case of a large motor start up connected to the same bus as VFD), shall not cause the control system to stop functioning and shall not trip the drive system

5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2

seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of re-synchronizing onto running motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached standard specification for Medium Voltage Induction Motors.

5.2.5 The power controller shall be regulated to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed regulated corresponding to 4-20 mA or 0-10 V reference input signal. Upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

a) With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated / Digital potentiometer shall be provided as a speed set point device.

b) With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.

c) Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, operator shall be able to start and speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above. (For local control station, also refer Cl. 5.5.6 below).

5.2.8 The required provision for the interface with PLC/DCS (located at remote control room) including the details of communication module and data transfer facility, I/O details shall be furnished. The communication interface shall be via serial communication link with industry standard open protocol i.e. MODBUS/Data Highway Plus/IEC-61850/ RS-485 etc. and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with owner's system (software) shall be provided.

5.2.9 Temperature controller in VFD shall receive signal from thermistor provided in the motor. Contact of the same from temperature controller shall be used in Start Permissive.

5.3 Panel Construction

5.3.1 Each VFD system shall preferably be housed in separate stand alone panel fabricated using Galvanised steel or any other material complying with EMC requirements & unpainted from inside. The sheet steel used for the panel shall be of minimum 2 mm thickness except the doors & covers which will be of minimum 1.5mm thickness. Alternatively common panel(s) for several VFD systems can be considered, provided suitable barrier for full height are provided between different VFD module for safety, operation and maintenance.

The VFD panel(s) shall be suitable for indoor installation, if not otherwise specified. The panel(s) shall be free standing with degree of protection as min. IP-41 & type test report shall be submitted for the same. The maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.2 Each VFD module shall include suitable isolating device (i.e. Circuit breaker/MCCB/ Switch fuse) for main supply, contactors, semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors, filters, output isolating device (for VFD with By-pass), control circuit, control accessories, indication and annunciation etc.

5.3.3 Main isolating device shall function as a manual disconnect and shall be an AC thermal-magnetic circuit breaker or a fused switch with dual element fuse to trip automatically on fault currents, as specified in data sheet. Devices shall be lockable in the open position and shall have a minimum interrupting capacity as specified in data sheet. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.

5.3.4 Bolted undrilled gland plate shall be provided at bottom with single compression type cable gland. Clamp type terminals shall be used for connection of all wires up to 10 mm^2 and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum clearance between gland plate to cable termination point for power cable termination shall be 300mm clear.

5.3.5 Bus bars shall be of electrolytic copper/aluminium, colour coded. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided. The type/material of construction for all name plates shall be preferably anodized aluminum or 3-ply (Black-White-Black) lamicoid sheets. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

5.3.6 All the power and control switches shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, wherever provided, shall be switch board type, back connected, 96x96mm size. Scale shall have red mark indicating maximum permissible operating rating. All components mounted on DIN RAIL shall be provided with end clamps except for components mounted firmly on base plates using screws.

5.3.7 Each panel shall be provided with LED type illuminating lamp with MCB & door limit switch for lamp control. 5/15A, 240V power socket with switch shall be provided. Each panel shall have space heater with variable setting thermostat. Dual pole MCB shall be provided for isolation and protection of utility components.

5.3.8 Copper earth bus of min. 30X6 mm size shall be provided at the bottom of the panel extending outside the panel on both sides. All the non-metallic components/parts shall be connected to the main earth bus bar. In case a separate earth bus for electronic control system is required, the same shall be indicated in the drawings.

5.3.9 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.

5.3.10 All the control wiring shall be enclosed in plastic channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, flame retardant, low smoke, copper conductor wire. 1.5 mm^2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm^2 size for control fuse rating above 16 A for electrical circuits and 0.5 mm^2 for electronic circuits.

5.3.11 All electronic modules and components shall be accessible from front of panel only. Modular plug-in/draw-out assemblies for both the system control electronic equipment and power electronic equipments shall be used.

5.3.12 Suitable removable type hooks shall be provided for lifting the panel(s).

5.3.13 Conformal coating shall be done for all PCB, electronic equipments as per min. Class 3C2 (Harsh environment) of IEC 60721-3-3. Alternatively, it shall comply with ANSI/ ISA S71.04 class G3 or IEC 60068-2-60 for mixed flow gas test or ASTM B845.

5.3.14 Spare terminals of all the devices viz. relays, transducers, Digital/Analog I/O Boards etc. shall be wired upto panel terminal strip.

5.3.15 VFD Panel including insulator supports, conductors etc. shall be designed to withstand specified short circuit currents for a period of min. 1 sec. Short circuit type test report alongwith busbar sizing calculations shall be submitted by vendor. For small rated VFD protected with incoming SFU/MCCB feeders having fault current limiting features, prospective short circuit current shall be considered.

5.4 Cooling

Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the VFD panels for these fans. In case redundant cooling fan is not possible to be mounted, same shall be supplied loose.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the attached standard specification for Medium Voltage Induction Motor, in addition to the following requirements:

a) The motor shall be converter grade motor suitable for operation with a solid state power supply consisting of an adjustable frequency inverter for speed control and shall comply to IS 16724, IEC-60034-25 and relevant part of IS/IEC-60079.

b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c) The motor shall be designed to operate continuously at any speed over the range (1-100%) of rated speed or as specified in data sheet.

d) Motor shall be provided with thermistor type temperature detector.

e) The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.

f) Motor shall be designed suitable to deliver the torque required for complete speed torque characteristics of the load considering the voltage available at the motor terminals after taking into account supply voltage tolerances, voltage drop within VFD panel and voltage drop within cable as specified in cl. no. 5.1.2.

g) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in line voltage, frequency and starting current limitations as specified in data sheet.

h) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid state power supply.

i) The motor insulation shall be designed to accept the applied voltage wave form, within the V_{peak} and dv/dt limits as per IEC-61800-2 and 60034-25.

j) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

k) Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning. Insulated bearing (Non Drive End) shall be provided irrespective of motor frame size.

l) Motor for hazardous area application shall have valid type test certificate issued by recognized independent test house certifying that motor is suitable for converter duty application. Corresponding statutory approval (e.g. PESO/DGMC etc.) as applicable for the specified location shall also be furnished for the hazardous area motor.

5.5.2 **Power Converter**

a) The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter.

b) Normally, for all output short circuits, the inverter shall interrupt the current before any semi-conductor fuse blows. For internal short circuits, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuseless design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

c) All power converter devices shall include co-ordination by peak voltage protecting snubber networks and di/dt and dv/dt networks.

d) The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range.

e) All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.

f) The power converter circuit shall be designed so that motor can be powered at its full name plate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.

g) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.

h) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

i) All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I²t particulars of the power controller devices and the fuses shall be properly co-ordinated for the selection of fuses.

5.5.3 **DC Link / AC line Reactor (if required as per vendor standard design)**

a) Smoothing reactors for the DC link shall be provided if required as per standard design of vendor. AC line reactors, if provided as per standard vendor design, shall be suitable for harmonic suppression and fault current limitation.

b) The reactor shall be dry type, air cooled or fan cooled type located within the panel. In case of fan cooled type, operation of fans shall be monitored.

c) Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.4 **Output Filter**

VFD output current waveform shall be inherently sinusoidal at all speeds. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds after a loss of AC voltage.

The VFD system shall inherently protect motor from high voltage dv/dt stress & Vpeak , independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.5 **Bypass Feature**

5.5.5.1 Output contactor or Load Break Switch shall be provided for isolation between the output of Controller and the motor for VFD systems with Bypass feature.

5.5.5.2 Bypass feature shall be provided, if specified in the data sheet along with VFD-Bypass selector switch. Accordingly Bypass feature with Bypass starter shall meet the following requirements, unless otherwise specified in the data sheet:-

- Bypass starter shall comprise of switch-fuse, contactor, bimetal relay meeting the requirements of Type-2 coordination as per IS/IEC-60947. CBCT and ELR shall be provided for motors rated above 22kW & upto 55kW unless otherwise specified in the data sheet. Heavy duty starters shall be provided with saturable type current transformer operated overload relay only, which shall be suitable for motor starting time of 15-60 seconds.

- Bypass starter shall be in separate compartment and it shall be possible to isolate and maintain the VFD while drive motor runs in Bypass mode. Three contactors/ breakers shall be used for this purpose, one contactor in the bypass and two contactors across the drive, such that in case of drive mal-operation, the motor could be taken on bypass control, while the drive could be attended by opening its contactors. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.6 **Local Control Station**

The local control station shall conform to the attached standard specification(s).

Meters in the local control station for motors rated above 5.5kW shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current unless specified otherwise. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. Local-off-Remote selector switch shall be provided in the LCS for selection of control from Local (i.e. LCS in Field) and Remote (i.e. from VFD panel / DCS / PLC).

Vendor to ensure that suitably sized canopy shall be provide by vendor for outdoor LCS which will cover LCS from all 3 sides and protect the LCS from rain water in all directions.

Auxiliary AC power supply for LCP/LCS shall be derived by vendor.

LCS shall be provided with 20% spare terminals.

5.6 Protection, Control, Metering and Indication / Annunciation

5.6.1 The manufacturer shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor based system.

5.6.3 **Operator Control Panel**

Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for Run/Stop, Local/Remote, Increase/Decrease, menu navigation and parameter select/save. All parameter names, fault messages, warnings and other information shall be displayed in Complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics.

5.6.4 **Protective Features**

The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:

i) Under / Over voltage protection
ii) Phase loss, phase reversal protection
iii) Programmable Over current protection
iv) Inverter Fault protection
v) Over frequency /Over speed protection of motor
vi) Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm. Suitable sensors as required for same shall be provided)
vii) Over temperature protection of equipment
viii) Complete motor protection
ix) System Earth fault Protection

5.6.5 **Alarms**

The system shall incorporate protection alarms, required for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system etc.

5.6.6 **Controls**

The controls shall be provided as a part of the Operator Control Panel as per clause 5.6.3 above.

5.6.7 **Indications**

The following indications shall be provided as a part of the Operator Control panel.

i) Motor running
ii) Motor stopped
iii) VFD System Fault
iv) System ready to start
v) AC mains ON
vi) Motor over speed
vii) Drive 'ON'
viii) Motor zero speed
ix) Remote breaker trip

Potential free contacts of items i) - vii) shall be wired separately for indications in DCS system.

5.6.8 **Metering**

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

i) Input AC voltage
ii) Input AC frequency
iii) Input AC Current
iv) Output voltage
v) Output current VFD / Bypass
vi) Output frequency
vii) Drive thermal state
viii) Motor speed
ix) Motor energy meter
x) Run hour meter

Necessary dual type transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS under both VFD and Bypass mode of operation.

5.6.9 **Annunciations**

Potential free contacts shall be provided for following annunciation and shall be wired up to terminal block for owner's use for remote monitoring:

i) Drive fault
All drive internal faults will be annunciated as drive fault.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system.

5.8 Control Circuit

Control supply for devices external to VFD module i.e contactors control, indicating lamps, digital meters (Ammeter, Voltmeter, Speedometer) etc. shall operate on 240V control supply

derived from single-phase control supply transformer, with switch-fuse provided in primary and MCB in secondary, located inside the drive controller.

One No. 110V DC /110V AC/ 230V AC UPS Supply for each VFD panel shall be provided by owner for VFD control logic. Power supply at any other voltage shall be derived by vendor. Conversion of this 110V DC / 110V AC / 230V AC supply to any other voltage level or to AC/DC power supply shall be take care by vendor by providing suitable converter/inverter module inside VFD panel.

240V AC space heater supply for panel and motor space heater shall be provided from external source by owner.

5.9 Reliability Features

i) The expected life time of the VFD shall be minimum 20 years. The VFD including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

ii) The controller design shall incorporate the following reliability features:
- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted.
- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

5.10 Maintenance Features

The controller design shall incorporate the following maintenance features:
- Modular construction
- Printed circuit boards shall be plug connected.
- All components shall be easily accessible from the front of the enclosure.
- Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.2 After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be RAL-7032, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the VFD shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of EIL/ Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 Complete VFD system (as defined in Cl.1.0 above) shall be offered for test & inspection as per EIL Std. ITP 6-81-1038. In case combined testing requirement is mentioned in PR/Data sheet, testing shall be carried out on Complete VFD with Job motor as per EIL Std. ITP 6-81-1038. For hazardous area application, requirements specified in cl. no. 5.5.1.l) above shall also be complied.

6.4. String Test with Driven Equipment

If a string test with driven equipment is required, this will be mentioned in the data sheet of the driven equipment.

7.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.