FORMAT NO. : HSE-24 REV 0

Boom Lift Inspection Checklist

Name of Contractor: **Project:**

Name of Work: **Job No:**

Vehicle Identification/Registration No: **Date:**

Sr. No.	Description	Observation	Remarks & Suggestions
1	Operating and emergency controls are in proper working condition, EMO button or Emergency Stop Device		
2	Functional upper drive control interlock (i.e. foot pedal, spring lock, or two hand controls)		
3	Emergency Lowering function operates properly		
4	Lower operating controls successfully override the upper controls		
5	Both upper and lower controls are adequately protected from inadvertent operation.		
6	Control panel is clean & all buttons/switches are clearly visible (no paint over spray, etc.)		
7	All switch & mechanical guards are in good condition and properly installed		
8	All Safety Indicator lights work		
9	Drive controls function properly & accurately labelled (up, down, right, left, forward, back)		
10	Motion alarms are functional		
11	Safety decals are in place and readable		
12	Guardrails and anchor points are in place, and in good condition		
13	Work platform & extension slides are clean, dry, & clear of debris		
14	Work platform extension slides in and out freely with safety locking pins in place to lock setting on models with extension platforms.		
15	Any defects such as cracked welds, fuel leaks, hydraulic leaks, damaged control cables or wire harness, etc.		
16	Braking devices are operating properly		
17	The manufacturer's operations manual is stored on AWP (in all languages of the operators)		
18	Oil level, Hydraulic Oil Level, Fuel Level, Coolant Level		

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19	Battery Charge		
20	Outriggers in place or functioning. Associated alarms working		
21	Tyres and wheels are in good condition, with adequate air pressure if pneumatic		
22	Wheel chokes are present and are used whenever required		
23	Moving & rotating parts guarded		
24	Load chart provided		
25	Fire Extinguisher		
26	Spark Arrestor, if operated by using fuel(For Running Refinery/ Petrochemical/Chemical Plant)		
27	Serial number plate with Load capacity		
28	TPI Certificate		
29	Colour Coding		
30	Insurance		
31	Pre Medical Check-up& Periodic Medical check-up (every 6 months) including vision test for Operator		
32	Safety Induction for Operator		
33	Others		

Signature & Name of Operator:

Signature & Name of Contractor's Concern Engineer

Signature & Name of Contractor's Safety Officer

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निर्माण स्थलों पर निगरानी और मापने के उपकरणों की आंशांकन आवश्यकताएँ

CALIBRATION REQUIREMENTS OF MONITORING AND MEASURING DEVICES AT CONSTRUCTION SITES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	25.07.2025	Revised & Updated	DK	SBB	KS	MN
1	02.07.2020	Revised & Updated	DG	RK	AKK	SKS
0	28.04.2015	Doc. No. 9-1940-0030 Rev 0 has been issued as Standard	DJ	SNB	MD	SC

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Abbreviations:

BIS	:	Bureau of Indian Standard
NABL	:	National Accreditation Board for Testing and Calibration Laboratories
CEIL	:	Certification Engineers International Ltd.
LRS	:	Llyod's Register Group Limited
BV	:	Bureau Veritas
ABS	:	ABS Consultancy
DNV	:	Det Norske Veritas
IRS	:	Indian Registrar for Shipping
PMI	:	Positive Material Identification

Construction Standards Committee

Convenor : Sh. K. Swaminathan HOD (Construction)

Members : Sh. DSN Murthy, ED (Projects)
Sh. Udayan Chakravarty, CGM (Piping)
Sh. SB Burman, Sr. GM (Construction)
Sh. Abhijit Chakraborty, GM (Construction)
Sh. Pankaj Kumar Rai, DGM (Construction)
Sh. S. Padmanathan, DGM (SCM)
Sh. Dhananjay, AGM (Construction)

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1.0 SCOPE

The standard covers the calibration requirement of monitoring & measuring devices used by construction contractor during implementation of construction works under their scope.

2.0 Requirement for control of monitoring and measuring devices.

Sl. No.	Description	Calibration requirements	Frequency	Remarks
A.	**Civil-Survey**			
A.1.	Theodolite	To check for permanent adjustments by traversing and observing the closing error. (Refer Note).	Once in a year or project duration whichever is earlier.	Record to be maintained
A.2.	Level Instruments (Auto Level / Dumply Level)	To check by backsight / foresight readings, the temporary adjustments of level. (Refer Note).	Every use.	Record to be maintained
A.3.	Steel measurement tapes	----	----	a. "Freemans" make or BIS approved make shall be used. b. Mutilated, or broken tapes shall not be used. c. Marking on the tape shall be legible.
A.4.	Cross staff	---	---	Same as 3b & 3c above.
A.5.	Distomat	Actual Physical Verification at Site.	Before using first time at site.	Records to be maintained.
A.6.	Total Station	To check for permanent adjustments by traversing and observing the closing error, etc. (Refer Note).	Once in a year or project duration whichever is earlier.	Record to be maintained
B.	**Civil Laboratory**			
B.1.	All balances - Mechanical	Check for zero error	Whenever used.	---
B.2.	Weigh Batcher / Batching Plant	Calibration of scales	Once in three Months.	Records to be maintained.
B.3.	Cube testing machine	Calibration certificate from manufacturers or from calibrating laboratories / agency. (Refer Note).	As per manufacturer specification or once a year whichever is earlier	Records to be maintained.
B.4.	Moisture Meter	Calibration of scales .	6 months.	Records to be maintained.
B.5	Vicat Appratus	Calibration certificate from manufacturers or from calibrating laboratories / agency. (Refer Note).	As per manufacturer specification or once a year whichever is earlier.	Records to be maintained.

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Sl. No.	Description	Calibration requirements	Frequency	Remarks
C.	**Mechanical/ Electrical/Welding**			
C.1	Pressure gauges/ Pressure Safety valve/ Pressure relief valve	Calibration certificate from calibrating laboratories / agencies or calibrate by dead weight testers with standard weights or with master Gauge. (Refer Note)	Once in 6 months	Records to be maintained.
C.2	Dial gauges	Check for Zero error.	Whenever used	---
C.3	Dead weight tester	Calibration from manufacturer or calibrating laboratories / agency. Calibration certificate shall not be older than one month from the date of mobilization. (Refer Note).	As per manufacturer's recommendation or once in a six month whichever is earlier.	Records (Calibration certificate) to be maintained.
C.4	Vernier caliper / screw gauge	Check for Zero error.	Whenever used.	---
C.5	Holiday tester	Calibration from manufacturer or calibrating laboratories / agency or calibration by zeep meter. (Refer Note).	Once in 6 months.	Records to be maintained.
C.6	Elcometer	Check with standard test films supplied by the manufactures.	Before use.	Records to be maintained.
C.7	Universal Testing machine	Calibration Certificate from various third-party inspection agency. Viz. CEIL, LRS, BV, ABS, DNV or IRS etc.	As per manufacturer's recommendation or once a year whichever is earlier.	Records to be maintained.
C.8	Charpy V-notch Impact testing machine.	Calibration Certificate from various third party inspection agency. Viz. CEIL, LRS, BV, ABS, DNV or IRS etc.	As per manufacturer's recommendation or once in a year whichever is earlier.	Records to be maintained.
C.9	Hardness Testing machine.	Check with the standard test block supplied with the machine as per manufacturer's Recommendation.	Before use.	Records to be maintained.
C.10	Chemical Analysis, ex : PMI etc.	Check with the standard samples.	Before use.	Records to be maintained.
C.11	Various Digital and Analog meters.	Calibration Certificate from calibrating laboratories / agencies or the Manufacturer (Refer Note).	Once in Six Months or as per manufacturer's recommendation whichever is earlier.	Records to be maintained.

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Sl. No.	Description	Calibration requirements	Frequency	Remarks
C.12	HIPOT Kit, Multimeter/ Clampmeter, Ohmicron Kit, CT Analyser, CRM Kit, BDV Kit, Tachometer etc.	Calibration Certificate from calibrating laboratories / agencies (Refer Note).	Once in Six months.	Records to be maintained.
C.13	Temperature / Pressure recorders	Calibration from manufacturer or any calibrating laboratories / agency (Refer Note).	Once in Six months.	Records to be maintained
C.14	Temperature gauges	Calibration Certificate from calibrating laboratories / agencies (Refer Note).	Once in Six months.	To be discarded in case of damage or malfunctioning.
C.15	Thermocouples	Manufacturer's Certificate or Chemical Check	---	---
C.16	Vibration probes	Calibration from calibrating laboratories / agencies (Refer Note).	Once in a year.	To be discarded in case of damage or Malfunctioning.
C.17	Decibel-Meter	Calibration from calibrating laboratories / agencies (Refer Note).	Once in a year.	To be discarded in case of damage or Malfunctioning.
C.18	Manual Torque Wrench / Electric Torque Machine	Calibration from manufacturer or any calibrating laboratories / agency (Refer Note).	As per manufacturer's recommendation or once in a year whichever is earlier.	Records to be maintained
C.19	Mother Oven	Calibration from manufacturer or any calibrating laboratories / agency (Refer Note).	As per manufacturer's recommendation or once in a year whichever is earlier.	Records to be maintained.

Note: If an instrument is out of acceptance limit as per instrument data sheet, it has to be sent to manufacturers or their authorized agents (Calibrating laboratories/ agency) or to any other lab/ agency for recalibration/ rectification and certification. The calibrating laboratory/ agency shall be NABL accredited or any other lab accredited as per ISO/IEC:17025 by any of the National/ International accreditation body for relevant testing.

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प्रमुख निर्माण कार्मिकों के लिए अपेक्षित योग्यता एवं अनुभव और तैनाती न करने पर जुर्माना

QUALIFICATION & EXPERIENCE REQUIREMENT OF KEY CONSTRUCTION PERSONNEL AND PENALTY FOR THEIR NON-MOBILIZATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	25.07.2025	Revised & Updated	DK	SBB	KS	MN
1	01.07.2020	Revised & Updated	DG	RK	AKK	SKS
0	12.06.2015	Doc. No. 9-1940-0001 Rev 1 has been revised and issued as Standard	DJ	RK	MD	SC

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Abbreviations:

CV	:	Curriculum Vitae
EPC	:	Engineering, Procurement & Construction
EPCC	:	Engineering, Procurement, Construction & Commissioning
ISO	:	International Organization for Standardization
NDT	:	Non-Destructive Testing
QA/QC	:	Quality Assurance /Quality Control
RT	:	Radiography Testing
UT	:	Ultrasonic Testing

Construction Standards Committee

Convenor : Sh. K. Swaminathan HOD (Construction)

Members : Sh. DSN Murthy, ED (Projects)
Sh. Udayan Chakravarty, CGM (Piping)
Sh. SB Burman, Sr. GM (Construction)
Sh. Abhijit Chakraborty, GM (Construction)
Sh. Pankaj Kumar Rai, DGM (Construction)
Sh. S. Padmanathan, DGM (SCM)
Sh. Dhananjay, AGM (Construction)

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Qualification & Experience (Post Qualification)

CATEGORY	QUALIFICATION & EXPERIENCE (POST QUALIFICATION) REQUIRED			
Resident Construction Manager/ Resident Engineer/Site-In-Charge	Degree or Diploma in Engineering with minimum following relevant experience in construction:			
	Awarded value (Rs) →	< 10 Cr. Works	10 - 50 Cr. Works	> 50 Cr. Works
	Degree holders	5 yrs	10 yrs	15 yrs
	Diploma holders	8 yrs	13 yrs	20 yrs
Lead Discipline Engineer (Mechanical, Civil, Electrical, Instrumentation)	Degree or Diploma in relevant Engineering discipline with following minimum experience in Construction:			
	Awarded value (Rs) →	≤ 10 Cr. Works	10-50 Cr. Works	> 50 Cr. Works
	Degree holders	3 yrs	5 yrs	10 yrs
	Diploma holders	5 yrs	8 yrs	13 yrs
Lead Welding/ NDT Engineer	Degree or Diploma in Mechanical Engineering/ Metallurgy with the minimum following experience in Welding & NDT (Non-Destructive Testing) and possessing valid Level-II certificate in the relevant NDT methodology (RT/UT)			
	Awarded value (Rs) →	≤ 10 Cr. Works	10-50 Cr. Works	> 50 Cr. Works
	Degree holders	3 yrs	5 yrs	10 yrs
	Diploma holders	5 yrs	8 yrs	13 yrs
Lead QA/QC Engineer	Degree or Diploma in Engineering with following experience (refer Note 1 also) :			
	Awarded value (Rs) →	≤ 10 Cr. Works	10-50 Cr. Works	> 50 Cr. Works
	Degree holders	3 yrs of construction experience of which minimum 1 years in QA/QC	5 yrs of construction experience of which minimum 2 years in QA/QC	10 yrs of construction experience of which minimum 3 years in QA/QC
	Diploma holders	5 yrs of construction experience of which minimum 3 years in QA/QC	8 yrs of construction experience of which minimum 5 years in QA/QC	13 yrs of construction experience of which minimum 6 years in QA/QC
Lead Planning Engineer	Degree or Diploma in Engineering with following experience in Planning & Scheduling			
	Awarded value (Rs) →	≤ 10 Cr. Works	10-50 Cr. Works	> 50 Cr. Works
	Degree holders	3 yrs	5 yrs	8 yrs
	Diploma holders	5 yrs	8 yrs	13 yrs
Safety Officer/ Supervisor	As per HSE Specification enclosed elsewhere in the bidding document.			

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Warehouse- In- Charge/ Materials Manager	Diploma in Engineering or Diploma in Materials Management or Graduate in any stream with min. following experience in Warehousing/ Stores Management:			
	Awarded value (Rs) →	≤ 10 Cr. Works	10-50 Cr. Works	> 50 Cr. Works
	Experience	3 years	5 yrs.	10 yrs.
Quantity Surveyor	Degree or Diploma in Engineering with minimum following experience in quantity estimation, field measurement, bill preparation etc. in Construction field:			
	Awarded value (Rs) →	≤ 10 Cr. Works	10-50 Cr. Works	> 50 Cr. Works
	Degree holders	2 yrs	3 yrs	5 yrs
	Diploma holders	4 yrs	6 yrs	8 yrs
Discipline Engineer	Degree in relevant Engineering Discipline with minimum 2 years of relevant experience in construction or Diploma in relevant Engineering Discipline with minimum 4 years of relevant experience in Construction. Welding / NDT engineer shall possess valid Level-II certificate in the relevant NDT methodology (RT/UT).			

NOTES: (For Table)

1. For Civil & Structural, Mechanical, Composite, EPC or EPCC Contracts of value more than Rupees 50 crores, the Lead QA/QC Engineer shall be a qualified internal auditor for ISO 9001.
2. CVs of key construction personnel proposed to be deployed shall be submitted to Owner/Engineer-in-Charge prior to their mobilization at site. The mobilization of key personnel shall be done at site subject to prior approval of their CVs by Owner/Engineer-in-Charge.

PENALTY FOR NON - MOBILIZATION OF KEY CONSTRUCTION PERSONNEL

Penalty for non-mobilization per day per person after the contractual mobilization period / mobilization schedule agreed during Kick off meeting / jointly agreed between contractor and PMC / Owner based on front availability etc.

- Rs. 10000/- for Resident Construction Manager/ Resident Engineer/ Site-in-Charge.
- Rs. 5000/- for Lead QA/QC Engineer, Lead Planning Engineer, Warehouse In-charge, Lead Discipline Engineers, Lead Welding / NDT Engineer and the Quantity surveyor.
- Safety Officer (As per HSE Specification).

NOTES: (For Penalty Clauses)

a) All intervening off days (Sundays etc.) and holidays will be counted for levy of penalty.

b) Mobilized personnel shall not be demobilized till contractual completion or based on consent of Engineer-in-Charge, else penalties as above shall be applied.

c) Total of above penalties shall not exceed 2% of the awarded contract value.

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WELDING SPECIFICATION FOR FABRICATION OF PIPING

(SMMS DIVISION)

PROJECT : P PU & REVAMP OF PFCC AT KOCHI REFINERY

OWNER : M/s BHARAT PETROLEUM COOPERATION LIMITED

JOB NO. : B895

0	19-06-2025	ISSUED FOR TENDER	Uttam	Prabhakar	R Chitara
Rev. No	**Date**	**Purpose**	**Prepared by**	**Checked by**	**Approved by**

AMENDMENTS/ADDITIONAL REQUIREMENTS

Specification No.: 6-77-0001 Rev.5

Title: Welding specification for fabrication of piping

Following amendments/additional requirements shall be applicable:

1. Addition in Clause 14.5:

   (k): Extent of conventional and digital radiography shall be 60% and 40% respectively.

WELDING SPECIFICATION CHARTS FOR PIPING CLASSES

PROJECT : PMC AND EPCM SERVICES FOR POLYPROPLENE PROJECT OF BPCL KOCHI REFINERY

OWNER : BHARAT PETROLEUM CORPORATION LIMITED (BPCL)

PMC / EPCM : ENGINEERS INDIA LIMITED (EIL)

JOB NO. : B895

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by
3	29-10-2025	REISSUED AFTER ADDING NEW PIPING CLASSES	RITIK N	U KUMAR	P CHOWDHARY
2	24-07-2025	REISSUED AFTER ADDING NEW PIPING CLASSES	U KUMAR	P CHOWDHARY	R CHITARA
1	02-12-2024	REISSUED AFTER ADDING NEW PIPING CLASSES	U KUMAR	P CHOWDHARY	R CHITARA
0	05-09-2024	ISSUED FOR IMPLEMENTATION	U KUMAR	P CHOWDHARY	R CHITARA

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WSC FOR PIPING CLASSES: A28M 17

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WSC FOR PIPING CLASSES: B5K 19

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Revision History:

Rev. No	Date	Purpose
1	02.12.2024	A91A, A92A, A93A, A94Y, A95A, A96A, A97A, A4A, B42K, D42K, A23K, A21K, D21K, F55K, A28K, A42K, A21A, A1A, A24A, A20K, B21A, B1A, B24A, B28A, B20K, D4A,D55A, A28M, A24K, B46K, D1A, B4A piping classes added
2	24.07.2025	WSC for piping classes A11A, A33Y, A44A, A98A, B16A, B19A, B1K, B29A, B3F, B44A, B5A, B5K, D44A added and Reissued for tender.
3	29.10.2025	WSC for piping classes A19A, B9A added and Reissued for tender.

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GENERAL NOTES

1.1 Scope:
This document covers the Welding Specification for the piping classes covered in the Piping Material Specification No. B895-0PP-6-44-0005-9801 Rev.A dated 14.10.24, B895-6-44-0005 Rev. 0). WPS and PQR for the field fabrication and erection of piping system shall be made in conformity with this document. In case of any conflict between this document and Piping Material Specification for any piping class, the most stringent requirement shall be followed.

1.2 This document shall be read in conjunction with the latest revisions/editions of the following documents:

a) ASME Boiler and Pressure Vessel Codes

Section II Part C – Specification for Welding Rods, Electrodes, and Filler Metals
Section V – Nondestructive Examination
Section IX - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators

b) ASME B31.3, Process Piping

c) ASTM E10, Standard Test Method for Brinell Hardness of Metallic Materials

d) Job Specification No. B895-6-44-0016, Specification for Non Destructive Examination Requirements of Piping

e) Welding Specification for Fabrication of Piping, 6-77-0001 Rev.5.

1.3 GTAW process can be applied in place of SMAW process with a corresponding suitable filler metal for the application.

1.4 Abbreviations:

GTAW : Gas Tungsten Arc Welding

PMS : Piping Material Specification

PQR : Procedure Qualification Record

SMAW : Shielded Metal Arc Welding

WSC : Welding Specification Chart

WPS : Welding Procedure Specification

1.5 ASME B31.3 PWHT thickness exemption for P no. 1 materials is not permitted for material thickness greater than 1.5 inch (38mm).

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WSC FOR PIPING CLASSES: **A3A, A91A, A92A, A98A, A33Y, A93A, A94Y, A95A, A96A, A97A, J2A**				
MATERIAL SPECIFICATIONS	PIPES	ASTM A 106 GR.B , IS-3589 GR.410, ASTM A 672 GR.B60 CL.12		
	FITTINGS	ASTM A 105, ASTM A234 GR.WPB, ASTM A234 GR.WPB-W, IS-3589 GR.410		
	FLANGES	ASTM A 105		
	OTHERS	-		
BASE METAL `P' NO	**1, Unassigned (IS-3589)**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW /SMAW**	FILLER PASS: **SMAW (NOTE-1)**	ROOT PASS **GTAW /SMAW**	FILLER PASS: **SMAW (NOTE-1)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER70S-2/E6010**	FILLER PASS: **E6013/E7016/E7018**	ROOT PASS: **ER70S-2/ E6010**	FILLER PASS: **E6013/E7016/E7018**
	FILLET JOINT/SOCKET JOINT: **E6013/ E7016/E7018/ ER70S-2**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING: -		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING: -		SHIELDING: **99.997%**	
PREHEATING **(NOTE-2)**	PREHEAT TEMP: **10°C MIN/100°C FOR THK >25 mm**		INTERPASS TEMP.: ---	
POST HEATING: ---				
POST WELD HEAT TREATMENT	HOLDING TEMP: --		HOLDING TIME: **---**	
	RATE OF HEATING: **---**		MIN. HOLDING TIME: **---**	
	METHOD OF COOLING: **---**		RATE OF COOLING: **---**	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS:			
CODE OF FABRICATION	ASME B31.3			

TECHNICAL NOTES:

1 GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL- BORE PIPING, DIAMETER 2" AND SMALLER.

2 PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK >=12.5 MM & <=25MM.

3 THREADED JOINTS FOR J2A PIPING CLASS SHALL BE MADE WITH 1" PTFE JOINING TAPE.

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WSC FOR PIPING CLASSES: **A40K, A23K, A20K, A21K, A24K, A28K, B20K, D20K, D21K**				
MATERIAL SPECIFICATIONS	PIPES	ASTM A 312 TP304/304L, ASTM A 358 TP304/304L CL.1		
	FITTINGS	ASTM A 182 GR.F304/304L, ASTM A 403 GR.WP304/304L-S, ASTM A 403 GR.WP304/304L-WX		
	FLANGES	ASTM A 182 GR.F304/304L		
	OTHERS	-		
BASE METAL `P' NO	8			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: GTAW	FILLERPASS: GTAW/SMAW (NOTE-1)	ROOTPASS: GTAW/SMAW	FILLER PASS: GTAW/ SMAW
	FILLET JOINTS/ SOCKET JOINTS: SMAW/GTAW			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: ER308L	FILLER PASS: ER308L / E308L-15/16	ROOT PASS: ER308L / E308L-15/16	FILLER PASS : ER308L/ E308L-15/16
	FILLET JOINT/SOCKET JOINT: E308L-15/16 /ER308L			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	ASME B31.3			
GASES	PURGING: - ARGON		SHIELDING: ARGON	
GAS COMPOSITION	PURGING: 99.997 %		SHIELDING: 99.997 %	
PREHEATING	PREHEAT TEMP: 10 °C		INTERPASS TEMP.: 175°C MAX.	
POST HEATING: -				
POST WELD HEAT TREATMENT	HOLDING TEMP: -		HOLDING TIME: -	
	RATE OF HEATING: -		MIN. HOLDING TIME: -	
	METHOD OF COOLING: -		RATE OF COOLING: -	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN:	AVERAGE:
	AT TEMPERATURE:		-	
	HARDNESS: -			
CODE OF FABRICATION	ASME B31.3			

TECHNICAL NOTES:

1. GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMETER 2" AND SMALLER.

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WSC FOR PIPING CLASSES: **A1A, A21A, A32A, B1A, B9A, B21A, B29A, D1A, F25A**				
MATERIAL SPECIFICATIONS	PIPES	**ASTM A 106 GR.B, ASTM A 53 TYPE E GRADE B, ASTM A 672 GR.B60 CL.12**		
	FITTINGS	**ASTM A 105, ASTM A234 GR.WPB, ASTM A 234 GR.WPB-W**		
	FLANGES	**ASTM A 105**		
	OTHERS	-		
BASE METAL `P' NO	**1**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW / SMAW (NOTE-1, 2)**	FILLER PASS: **GTAW / SMAW (NOTE-2)**	ROOT PASS: **GTAW / SMAW (NOTE-1, 2)**	FILLER PASS: **GTAW / SMAW (NOTE- 2)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2 / E7016 / E7018**	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2 / E7016 / E7018**
	FILLET JOINT/SOCKET JOINT: **E7016 / E7018/ ER70S-2**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING: -		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING: -		SHIELDING: **99.997%**	
PREHEATING **(NOTE-3)**	PREHEAT TEMP: **10°C MIN/ 100°C FOR THK >25 mm**		INTERPASS TEMP.: **----**	
POST HEATING: --				
POST WELD HEAT TREATMENT	HOLDING TEMP---		HOLDING TIME: **----**	
	RATE OF HEATING: **---**		MIN. HOLDING TIME: **---**	
	METHOD OF COOLING: **---**		RATE OF COOLING: **---**	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS:			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES:

1 **THE ROOT PASS FOR SINGLE SIDE WELDING SHALL BE DONE BY GTAW PROCESS.**

2 **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL- BORE PIPING, DIAMETER 2" AND SMALLER.**

3 **PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK>=12.5 mm & ≤ 25 mm.**

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WSC FOR PIPING CLASSES: **A24A, B24A, B27A, B28A, D28A**					
MATERIAL SPECIFICATIONS	PIPES	**ASTM A 106 GR.B, ASTM A 53 TYPE E GRADE B, ASTM A 672 GRADE C 70 CLASS 32**			
	FITTINGS	**ASTM A 105, ASTM A234 GR.WPB, ASTM A 234, GRADE WPB-W**			
	FLANGES	**ASTM A 105**			
	OTHERS	-			
BASE METAL `P' NO	**1**				
WELDING PROCESS	GROOVE JOINTS				
	BUTT		OTHER THAN BUTT		
	ROOT PASS: **GTAW**	FILLER PASS: **GTAW / SMAW (NOTE-2)**	ROOT PASS: **GTAW / SMAW (NOTE-1, 2,3)**	FILLER PASS: **GTAW / SMAW (NOTE- 2)**	
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**				
WELDING MATERIALS	GROOVE JOINTS				
	BUTT		OTHER THAN BUTT		
	ROOT PASS: **ER70S-2**	FILLER PASS: **ER70S-2 / E7016 / E7018**	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2 / E7016 / E7018**	
	FILLET JOINT/SOCKET JOINT: **E7016 / E7018/ ER70S-2**				
	BACKING RING: -		CONSUMABLE INSERT: -		
JOINT PREPARATION	**ASME B31.3**				
GASES	PURGING: -		SHIELDING: **ARGON**		
GAS COMPOSITION	PURGING: -		SHIELDING: **99.997%**		
PREHEATING **(NOTE-4)**	PREHEAT TEMP: **10°C MIN/ 100°C FOR THK >25 mm**		INTERPASS TEMP.: **----**		
POST HEATING: --					
POST WELD HEAT TREATMENT	HOLDING TEMP---		HOLDING TIME: **----**		
	RATE OF HEATING: **---**		MIN. HOLDING TIME: **---**		
	METHOD OF COOLING: **---**		RATE OF COOLING: **---**		
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -	
	AT TEMPERATURE:		-		
	HARDNESS:				
CODE OF FABRICATION	**ASME B31.3**				

TECHNICAL NOTES:

1 **THE ROOT PASS FOR SINGLE SIDE WELDING SHALL BE DONE BY GTAW PROCESS.**

2 **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMETER 2" AND SMALLER.**

3 **FOR PIPING CLASS B27A & B28A, GTAW SHALL BE USED FOR THE ROOT PASS OF ALL WELDS.**

4 **PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK>=12.5 mm & ≤ 25 mm.**

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WSC FOR PIPING CLASSES: **B5A**, **B55A, D55A**				
MATERIAL SPECIFICATIONS	PIPES	**ASTM A 106 GR.B, ASTM A 672 GR.B60 CL.32**		
	FITTINGS	**ASTM A 105, ASTM A234 GR.WPB, ASTM A 234 GR.WPB-W**		
	FLANGES	**ASTM A 105**		
	OTHERS	-		
BASE METAL `P' NO	**1**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW / SMAW (NOTE- 1,2)**	FILLERPASS: **GTAW / SMAW (NOTE-1)**	ROOTPASS: **GTAW / SMAW (NOTE-1,2)**	FILLER PASS: **GTAW / SMAW (NOTE-1)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2/ E7016/E7018**	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2/ E7016/E7018**
	FILLET JOINT/SOCKET JOINT: **E7016/E7018/ ER70S-2**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING: ---		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING: ---		SHIELDING: **99.997%**	
PREHEATING**(NOTE-3)**	PREHEAT TEMP: **10°C MIN./100°C (FOR THK>25 MM)**		INTERPASS TEMP.: ---	
POST HEATING: **-**				
POST WELD HEAT TREATMENT **(NOTE-5)**	HOLDING TEMP: **-**		HOLDING TIME: **-**	
	RATE OF HEATING: **-**		MIN. HOLDING TIME: **-**	
	METHOD OF COOLING: **-**		RATE OF COOLING: **-**	
MECHANICAL PROPERTY REQUIREMENTS **(NOTE-4)**	CHARPY `V' NOTCH VALUE:		MIN: **20J**	AVERAGE: **27J**
	AT TEMPERATURE:		-	
	HARDNESS: **200 BHN MAX. (NOTE-5)**			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES:

1. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMETER 2" AND SMALLER.**

2. **THE ROOT PASS FOR SINGLE SIDE WELDING SHALL BE DONE BY GTAW PROCESS.**

3. **PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK >=12.7 MM & <= 25 MM.**

4. **CHARPY V-NOTCH IMPACT TESTING OF WELD METAL SHALL BE CARIED OUT DURING WELDING PROCEDURE QUALIFICATION FOR THE PIPE WALL THICKNESS OVER 20 MM. IMPACT TESTING SHALL BE CARRIED OUT AT –(MINUS) 29°C.**

5. **PWHT SHALL BE DONE FOR PIPING WELDS HAVING NOMINAL THICKNESS >20 MM AS PER LATEST EDITION OF ASME B31 3. HARDNESS SHALL BE MEASURED AFTER PWHT.**

   ALL LINES WITH DESIGN TEMPERATURE GREATER THAN 204 DEG. C, POST WELD HEAT TREATMENT IS REQUIRED FOR ALL WELD JOINTS IRRESPECTIVE OF THICKNESS. HARDNESS SHALL BE MEASURED AFTER PWHT.

6. **HARDNESS RESTRICTION IS APPLICABLE FOR NON-PWHT WELDS ALSO.**

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WSC FOR PIPING CLASSES: **A2A, B2A, D2A**				
MATERIAL SPECIFICATIONS	PIPES	ASTM A106 GR. B, ASTM A672 GR. B60 CL.12		
	FITTINGS	ASTM A 105, ASTM A234 GR.WPB, ASTM A234 GR.WPB-W		
	FLANGES	ASTM A 105		
	OTHERS	-		
BASE METAL `P' NO	**1**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW / SMAW (NOTE 1)**	FILLER PASS: **GTAW / SMAW (NOTE 1)**	ROOT PASS: **GTAW / SMAW (NOTE-1)**	FILLER PASS: **GTAW/ / SMAW (NOTE-1)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2 / E7016/E7018**	ROOT PASS: **ER70S-2/ E6010**	FILLER PASS: **ER70S-2 / E7016/ E7018**
	FILLET JOINT/SOCKET JOINT: **E7016/E7018/ER70S-2**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING: -		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING: -		SHIELDING: **99.997%**	
PREHEATING **(NOTE-2)**	PREHEAT TEMP: **10°C MIN/ 100°C FOR THK >25 mm**		INTERPASS TEMP: ---: -	
POST HEATING: ---				
POST WELD HEAT TREATMENT **(NOTE-3)**	HOLDING TEMP: **-**		HOLDING TIME**: -**	
	RATE OF HEATING: **-**		MIN. HOLDING TIME: **-**	
	METHOD OF COOLING: **-**		RATE OF COOLING: **-**	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS:			
CODE OF FABRICATION	**ASME B31.3& IBR**			

TECHNICAL NOTES:

1. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMETER 2" AND SMALLER. THE ROOT PASS FOR SINGLE SIDE WELDING SHALL BE DONE BY GTAW PROCESS.**

2. **PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK>= 12.7MM & ≤ 25 MM.**

3. **PWHT SHALL BE DONE AS PER IBR FOR WALL THICKNESS EXCEEDING 20MM.**

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WSC FOR PIPING CLASSES: **A4A, A44A, B4A, D4A, B44A, D44A**				
MATERIAL SPECIFICATIONS	PIPES	ASTM A 333 GR.6, ASTM A 671 GR.CC60 CL.32		
	FITTINGS	ASTM A 350 GR.LF2 CL.1, ASTM A 420 GR.WPL6, ASTM A 420 GR.WPL6-W		
	FLANGES	ASTM A 350 GR.LF2 CL.1		
	OTHERS	-		
BASE METAL `P' NO	**1**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW**	FILLERPASS: **GTAW / SMAW (NOTE-2)**	ROOTPASS: **GTAW**	FILLER PASS: **GTAW / SMAW (NOTE-2)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER 80SNi 1 (NOTE-1)**	FILLER PASS: **ER 80SNi 1 /E7018-1 (NOTE-1)**	ROOT PASS: **ER80S-Ni1 (NOTE-1)**	FILLER PASS: **ER 80SNi 1 /E7018-1 (NOTE-1)**
	FILLET JOINT/SOCKET JOINT: **E7018 -1/ER 80SNi 1 (NOTE-1)**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING: -		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING: -		SHIELDING: **99.997%**	
PREHEATING **(NOTE-3)**	PREHEAT TEMP: **10°C MIN/ 100°C FOR THK >25 mm**		INTERPASS TEMP.: **315°C MAX.**	
POST HEATING: -				
POST WELD HEAT TREATMENT	HOLDING TEMP: **-**		HOLDING TIME: **-**	
	RATE OF HEATING: **-**		MIN. HOLDING TIME: **-**	
	METHOD OF COOLING: **-**		RATE OF COOLING: **-**	
MECHANICAL PROPERTY REQUIREMENTS **(NOTE-4)**	CHARPY `V' NOTCH VALUE:		MIN: **20 J**	AVERAGE: **27 J**
	AT TEMPERATURE:		**-45 DEG C**	
	HARDNESS:			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES:

1. **ALL BATCHES OF WELDING CONSUMABLES SHALL BE IMPACT TESTED AT - 45°C. FOR B4A AND A44A,B44A, D44A PIPING CLASSES, IMPACT TEST OF WELDING CONSUMABLES BATCH SHALL BE PERFORMED AT - 46°C AND - 48°C RESPECTIVELY.**

2. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMTER 2" AND SMALLER.**

3. **PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK >=12.7 MM & <= 25 MM.**

4. **DURING PQR, IMPACT TESTING SHALL BE CARRIED OUT AT – (MINUS) 45°C. FOR B4A AND A44A,B44A,D44A PIPING CLASSES, IMPACT TESTING SHALL BE CARRIED OUT AT – (MINUS) 46°C AND - (MINUS) 48°C RESPECTIVELY.**

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WSC FOR PIPING CLASSES: **A11A**

MATERIAL SPECIFICATIONS	PIPES	**ASTM A106 GR. B, ASTM A672 GR. B60 CL.12**		
	FITTINGS	**ASTM A 105, ASTM A234 GR.WPB, ASTM A234 GR.WPB-W**		
	FLANGES	**ASTM A 105**		
	OTHERS	-		
BASE METAL `P' NO	**1**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW/SMAW (NOTE-1,2)**	FILLERPASS: **GTAW/SMAW (NOTE-1)**	ROOT PASS: **GTAW/ SMAW (NOTE-1,2)**	FILLER PASS: **GTAW/SMAW (NOTE-1)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2 / E7016/E7018**	ROOT PASS: **ER70S-2 / E6010**	FILLER PASS: **ER70S-2 / E7016/E7018**
	FILLET JOINT/SOCKET JOINT: **E7016/E7018/ER70S-2**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING:		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING:		SHIELDING: **99.997%**	
PREHEATING **(NOTE-3)**	PREHEAT TEMP: **10°C MIN./100°C (FOR THK>25MM)**		INTERPASS TEMP.: -	
POST HEATING:-				
POST WELD HEAT TREATMENT	HOLDING TEMP: -		HOLDING TIME: -	
	RATE OF HEATING: -		MIN. HOLDING TIME: -	
	METHOD OF COOLING: -		RATE OF COOLING: -	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS: **200 BHN MAX. (NOTE-4)**			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES:

1 GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL- BORE PIPING, DIAMETER 2" AND SMALLER.

2 ROOT PASS FOR SINGLE SIDE WELDING SHALL BE DONE BY GTAW PROCESS.

3 PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FORTHK>=12.5 MM & <= 25 MM.

4 HARDNESS SHALL BE RESTRICTED TO LESS THAN 200 BHN.

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WSC FOR PIPING CLASSES: **B16A**

MATERIAL SPECIFICATIONS	PIPES	**ASTM A106 GR. B, ASTM A672 GR. B60 CL.22**		
	FITTINGS	**ASTM A 105, ASTM A234 GR.WPB, ASTM A234 GR.WPB-W**		
	FLANGES	**ASTM A 105**		
	OTHERS	**-**		
BASE METAL `P' NO	**1**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW**	FILLERPASS: **GTAW/SMAW (NOTE -1)**	ROOTPASS: **GTAW**	FILLER PASS: **GTAW/ SMAW (NOTE-1)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER70S-2 (NOTE -2)**	FILLER PASS: **ER70S-2 / E7018-1/E7018 (NOTE -2)**	ROOT PASS: **ER70S-2 (NOTE -2)**	FILLER PASS: **ER70S-2 / E7018-1/E7018 (NOTE -2)**
	FILLET JOINT/SOCKET JOINT: **E7018/E7018-1 /ER70S-2 (NOTE - 2)**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING: **-**		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING: **-**		SHIELDING: **99.997%**	
PREHEATING **(NOTE-3)**	PREHEAT TEMP: **10°C MIN./ 100°C (FOR THK>25MM)**		INTERPASS TEMP.: **-**	
POST HEATING: **-**				
POST WELD HEAT TREATMENT **(NOTE-4)**	HOLDING TEMP: **-**		HOLDING TIME: **-**	
	RATE OF HEATING: **-**		MIN. HOLDING TIME: **-**	
	METHOD OF COOLING: **-**		RATE OF COOLING: **-**	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS: **200 BHN MAX. (NOTE-4)**			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES:

1. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL- BORE PIPING, DIAMTER 2" AND SMALLER.**
2. **EVERY BATCH OF ALL WELDING CONSUMABLES SHALL BE QUALIFIED FOR NACE SERVICE (NACE MR0175/TM0177 and TM0284).**
3. **PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK >=12.5 MM & <=25MM.**
4. **PWHT SHALL BE DONE AS PER LATEST ASME B31.3 FOR ALL WALL THICKNESSES. HARDNESS SHALL BE MEASURED AFTER PWHT.**

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WSC FOR PIPING CLASSES: **A19A, B19A**

MATERIAL SPECIFICATIONS	PIPES	**ASTM A 106 GR.B, ASTM A 672 GR.B60 CL.22**		
	FITTINGS	**ASTM A 105, ASTM A234 GR.WPB, ASTM A234 GR.WPB-W**		
	FLANGES	**ASTM A 105**		
	OTHERS	**-**		
BASE METAL `P' NO	**1**			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **GTAW**	FILLERPASS: **GTAW/SMAW (NOTE-1)**	ROOTPASS: **GTAW**	FILLER PASS: **GTAW/ SMAW (NOTE-1)**
	FILLET JOINTS/ SOCKET JOINTS: **SMAW/GTAW**			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: **ER70S-2**	FILLER PASS: **ER70S-2/ E7016/E7018**	ROOT PASS: **ER70S-2**	FILLER PASS: **ER70S-2/ E7016/E7018**
	FILLET JOINT/SOCKET JOINT: **E7016/E7018/ER70S-2**			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	**ASME B31.3**			
GASES	PURGING: -		SHIELDING: **ARGON**	
GAS COMPOSITION	PURGING: -		SHIELDING: **99.997%**	
PREHEATING**(NOTE-2)**	PREHEAT TEMP: **10°C MIN./ 100°C (FOR THK>25 MM)**		INTERPASS TEMP.: ---	
POST HEATING: -				
POST WELD HEAT TREATMENT **(NOTE-3,4)**	HOLDING TEMP: **620-650 °C**		HOLDING TIME: **-**	
	RATE OF HEATING: **-**		MIN. HOLDING TIME: **-**	
	METHOD OF COOLING: **-**		RATE OF COOLING: **-**	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS: **200 BHN MAX. (NOTE-3)**			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES

1. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL- BORE PIPING, DIAMETER 2" AND SMALLER.**
2. **PRE-HEAT TEMPERATURE OF ATLEAST 50°C SHALL BE PROVIDED FOR THE FIRST TWO PASSES FOR THK >=12.5 MM & ≤ 25 MM.**
3. **ALL WELD JOINTS INCLUDING ATTACHMENT WELDS SHALL BE STRESS RELIEVED IRRESPECTIVE OF THICKNESSES AND PWHT SHALL BE DONE AS PER LATEST EDITION OF ASME B31.3. HARDNESS SHALL BE MEASURED AFTER PWHT.**
4. **HOLDING TEMPERATURE FOR PWHT SHALL BE 620-650°C.**

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WSC FOR PIPING CLASSES: **B3F**

MATERIAL SPECIFICATIONS	PIPES	ASTM A 335 GR.P5, ASTM A 691 GR 5CR CL.42		
	FITTINGS	ASTM A 182 GR.F5, ASTM A 234 GR.WP5 CL. 1, ASTM A 234 GR.WP5-W CL.1		
	FLANGES	ASTM A 182 GR.F5		
	OTHERS	-		
BASE METAL `P' NO	5B			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: GTAW	FILLERPASS: GTAW/SMAW (NOTE-1)	ROOTPASS: GTAW	FILLER PASS: GTAW/ SMAW (NOTE-1)
	FILLET JOINTS/ SOCKET JOINTS: SMAW/GTAW			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: ER80S- B6	FILLER PASS: ER80S-B6/ E8016-B6L/ E8018-B6L/ E8016-B6/ E8018-B6	ROOT PASS: ER80S- B6	FILLER PASS: ER80S-B6/ E8016-B6L/ E8018-B6L/ E8016-B6/ E8018-B6
	FILLET JOINT/SOCKET JOINT: E8016-B6L/ E8018-B6L/ E8016-B6/ E8018-B6/ ER80S-B6			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	ASME B31.3			
GASES	PURGING: ARGON		SHIELDING: ARGON	
GAS COMPOSITION	PURGING: 99.997%		SHIELDING: 99.997 %	
PREHEATING	PREHEAT TEMP: 200°C MIN.		INTER PASS TEMP.: 300°C MAX	
POST HEATING: 300°C MIN. FOR 30 MINUTES FOLLOWED BY SUITALBE INSULATION COVER BEFROE PWHT				
POST WELD HEAT TREATMENT (NOTE-2)	HOLDING TEMP: -		HOLDING TIME: -	
	RATE OF HEATING: -		MIN. HOLDING TIME: -	
	METHOD OF COOLING: -		RATE OF COOLING: -	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS: 241 BHN MAX. (NOTE-2)			
CODE OF FABRICATION	ASME 31.3			

TECHNICAL NOTES:

1. GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL- BORE PIPING, DIAMETER 2" AND SMALLER.

2. PWHT SHALL BE DONE AS PER LATEST EDITION OF ASME B31.3 FOR ALL WALL THICKNESSES. HARDNESS SHALL BE MEASURED AFTER PWHT.

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WSC FOR PIPING CLASSES: **A42K, B42K, B46K, D42K, D54K, F55K**				
MATERIAL SPECIFICATIONS	**PIPES**	**ASTM A 312 TP304/304L**		
	FITTINGS	**ASTM A 182 GR.F304/304L, ASTM A 403 GR.WP304/304L-S, ASTM A 403 DUAL GRADE WP-WX 304 / 304L**		
	FLANGES	**ASTM A 182 GR.F304/304L**		
	OTHERS	**-**		
BASE METAL `P' NO	**8**			
WELDING PROCESS	**GROOVE JOINTS**			
	BUTT		**OTHER THAN BUTT**	
	ROOT PASS: GTAW	**FILLERPASS: GTAW/SMAW (NOTE-1)**	**ROOTPASS: GTAW/SMAW**	**FILLER PASS: GTAW/ SMAW (NOTE-1)**
	FILLET JOINTS/ SOCKET JOINTS: SMAW/GTAW			
WELDING MATERIALS	**GROOVE JOINTS**			
	BUTT		**OTHER THAN BUTT**	
	ROOT PASS: ER308L (NOTE-2,3)	**FILLER PASS:ER308L / E308L-15/16 (NOTE-2,3)**	**ROOT PASS: ER308L / E308L-15/16 (NOTE-2,3)**	**FILLER PASS : ER308L/ E308L-15/16 (NOTE-2,3)**
	FILLET JOINT/SOCKET JOINT: E308L-15/16 /ER308L (NOTE-2,3)			
	BACKING RING: -		**CONSUMABLE INSERT: -**	
JOINT PREPARATION	**ASME B31.3**			
GASES	**PURGING: - ARGON**		**SHIELDING: ARGON**	
GAS COMPOSITION	**PURGING: 99.997 %**		**SHIELDING: 99.997 %**	
PREHEATING	**PREHEAT TEMP: 10 °C**		**INTERPASS TEMP.: 175°C MAX.**	
POST HEATING: -				
POST WELD HEAT TREATMENT	**HOLDING TEMP: -**		**HOLDING TIME: -**	
	RATE OF HEATING: -		**MIN. HOLDING TIME: -**	
	METHOD OF COOLING: -		**RATE OF COOLING: -**	
MECHANICAL PROPERTY REQUIREMENTS	**CHARPY `V' NOTCH VALUE:**		**MIN: 0.38MM**	**AVERAGE: 0.38MM**
	AT TEMPERATURE:		**MINUS (-) 196°C**	
	HARDNESS:			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES:

1. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMETER 2" AND SMALLER.**
2. **FOR PIPING CLASS B46K, GTAW SHALL BE USED FOR THE ROOT PASS OF ALL WELDS.**
3. **ALL THE BATCHES OF FILLER MATERIALS SHALL HAVE GUARANTEED MINIMUM AS WELDED IMPACT VALUE OF 0.38 MM LATERAL EXPANSION AT MINUS (-) 196°C AT SITE. ALL THE FIVE VALUES SHALL BE OVER 0.38 MM.**
4. **FERRITE NUMBER IN THE WELDING CONSUMABLES SHALL BE GREATER THAN 1.**

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WSC FOR PIPING CLASSES: **A28M**

MATERIAL SPECIFICATIONS	PIPES	ASTM A 312 TP316/316L DUAL		
	FITTINGS	ASTM A 182 GR.F316/316L DUAL, ASTM A403GR.WP316/316L-WX DUAL		
	FLANGES	ASTM A 182 GR.F316/316L DUAL		
	OTHERS	-		
BASE METAL `P' NO	8			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: GTAW	FILLERPASS: GTAW/SMAW	ROOTPASS: GTAW/SMAW	FILLER PASS: GTAW/ SMAW
	FILLET JOINTS/ SOCKET JOINTS: SMAW/GTAW			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: ER316L(NOTE-1)	FILLER PASS: : ER316L/ E316L-15/16(NOTE-1)	ROOT PASS: ER316L/ E316L-15/16(NOTE-1)	FILLER PASS : ER316L/ E316L-15/16(NOTE-1)
	FILLET JOINT/SOCKET JOINT: ER316L/ E316L-15/16 (NOTE-1)			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	ASME B31.3			
GASES	PURGING: - ARGON		SHIELDING: ARGON	
GAS COMPOSITION	PURGING: - 99.997 %		SHIELDING: 99.997 %	
PREHEATING	PREHEAT TEMP: 10 °C MIN.		INTERPASS TEMP.: 175°C MAX.	
POST HEATING: -				
POST WELD HEAT TREATMENT	HOLDING TEMP: -		HOLDING TIME: -	
	RATE OF HEATING: -		MIN. HOLDING TIME: -	
	METHOD OF COOLING: -		RATE OF COOLING: -	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN:	AVERAGE:
	AT TEMPERATURE:		-	
	HARDNESS: -			
CODE OF FABRICATION	ASME B31.3			

TECHNICAL NOTES:

1. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMETER 2" AND SMALLER.**

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WSC FOR PIPING CLASSES: **A1K, A3K, B1K**				
MATERIAL SPECIFICATIONS	PIPES	ASTM A 312 TP304, ASTM A 358 TP304 CL.1		
	FITTINGS	ASTM A 182 GR.F304, ASTM A 403 GR.WP304-S, ASTM A 403 GR.WP304-WX		
	FLANGES	ASTM A 182 GR.F304		
	OTHERS	-		
BASE METAL `P' NO	8			
WELDING PROCESS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: GTAW	FILLERPASS: GTAW/SMAW	ROOTPASS: GTAW/SMAW	FILLER PASS: GTAW/ SMAW
	FILLET JOINTS/ SOCKET JOINTS: SMAW/GTAW			
WELDING MATERIALS	GROOVE JOINTS			
	BUTT		OTHER THAN BUTT	
	ROOT PASS: ER308/ER308L	FILLER PASS: ER308/ ER308L/ E308-15/16/ E308L-15/16 (NOTE-1)	ROOT PASS: ER308/ ER308L/ E308-15/16/ E308L-15/16 (NOTE-1)	FILLER PASS: ER308/ ER308L/ E308-15/16/ E308L-15/16 (NOTE-1)
	FILLET JOINT/SOCKET JOINT: E308-15/16/ E308L-15/16 /ER308 / ER 308L			
	BACKING RING: -		CONSUMABLE INSERT: -	
JOINT PREPARATION	ASME B31.3			
GASES	PURGING: - ARGON		SHIELDING: ARGON	
GAS COMPOSITION	PURGING: 99.997 %		SHIELDING: 99.997 %	
PREHEATING	PREHEAT TEMP: 10 °C		INTERPASS TEMP.: 175°C MAX.	
POST HEATING: -				
POST WELD HEAT TREATMENT	HOLDING TEMP: -		HOLDING TIME: -	
	RATE OF HEATING: -		MIN. HOLDING TIME: -	
	METHOD OF COOLING: -		RATE OF COOLING: -	
MECHANICAL PROPERTY REQUIREMENTS	CHARPY `V' NOTCH VALUE:		MIN: -	AVERAGE: -
	AT TEMPERATURE:		-	
	HARDNESS: -			
CODE OF FABRICATION	ASME B31.3			

TECHNICAL NOTES:

1. GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMALL BORE PIPING, DIAMETER 2" AND SMALLER.

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WSC FOR PIPING CLASSES: **B5K**				
MATERIAL SPECIFICATIONS	**PIPES**	**ASTM A 312 TP304H**		
	FITTINGS	**ASTM A 182 GR.F304H, ASTM A 403 GR.WP304H-S**		
	FLANGES	**ASTM A 182 GR.F304H**		
	OTHERS	**-**		
BASE METAL `P' NO	**8**			
WELDING PROCESS	**GROOVE JOINTS**			
	BUTT		**OTHER THAN BUTT**	
	ROOT PASS: GTAW	**FILLERPASS: GTAW/SMAW**	**ROOTPASS: GTAW/SMAW**	**FILLER PASS: GTAW/ SMAW**
	FILLET JOINTS/ SOCKET JOINTS: SMAW/GTAW			
WELDING MATERIALS	**GROOVE JOINTS**			
	BUTT		**OTHER THAN BUTT**	
	ROOT PASS: ER308H (NOTE-1,2,3)	**FILLER PASS: ER308H/ E308H-15/16 (NOTE-1,2,3)**	**ROOT PASS: ER308H/E308H-15/16 (NOTE-1,2,3)**	**FILLER PASS ER308H/E308H-15/16 (NOTE-1,2,3)**
	FILLET JOINT/SOCKET JOINT: E308H-15/16 / ER308H			
	BACKING RING: -		**CONSUMABLE INSERT: -**	
JOINT PREPARATION	**ASME B31.3**			
GASES	**PURGING: - ARGON**		**SHIELDING: ARGON**	
GAS COMPOSITION	**PURGING: - 99.997 %**		**SHIELDING: 99.997 %**	
PREHEATING	**PREHEAT TEMP: 10 °C**		**INTERPASS TEMP.: 175°C MAX.**	
POST HEATING: -				
POST WELD HEAT TREATMENT	**HOLDING TEMP: -**		**HOLDING TIME: -**	
	RATE OF HEATING: -		**MIN. HOLDING TIME: -**	
	METHOD OF COOLING: -		**RATE OF COOLING: -**	
MECHANICAL PROPERTY REQUIREMENTS	**CHARPY `V' NOTCH VALUE:**		**MIN:**	**AVERAGE:**
	AT TEMPERATURE:		**-**	
	HARDNESS: -			
CODE OF FABRICATION	**ASME B31.3**			

TECHNICAL NOTES:

1. **GTAW SHALL BE EMPLOYED FOR ENTIRE WELDING OF SMAL -BORE PIPING, DIAMETER 2" AND SMALLER.**
2. **FERRITE LEVELS IN THE WELDING CONSUMABLE SHALL BE MEASURED DURING PQR AND SHALL BE IN THE RANGE OF 3-10 FN.**
3. **CARBON CONTENT OF WELDING CONSUMABLES SHALL BE GREATER THAN OR EQUAL TO 0.04 WT.%.**

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JOB SPECIFICATION FOR SURFACE PREPARATION AND PROTECTIVE COATING

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by
2	14.05.2025	REVISED AND REISSUED FOR AS JOB SPECIFICATION	JATIN	SAHIL	SRIDHAR
1	30.07.2024	CLIENT COMMENTS INCORPORATED AND REISSUED AS JOB SPECIFICATION	JATIN	SAHIL	SRIDHAR
0	24.07.2024	ISSUED AS JOB SPECIFICATION	JATIN	SAHIL	SRIDHAR
A	16.07.2024	ISSUED FOR CLIENT COMMENTS	JATIN	SAHIL	SRIDHAR

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Abbreviations:

AS	:	Alloy Steel
ASTM	:	American Society for Testing and Materials
AWWA	:	American Water Works Association
CS	:	Carbon Steel
DFT	:	Dry Film Thickness
GI	:	Galvanized Iron
ID	:	Internal Diameter
ISO	:	International Organization for Standardization
LTCS	:	Low temperature Carbon Steel
MS	:	Mild Steel
MR	:	material requisition
NB	:	Nominal Bore
NA	:	Not applicable
OD	:	Outside Diameter
OEM	:	Original Equipment Manufacturer
OSHA	:	Occupational Safety and Health Act
RCC	:	Reinforced Cement Concrete
RH	:	Relative humidity
SS	:	Stainless Steel
SOR	:	Schedule of Rate
SSPC	:	Steel Structure Painting Council
WFT	:	Wet Film Thickness

Document History:

Rev.2:

Client comments incorporated and Table-12 is included in this specification for PFCCU Revamp work i.e. Coating systems for corrosive areas - brown field painting (revamp, refurbishment and maintenance).

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1.0 GENERAL

1.1 This technical specification shall be applicable for the work covered by the contract and without prejudice to the provisions of various international codes of practice, standard specifications etc. It is understood that the CONTRACTOR shall carry out the work in all respects with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of Engineer-In-Charge in consultation with SMMS.

1.2 This specification covers the requirement for protective coating for new construction, revamp and refurbishment.

2.0 SCOPE

2.1 Scope of work covered in the specification shall include, without being limited to, the following:

This specification defines the requirements for surface preparation, selection and application of primers and coatings on external surfaces of items mentioned in clause 2.2 of this specification and quality control, inspection & testing of the coating systems. The items listed in clause 2.2 and the heading of tables of paint systems are non-exhaustive. However, the CONTRACTOR is fully responsible for carrying out all the necessary painting, coating and lining job on external and internal surfaces as per the contract requirement.

2.2 Extent of work covered in this specification

2.2.1 The following surfaces and materials shall require shop, pre-erection and field painting, as applicable:

a. All Carbon Steel structures.

b. All Carbon Steel and Alloy steel piping, equipment, valves, fittings & stacks.

c. All Carbon Steel and Alloy steel tanks.

d. Tanks internal as per applicable datasheets & contract requirements.

e. All insulated CS pipes, equipment, valves, fittings & stacks.

f. All insulated SS pipes, equipment, valves, fittings, vessels & stacks.

g. All structural steel supports, walkways, handrails, ladders, platforms etc.

h. Flare lines, external surfaces of steel chimney with or without refractory lining and internal surfaces of steel chimney without refractory lining.

2.2.2 Marking and Identification of painted items:

a. Identification of color bands on all piping, as required, including aluminum cladding over insulation, galvanized, SS and nonferrous piping.

b. Identification lettering/ numbering on all painted surfaces of equipment/piping, aluminum cladding over insulation, galvanized, SS and non-ferrous piping.

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c. Marking / identification signs on painted surfaces of equipment and piping including hazardous service.

2.2.3 Supply and prequalification testing of all primers, paints and all other materials required for painting (other than OWNER supplied materials)

2.2.4 Application of pre-erection/fabrication and shop primer.

2.2.5 Repair work of damaged pre-erection/ fabrication and shop primer and weld joints in the field/site before and after erection.

2.2.6 Quality control, testing and inspection during all stages of work (surface preparation, application of coating and testing of applied coating).

2.2.7 Exclusions:

All metallic surfaces do require painting except for following materials. These materials are not painted unless specified by the contractual provisions and the same shall be painted as per the relevant specifications:

a. Un-insulated stainless steel.
b. Plastic and/or plastic-coated materials.
c. Galvanized Iron.
d. Aluminum.
e. Ni-Alloys.
f. Glass.
g. Ceramics.
h. Machined surfaces.
i. Label and names plates.

Note: Galvanized steel doesn't require painting for corrosion protection. However, if painting is mandated due to OWNERs instructions/contractual provision/ for colour coding requirement mentioned in this specification or by OWNER, then the coating system in Table 4.0 shall be followed.

3.0 REFERENCE CODES & STANDARDS

3.1 Latest editions of the following codes and standards are applicable for the work covered by this standard:

Steel Structures Painting Council (SSPC)

SSPC SP-1	Solvent cleaning
SSPC Painting manual Vol.1	Good Painting practices
SSPC Painting manual Vol.2	Systems & specification
SSPC VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
SSPC AB1	Mineral and Slag Abrasives
SSPC PA 2	Measurement of Dry Paint Thickness with Magnetic Gauges

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American Society for Testing and Materials (ASTM):

ASTM Volume 6.01	Paint - Tests for Chemical, Physical, and Optical Properties; Appearance
ASTM Volume 6.03	Paint -- Pigments, Polymers, Resins, Naval Stores, Cellulosic Esters, and Ink Vehicles
ASTM D6677	Standard Test Method for Evaluating Adhesion by Knife
ASTM D5894	Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)
ASTM D870	Standard Practice for Testing Water Resistance of Coatings Using Water Immersion
ASTM D2485	Standard Test Methods for Evaluating Coatings for High Temperature Service
ASTM D2247	Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D4060	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D4752	Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D4940	Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blast Cleaning Abrasives
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D543	Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
ASTM C868	Standard Test Method for Chemical Resistance of Protective Linings
ASTM G42	Standard Test Method for Cathodic Disbonding of Pipeline Coatings Subjected to Elevated Temperatures
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1475	Standard Test Method for Density of Liquid Coatings, Inks, and Related Products
ASTM D823	Standard Practices for Producing Films of Uniform Thickness of Paint, Coatings and Related Products on Test Panel
ASTM D2369	Standard Test Method for Volatile Content of Coatings
ASTM D1640/D1640M-14	Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings
ASTM D522/D522M	Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings
ASTM D968	Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

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ASTM D1044	Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion
ASTM D1849	Standard Test Method for Package Stability of Paint
ASTM D2247	Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
ASTM D5146	Standard Guide to Testing Solvent-Borne Architectural Coatings

National Association for Corrosion Engineer (NACE):

NACE RP 0287	Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape
NACE SP 0198	Control of Corrosion under Thermal Insulation and Fireproofing Materials
NACE SP 0188	Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

International Organization for Standardization (ISO):

ISO 12944	Corrosion Protection of steel Structures by Protective Paint System
ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles-Specifications and test methods.
ISO 8501-1/ SIS-05 59 00	Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness— Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
ISO 8502-3	Preparation of steel substrates before application of paints and related products -Tests for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
ISO 8502-9	Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness—Part 9: Field method for the conductometric determination of water-soluble salts
ISO 2808	Paints and varnishes - Determination of film thickness
ISO 2811	Paints and varnishes — Determination of density

Other Standards

NORSOK M-501	Surface preparation and protective coating
RAL CLASSIC	Color matching system

4.0 SURFACE PREPARATION

4.1 General

Adhesion of the paint film to the surface depends largely on the degree of cleanliness of the metal surface and proper surface preparation have large contribution to the success of the paint protective system. Following method shall be employed for surface preparation:

a. Abrasive blast cleaning: Applicable in all cases.

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b. Mechanical or power tool cleaning: Shall be used for repair & touch up, and any other area due to practical constraints with prior permission from EIL Engineer-in charge.

4.2 Applicable Standards:

Latest editions of the following codes and standards are applicable for the surface preparation work:

TABLE-1: SURFACE PREPARATION STANDARDS

Sl. No.	GRADE OF SURFACE CLEANLINESS	VARIOUS INTERNATIONAL STANDARDS (EQUIVALENT)		
		ISO 8501-1/ SIS-05 59 00	SSPC, USA	NACE, USA
1.	Solvent cleaning	-	SSPC-SP-1	-
2.	Manual or hand tool cleaning	St 2	SSPC-SP-2	-
3.	Mechanical or power tool cleaning	St 3	SSPC-SP-3	-
4.	White metal	Sa 3	SSPC-SP-5	NACE No.1
5.	Near white metal	Sa 2½	SSPC-SP-10	NACE No.2
6.	Commercial Blast	Sa 2	SSPC-SP-6	NACE No.3
7.	Brush-off Blast for SS, galvanized steel and non-ferrous metals	-	SSPC-SP-16	-
8.	Surface Preparation of Concrete	-	SSPC-SP-13	NACE No.6

4.3 Sequence of surface preparation:

4.3.1 Solvent Cleaning

Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. Unless otherwise specified, surface preparation shall be done as per provisions of relevant tables given elsewhere in this specification. Before surface preparation by blast cleaning, the surface shall be cleaned to remove all grease, oil etc. as per SSPC-SP-1.

4.3.2 Blast cleaning with abrasives

The surfaces shall be blast cleaned using one of the abrasives listed below and at an appropriate distance & angle depending on nozzle size maintaining constant velocity and pressure.

a. The quality of abrasives shall be free from contaminants and impurities and shall meet the requirements of SSPC AB1.

b. The compressed air shall be free from moisture and oil.

c. On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust. Blast cleaning shall not be done outdoors in bad weather without adequate protection. If there is dew on the metal surface, it shall be cleaned. If possible, a vacuum collector shall be installed to collect and recycle the abrasives.

d. Surface roughness profile: The surface roughness profile for carbon steel and low alloy steels to be coated shall be in accordance with the written recommendations of the paint Manufacturer and shall be measured as per ASTM D4417, method B. When roughness profile is not specified by

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the paint Manufacturer, then surface roughness profile as specified below in this specification shall be followed.

- The surface roughness profile shall be between 40 µm and 70 µm for coatings up to thickness 500 µm and between 70 µm and 125 µm for coating systems over 500 µm thickness. In all cases, the surface roughness shall have a sharp angular profile.

- If stainless steel, hot dip galvanised or non-ferrous metal surfaces are to be painted then blast cleaning shall be carried out as per SSPC-SP-16, using a fine non-iron containing abrasive.

- On galvanised surfaces, the zinc layer shall not be damaged; a smooth uniform surface roughness shall be achieved. No defects such as break through or crisping of the zinc layer shall occur. The surface roughness shall be in the range of 20 µm to 30 µm or as agreed with the paint Manufacturer.

e. Abrasives: Abrasive for use in blast cleaning steels shall be in accordance with ISO 8504-2. Steel or iron grit is commonly used as recyclable abrasives. When steel shot is used, it shall be used together with steel grit. The shot content of such a mix shall not exceed 67 %.For blasting stainless steel, non-(free) iron containing abrasive shall be used, e.g. Garnet or aluminium oxide. Abrasives used for blast cleaning shall be free from oil, grease, moisture, chloride contamination etc. and shall have crystalline silica not more than 1%.

Test methods for abrasives shall be in accordance with the tests specified in the ISO 11125 and ISO 11127 series for metallic and non-metallic abrasives respectively. Each batch of abrasive should be tested to check that the abrasive meets the requirements as specified in the relevant ISO standard. The conductivity of non-metallic abrasives to be used for stainless steels shall be maximum 15 mS/m. For all other non-metallic abrasives, the conductivity shall not exceed 25 mS/m. OWNER/PMC shall approve the use of alternative abrasive materials. Abrasive used shall be as per following specification:

Type	Generic Name	Standard
Metallic	Iron grit	ISO 11124-2
	Steel grit	ISO 11124-3
Natural mineral	Staurolite	ISO 11126-9
	Garnet	ISO 11126-10
Synthetic mineral	Copper slag	ISO 11126-3
	Aluminium oxide	ISO 11126-7

4.3.3 Mechanical or power tool cleaning

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

4.4 General Notes for surface preparation/blasting:

a. Surface shall not be coated in rain, wind or in an environment where injurious airborne elements exist.

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b. Surface shall not be coated when the steel surface temperature is less than 3 ^{0}C above dew point.

c. Surface shall not be coated, when the relative humidity is greater than 85%.

d. Surface shall not be coated when the temperature is below 10^{o}C and the ambient/substrate temperature is below the paint manufacturers recommended temperature of application and curing.

e. The paint application shall not be done when the wind speed exceeds 20 km per hour.

f. The illuminance during coating and inspection shall be at least 1000 Lux.

4.5 Use of Dehumidifier

In case of internal coating of storage tanks, dehumidifier shall be used to control humidity level below 60%. Dehumidifier should depress the dew point of air in the enclosed space, sufficient enough so as to maintain it more than 3ºC below the metal substrate temperature during entire period of blasting and coating application. During the interval time between application of primer coat and subsequent intermediate and top coats or between blast cleaning completion and start of application of primer coat, dehumidifier unit should be in continuous operation to ensure that no condensation occurs on the substrate.
The Engineer in-Charge shall have the right to disallow usage of dehumidifier if the performance is not meeting the specified requirements. Under such circumstances, the CONTRACTOR shall remove the equipment and replace the same with another equipment to provide satisfactory results without any additional cost to the OWNER.

4.6 Surface preparation of concrete:

The external surface of RCC to be painted shall be dry and clean. Any loose particle of sand, cement, aggregate etc. shall be removed and surface shall be prepared as per SSPC-SP-13.

5.0 COATING APPLICATION

5.1 Blast cleaned surface shall be coated with complete application of primer as soon as practicable but in no case later than 4 hours the same day. However, at times of unfavorable weather conditions, the Engineer-In-Charge shall have the liberty to control the time period, at his sole discretion and/or to insist on re-cleaning before primer application is taken up. In general, during unfavorable weather conditions, blasting and painting shall be avoided as far as practicable.

5.2 To the maximum extent practicable, each coat of paint shall be applied as a continuous film with uniform thickness and free of probes. Any spots or areas missed in application shall be re-coated and permitted to dry before the next coat is applied.

5.3 Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for re-coating when an additional coat can be applied without the development of any detrimental film irregularities such as lifting or loss of adhesion of the under coat. Manufacturer's instructions shall be followed for inter-coat interval.

5.4 When the successive coat of the same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate the complete coverage of the

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surface. The tinting material shall be compatible with the material underneath and shall not be detrimental to its service life and shall be recommended by the original paint manufacturer.

5.5 Airless spray application shall be in accordance with steel structure paint manual Vol.1 & Vol.2 by SSPC, USA

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

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

b. Round or oval brushes are most suitable for rivets, bolts, irregular surfaces, and rough/ pitted steel. Wide flat brushes are suitable for large flat areas but they shall not have width over 5 inches.

c. Paint shall be applied into all corners.

d. Any runs or sags shall be brushed out.

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

f. Surfaces not accessible to brushes shall be painted by spray, daubers, or sheepskin.

5.7 Applied paint should have the desired wet film thickness specified by manufacturer. For each coat, the painter should know the WFT corresponding to the specified DFT and standardize the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.

5.8 Irregular surfaces such as sharp edges, welds, small brackets, and interstices may stripe coated to ensure specified DFT is achieved. Paint manufacturer recommendation should be followed before deciding for brush application.

5.9 Unless otherwise instructed, final coating (i.e. application of field primer, intermediate and top coats) on pre-erection/ shop primed equipment shall be applied at site, only after all welding & testing like NDT are completed as well as after completion of steam blowing.

5.10 Drying of coated surfaces

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

b. No paint shall be force dried under conditions which will cause chalking, wrinkling, blistering formation of pores, or detrimentally affect the conditions of the paint.

c. No drier shall be added to paint on the job unless specifically called for in the manufacturers' specification for the paint.

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

5.11 Spot repair of damaged primer

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a. Where pre-erection/shop primer has been damaged at isolated localized spots during handling and transportation or after erection / welding, its repair shall be done as given below and as per the Table-3 of this specification.

b. Surface preparation: Quickly remove the primer from damaged area by mechanical scraping and emery paper conforming to SSPC-SP-3 to expose the white metal. Blast clean the surface, if possible. Feather the primed surface, over the intact adjacent surface surrounding the damaged area, by emery paper.

Primer coating: One coat of F-8/F-9/F-16 shall be applied (as per the applicable design temperature and in conjunction with Table-3) wherever damage was observed on pre-erection / pre fabrication or shop primer.

c. If damaged areas are found to be extensive and spread over large areas (as required by Engineer-in charge), then entire pre-erection/pre-fabrication/shop primer shall be removed by blasting to achieve SSPC-SP-10 and entire blasted surface shall be primed again with F-8/ F-9 or F-16, as applicable, for the intended design temperature. (See note of Table-3). If the prepared surface lies adjacent to a sound coated surface, the surface preparation shall overlap the coated surface by at least 50mm. The remainder of existing coated surface shall be properly protected with shields or screens to prevent any possible damage to the coating.

5.12 Equipment:

a. All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning, all equipment, scaffolding materials, shot & grit blasting equipment , air compressors etc. required shall be suitable for the work and shall be arranged by the CONTRACTOR in sufficient quantity at the site. The manufacturers test certificates **/** data sheets for all the above mentioned items shall be reviewed by Engineer-In-Charge at site before start of the work.

b. All paint spraying equipment, including mixers, shall be thoroughly cleaned before mixing of new materials. All coating materials shall be mixed and thoroughly stirred in accordance with the instructions of the paint Manufacturer. Sufficient agitation to maintain good mixing shall be applied until the product is used. If air is entrapped in the product during mixing/stirring, sufficient time should be allowed for the air bubbles to escape before application. Only thinners specified by the paint Manufacturer shall be used.

5.13 Shop coating

a. Shop coated equipment (coated with primer & finishing coat) should not be repainted unless paint is damaged. Repair of primer shall be carried out as per Table-3 of paint systems depending upon the compatibility of paint. Intermediate and final coats over repaired primer shall be as per applicable tables mentioned in this specification**.**

c. Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer, unless otherwise specified. If shop primer is not compatible with field primer, then shop coated primer should be completely removed before application of selected paint system for a particular environment.

d. For package units/Items/ OEM equipment, shop primer & coating system should be as per the paint system given in this specification. However, manufacturers' standard may be followed after review by EIL but shall adhere to the minimum DFT specified in ISO-12944-5; C5 (Very high

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durability). For system under insulation, minimum guidelines as per NACE RP 0198 shall be followed.

In this case, guarantee of the coating system lies with package supplier/OEM. EIL's decision in this regard is final and binding on Supplier/Contractor/manufacturer

5.12 Guidelines for Documentation / records

a. A written quality plan with procedure for qualification trials and for the actual work including test and inspection plan & procedure for approval before start of work.

b. Daily progress report with details of weather conditions, particular of applications, no. of coats and type of materials applied, anomalies, progress of work versus program.

c. Results of measurement of temperatures, relative humidity, surface profile, film thickness, holiday detection, adhesion tests with signature of appropriate authority.

d. Particulars of surface preparation and paint application during trials and during the work.

e. Details of non-compliance, rejects and repairs.

f. Type of testing equipment and calibration.

g. Code and batch numbers of paint materials used.

Note: The coating applicator must maintain a job record consisting of all the information as per 5.12.b. to 5.12.g above as well as the approved procedure of work (5.12.a. above). The job record consisting of information in accordance to 5.12.b. to 5.12.g shall be entered on daily basis and should be daily signed by Engineer-in-charge.

6.0 PAINT MATERIALS

Typical characteristics and codes of various paint materials used in this specification are as follows.

TABLE-2: PAINT MATERIALS
(Refer to *general notes* at the end of this table)

DESCRIPTION	P-6	P-7	P-4
Technical name	Epoxy Zinc Phosphate Primer	Cold Galvanizing product	Etch Primer/Wash Primer
Type and composition	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.	Two pack polyvinyl butyral resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate.
Volume solids % Minimum	49	37	9
DFT per coat, µ	40-50	40-50	8-10

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Theoretical covering capacity in m^2/coat/ litre	9.8-12.2	3.4-4.4 m²/kg	9.0-11.2
Weight per liter in Kg/litre (min.)	1.4±0.05	2.67 kg at 15°C	1.2±0.05
Touch dry at 30°C (max.)	30 min.	10 min.	2 hrs.
Hard dry at 30°C (max.),Hrs.	8	24	24
Over-coating interval, hrs.	Min. 8	Min. 4	Min. 4-6
Pot life at 30°C for two Component paints, hrs.	6 - 8	NA	NA
Adhesion (ASTM D 4541)	>7	NA	NA
Temperature resistance (min) ° C (ASTM D 2485) *Note 8	80 (Method A)	50 (Method A)	NA

TABLE- 2: PAINT MATERIALS (Contd.)

DESCRIPTION	F-2	F-3	F-6A/B	F-6C
Technical name	Acrylic Polyurethane finish paint	Chlorinated rubber-based finish paint	Epoxy-High Build coating	Solvent less epoxy coating
Type and composition	Two-pack aliphatic isocynate cured acrylic finish paint (free of alkyd/polyester resins).	Single pack Plasticized chlorinated rubber based medium with chemical and weather resistant pigments.	F-6A Two-Pack Aromatic polyamine cured epoxy resin medium suitably pigmented. F-6B: polyamide cured epoxy resin medium suitably pigmented with MIO.	Two pack, cured with Amine Adduct; catalyzed epoxy resin suitably pigmented
Volume Solids % (min.)	40	36	57	98
DFT per coat, µ	30-40	30-40	100-125	300-450
Theoretical covering capacity in m^2/coat/litre	10-13.3	9-12	4.6-5.7	2-3.9
Weight per liter in Kg/litre (min.)	1.15	1.15	1.42	1.40
Touch dry at 30°C (max)	30 min.	30 min.	3 hrs.	3 hrs.
Hard dry at 30°C				

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(max.).	8 hrs.	8 hrs.	16 hrs.	16 hrs.
Full cure at 30 °C (for immersion/ high temperature service)	NA	NA	5 days	5 days
Over-coating Interval, hrs	Min.12.	Min. Overnight	Min. Overnight Max. 5 days	Min. 8. Max. 48
Pot life (approx.) at 30 °C for two component paints, hrs	5-8	NA	3-6	0.5
Adhesion (ASTM D 4541)	>5	>4	>7	>8
Abrasion Resistance (ASTM D4060) For 1000 g load	<300 mg /1000 cycles/CS17 or <100 mg /1000 cycles/CS10	NA	NA	NA
Temperature resistance (min.) ° C (ASTM D 2485) *Note 8	80 (Method A)	60 (Method A)	80 (Method A)	120 (Method A)

TABLE- 2: PAINT MATERIALS (Contd.)

DESCRIPTION	F-7	F-8	F-9	F-11	F-12
Technical name	High build coal tar epoxy coating.	Self-priming type surface tolerant high build epoxy coating (complete rust control Coating)	Inorganic zinc silicate Coating containing zinc content min. 80%. Shall pass MEK rub test as per ASTM D4752 with resistance rating >4	Heat resistant synthetic medium based two pack Aluminum Paint suitable up to 250°C dry temp.	Heat resistant silicone Aluminum Paint suitable up to 540°C dry temp.
Volume Solids % Minimum.	62	75	57	35	18
DFT per coat in µ	100-125	100-125	65-75	15-20	15-20
Theoretical covering capacity in	5-6.2	6-7.5	7.6-8.8	17.5-23.3	9-12

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M^2/coat/ litre					
Weight per liter in Kg/litre (min.)	1.40	1.41	2.3	0.95	1.00
Touch dry at 30°C (maximum)	4 hrs.	3 hrs.	0.5 hrs.	3 hrs.	0.5 hrs.
Hard dry at 30°C (maximum),	48 hrs.	24 hrs.	12 hrs.	12 hrs	24 hrs.
Full cure 30°C (for immersion /high Temperature sev.)	5 days	5 days	NA	NA	NA
Over-coating interval, hrs	Min. 24 hrs Max.5days	Min. 10	Min. 12 hrs at 20°C & 50% RH	Min. 24	Min. 24
Pot life at 30°C for two component Paints, hrs	4-6	1.5	4-6	NA	NA
Adhesion MPa (ASTM D 4541)	>5	>5	>5	NA	NA
Temperature resistance (min.) ° C (ASTM D 2485) *Note 8	80 (Method A)	80 (Method A)	400 (Method B)	250 (Method A)	540 (Method B)

TABLE- 2: PAINT MATERIALS (Contd.)

DESCRIPTION	F-14	F-15	F-16	F-17	F-20
Technical name	Polyamine cured coal tar epoxy	Two-component Epoxy phenolic coating cured with Polyamine adduct hardener	Inert polymeric matrix coating suitable for under insulation for CS and SS.	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Glass flake reinforced vinyl ester coating.
Type & composition	Specially formulated polyamine cured coal tar epoxy suitable for application under insulation	Two pack ambient temperature curing epoxy phenolic coating system suitable for application under insulation	Suitable for high temperature service and under insulation coating for CS, alloy steel and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Two component glass flake filled vinyl ester lining for under immersion services up to 90 deg. C.

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Volume Solids % Minimum.	67	67	50	98	98
DFT per coat in microns	100-125	75-100	100-125	300-450	500-600
Theoretical covering capacity in M^2/coat/ litre	5.4-6.7	6.7-8.9	4-5	2.2-3.3	1.6-2
Weight per liter in Kg/litre (min.)	1.45	1.65	>1.3	1.7	>1.2
Touch dry at 30°C (max)	4 hrs.	3 hrs.	1 hrs.	2 hrs.	2 hrs.
Hard dry at 30°C (max).	24 hrs.	24 hrs.	16 hrs.	24 hrs.	4 hrs.
Full cure 30°C (for immersion / high temp service)	168 hrs (7 days)	168 hrs (7 days)	NA	168 hrs (7 days)	96 hrs (4 days)
Over-coating interval	Min. 6 hrs Max.5 days	Min. 36 hrs Max.21 days	Min.6 hrs Max. Not applicable	Min. 16 hrs Max.21 days	Min. 4 hrs Max.3 days
Pot life at 30ºC, hrs (for two component paints)	4	4-6	1	1	50 min-1 hr.
Adhesion, MPa (ASTM D 4541)	>6	>7	NA	>8	>7, Tensile strength >20N/mm2 (ASTM D 638)
Temperature resistance (min.) º C (ASTM D 2485) *Note 8 & 9	125 (Method A)	150 (Method A)	650 (Method B) Note: 10	200 (Method A)	90 (Method A)

General notes for TABLE-2:

1. Covering capacity and DFT achieved per coat depends on method of application. Covering capacity specified above is theoretical. For estimation of actual quantity of paints required, include the losses during application. Minimum specified DFT should be maintained in any case.

2. All primers and finish coats should be ambient temperature curing 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. Wherever a deviation is noticed from the specification in manufacturer data sheet, more stringent one between the data sheet and the specification shall

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prevail e.g. if this specification recommends Sa 2 ½ and the manufacturer data sheet requires Sa3, the surface preparation shall be done as per Sa 3. However, in another case if this specification requires the surface preparation of Sa 2 ½ and the manufacturer data sheet recommends only Sa 2 as minimum, the surface preparation shall be done as per Sa 2 ½.

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

5. Internationally recognized & acceptable testing method shall be used for lab testing wherever testing standards are not mentioned.

6. Touch dry, hard dry, pot life, full cure period, & over coating interval shall be as per manufacturer's data sheets and no testing is required. Slight variation in the values of these parameters along with weight per liter may be permissible with the discretion of engineer-in-charge in consultation with SMMS.

7. Temperature resistance tests (ASTM D2485) shall be carried out for minimum required temperature resistance indicated.

8. Wherever ASTM D 2485 method B is applicable, test results of the panels subjected to salt spray (ASTM B 117) after muffle furnace exposure shall be submitted for pre-qualification purpose.

9. F6-C shall be suitable for drinking water service and should have certification from competent authority.

10. Maximum design temperature of CS/LTCS is upto 425°C and for Stainless steel is upto 650°C.

7.0 SELECTION OF COATING SYSTEMS

The external coating system for EIL projects should be selected based on the C5 environment (very high durability) as per ISO12944-2, design temperature, involved services of the steel substrate and plant location.

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

a. Identify the environment from area classification details and choose the appropriate table.
b. Identify the design temperature from the technical documents.
c. Identify the specific field paint system and surface preparation requirement from the above identified table and temperature range.
d. Identify the shop priming requirement from based on compatibility of the above paint system.
e. Identify the need of repair of shop primer and execute as per Table-3.

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TABLE-3: REPAIR OF PRE-ERECTION/PRE-FABRICATION OR SHOP PRIMER AFTER ERECTION/WELDING

(For all un-insulated CS, LTCS & alloy steel items in all environments)

Sl. No.	Design Temp. in °C	Surface Preparation	Coating System	Total DFT in Microns (min.)	Remarks
3.1	-45 to 80	SSPC-SP-3	1 coat of F-8 @ 125 µ DFT/coat	125	See Note-1 below and clause 5.11
3.2	81 to 400	SSPC-SP-3	1 coat of F-9 @ 65-75 µ DFT/coat	65-75	
3.3	401 to 550	SSPC-SP-3	1 coat of F-16 @ 125 µ DFT/coat	125	

Note for Table-3:

1. The application and repair of pre-erection/pre-fabrication and shop primer given in above tables shall be done for all the items to be painted. In case the damages of primer are severe and spread over large area, entire primer shall be removed by blasting to achieve SSPC-SP-10 and surfaces to be primed again with F-8/ F-9/F-16, as applicable. After the repairs of the primer, suitable intermediate and final coats shall be applied as per applicable coating systems mentioned in Table 5.0 to Table 11.0.

TABLE-4: COATING SYSTEM FOR GALVANIZED ITEMS (Refer clause 2.2.7)

Sl. No.	Design Temp. in °C	Coating System	Total DFT in Microns (min.)	Remarks
4.1	Up to 60	Hot Dip Galvanizing with thickness as per ISO 1461, Surface preparation over galvanization as per SSPC SP 16 & ISO 12944-4; 1 coat of F-6B @ 100µ DFT/coat + 1 coat of F-2 @ 40 microns DFT/coat	140µ of finish coat (excluding the thickness of galvanizing)	Special primers like etch primer may also be considered for coating on galvanized surfaces

Notes for Table-4:

1. F-6B shall be modified type and suitable for coating over galvanization.
2. Repair of the damaged areas of galvanized coatings due to welding during erection shall be carried out as per recommended practice ISO 1461, using cold galvanizing spray process. Organic paint systems are not acceptable for the repair.
3. After repair of damaged galvanized coating by cold galvanization (P-7), the repaired area shall be top coated with paint system as given in table-4 above (i.e. 1 coat of F-6B @ 100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat).
4. Galvanized gratings don't require painting in general until otherwise specified elsewhere or as per the requirement of the OWNER. Galvanized items may require painting to meet the colour coding requirement of the OWNER. Contractor has to ensure the applicable colour coding prior to application of coating as per this clause.

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TABLE-5: COATING SYSTEM FOR CORROSIVE AREAS

(For all un-insulated above ground CS, LTCS & Alloy steel piping, equipment, structures, valves, vessels & columns, furnace stacks etc.)

Sl. No.	Design Temp. °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
5.1	-45 to -15	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/	-	-	65-75	a) No over coating on F-9 is allowed b) F-12 shall be ambient temperature curing type c) Surface profile for F-9 shall be 30-40 µm
5.2	-16 to 80	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/ coat	1 coat of P-6 @ 40 µ DFT/ coat	2 coats of F-6B @ 100 µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat (2x100 + 40= 240)	345-355	
5.3	81 to 400	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/ coat	-	2 coats of F-12 @ 20µ DFT/coat 2x20=40	105-115	
5.4	401-650	SSPC-SP-10; 1 coat of F-16 @ 125 µ	-	1 coat of F-16 @ 125 µ	250-300	-

NOTES for TABLE-5:

1. The list of items given in the heading of the above table is not exhaustive. There may be more items for a particular contract where these specifications are used. The CONTRACTOR is fully responsible for completing painting including prefabrication primer for all the items supplied and fabricated as per contract document and scope of work.

2. If the application of pre-erection/pre-fabrication/shop primer has already been completed, the same shall not be repeated in the field. In case the damages to the primer coat are severe and spread over large areas, the Engineer-In-Charge may decide & advise re-blasting and re-application of the primer coat. Repair of pre-fabrication/pre-erection primer, if required, shall be done as per Table-3.

3. Flare line within unit or offsite areas shall be coated as per clause 5.3 of Table-5.

4. For external surface of RCC Chimney, 2 coats of F-6 B@ 100µ DFT/coat to obtain a total DFT of 200 µ shall be applied after proper surface preparation as per guidelines in clause 4.6.

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TABLE-6: COATING SYSTEMS FOR EFFLUENT TREATMENT PLANT (ETP)

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
6.1	For external surfaces of steel items: screens, walk way bridges, clarifier/thickener scrapping mechanism, baffles, Media filters/vessels (PSF, DMF, MMF, & ACF etc.), vertical pumps, CS/MS tanks/ vessels and structures.					
	-14 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat	2 coats of F-6B @100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat (2x100+40= 240)	305	-
6.2	For internal surfaces of steel items: all effluent handling units such as TPI, DAF, tube settlers, clarifiers, tanks, sludge tanks and sewage tank, wet slop oil tanks etc., scrapping mechanism in clarifier etc.					
	-14 to 80	SSPS-SP-10	1 coat of F-15 @ 80µ DFT/coat.	2 coats of F-15 @180µ DFT/coat (2x80=160)	240	-
6.3	All R.C.C./concrete surfaces exposed to effluent water / liquid such as tanks, structures, drains etc., all effluent handling units such as API, TPI, DAF, tube settlers, clarifiers, tanks, sumps, sludge sumps/tanks and sewage sumps/tank, wet slop oil sump/tanks etc.					
	-14 to 80	As per clause 4.6 of this specification	Epoxy screed lining		3000	Note 1
6.4	Internal surface of equipment like Media filters/vessels (PSF, DMF, MMF, & ACF etc.), activated carbon filters, alkaline, acids & other high corrosive service					
	Up to 90	SSPC-SP-10	1 coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat + 2 coats of F-20 @ 500µ DFT/ Coat		1100	Note-2

NOTES for TABLE-6:

1. Contractor shall follow manufacturer recommendations to develop epoxy screed lining procedure for EIL review and approval.

2. This coating system is applicable in conjunction with relevant PDS of the equipment.

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TABLE-7: EXTERNAL COATING SYSTEMS FOR CARBON STEEL AND LOW ALLOY STEEL STORAGE TANKS

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system (Note-1)		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
7.1	All external surfaces of shell, wind girders, appurtenances, roof tops of all above ground tank including top side of external and internal floating roof and associated external structural works.					
7.1.1	-14 to 80	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat + 1coat of P-6 @ 40µ DFT/ coat	2 coats of F-6B @ 100µ DFT /coat + 1 coat of F-2 @ 40µ DFT/ coat	345-355	-
7.1.2	81 to 450	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat	1 coat of F-16 @ 125 µ DFT / coat	190-200	
7.2	External surfaces of bottom plate (in contact with soil) for all storage tanks.					
7.2.1	-14 to 80	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	3 coats of F-7@ 150µ DFT/coat (3x150=450)	515-525	-
7.2.2	81 to 200	SSPC-SP-10	1 coat of F-17 primer @ 400µ DFT/ coat	1 coat of F-17 finish coat @ 400µ DFT/ coat	800-825	Note-4
7.3	For underside of the bottom plate (not in contact with soil)(in case tank is not lifted during PWHT) (Note- 2)					
7.3.1	-29 to 400	SSPC SP-10	1 coat of F-16 @ 125 µ	1 coat of F-16 @ 125 µ	250-300	Note-3

Notes for TABLE-7:

1. All paint coating application including primer for tanks shall be carried out at field after erection and completion of entire welding.

2. For underside of bottom plate as per clause no.7.3.1:

   a) Painting shall be carried out before laying the bottom plate for tanks with non-Post Weld Heat Treatment (PWHT).

   b) For tanks with PWHT, painting shall be carried out after PWHT.

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c) In case tank is not lifted during PWHT then painting shall be applied before laying the bottom plate.

3. This coating system (7.3.1) is also applicable for temperature ranges not covered in 7.2 above.

4. This coating system (7.2.2) is also applicable for bottom plates having MOC as Stainless Steel.

TABLE-8: INTERNAL COATING SYSTEMS FOR CARBON STEEL AND ALLOY STORAGE TANKS

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
8.1	Internal side of bottom plate and first shell course of Crude oil tanks					
8.1.1	-14 to 90	SSPC-SP-10	1 Coat of F-6A @ 100 µ DFT/coat	1 Coat of F-6C @ 400 µ DFT/coat	500	-
8.2	Underside of floating roof, internal surfaces of shell for full height above first course, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures, roof legs, drain pipes and ladders etc. of crude oil tanks					
8.2.1	-14 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-
8.3	All internal surfaces of hydrocarbon, slops, amine solutions, sour water and other hydrocarbon-water solutions tanks but not limited to: Underside of floating roofs, internal surface of cone roof, inside of bottom plate, internal surfaces of shell for full height, underside of floating roof, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures, roof legs, drain pipes and ladders etc.					
8.3.1	-14 to 45	SSPC-SP-10	1 coat of F-9 @ 65-75 µ DFT/coat	-	65-75	-
8.3.2	46 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-
8.3.3	91 to 200	SSPC-SP-10	-	1 coat of F-17 @ 400µ DFT/coat	400	-
8.4	Potable, Raw & Fire water, De-mineralized (DM) water & Condensates etc. All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					

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8.4.1	-14 to 60	SSPC-SP-10	1 Coat of F-6A @ 100µ DFT/coat	1 coat of F-6C @ 300-350 µ DFT/ coat	400-450	-
8.4.2	61 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat (80+80=160)	240	-
8.5	Hydrochloric acid (HCl) 10 %: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.5.1	-14 to 60	SSPC-SP-10	1 Coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat	2 Coats of F-20 @ 500µ DFT/ Coat	1100	-
8.6	Aggressive solvents like hexane, hexene, benzene, xylene and toluene etc.: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.6.1	-14 to 65	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	-	65-75	-
8.7	Ethylene glycol tanks: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.7.1	All	SSPC-SP-10	-	3 coats of vinyl chloride co-polymer @ 75µ /Coat; (3x75=225)	225	-
8.8	Inside pontoon and inside of double deck of all floating roofs					
8.8.1	-14 to 80	SSPC-SP-3	1 coat of F-8 @ 100µ DFT/coat	1 coat of F-8 @ 100µ DFT/coat	200	-
8.8.2	81 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat (80+80=160)	240	-
8.8.3	151 to 200	SSPC-SP-10	-	1 coat of F-17 @ 400µ DFT/coat	400	-
8.9	Alkalis up to 50 % concentration: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					

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8.9.1	Up to 60°C	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	2 Coats of F-6 A @ 100µ DFT/coat (2x100=200)	280	-

General Note for Table-8: The list of surfaces to be painted are not exhaustive. All internal surfaces of all type of tanks including structural items shall be coated as per the above table. No CS surface shall be kept un-painted.

TABLE-9: COATING SYSTEMS FOR EXTERNAL SIDE OF UNDERGROUND CARBON STEEL PLANT PIPING AND VESSELS

Sl. No.	Design Temp. in °C	Surface Preparation & Shop Primer	Coating system		Total DFT in Microns (min.)	Remarks
			Surface Preparation & Primer	Finish Coat		
9.1	Underground carbon steel plant piping.					
9.1.1	Upto 50	Wrapping coating-SYSTEM-10-Annexure-1 (Note-1)				
9.1.2	50 to 100	SYSTEM-11- Annexure-1				
9.1.3	100 to 200	-	SSPC-SP-10; 1 coat of F-17 primer @400 µ DFT/ coat	1 coat of F-17 @ 400 DFT/coat	800	-
9.2	External side of underground storage vessels					
9.2.1	Upto 100	SYSTEM-11- Annexure-1				
9.2.2	100 to 200	SSPC-SP -10	1 coat of F-17 primer @400 µ DFT/ coat	1 coat of F-17 @400µ DFT/ coat	800	-

Notes for TABLE-9:

1. EIL standard-6-79-0011 latest revision shall be referred for prequalification of wrapping coating and selection of vendor.

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TABLE-10: COATING SYSTEMS FOR UNDER INSULATION (ALL UNIT AREAS & OFFSITES)
(For insulated piping, equipment, storage vessels, tanks, columns etc. of CS, LTCS, Alloy steel, SS, DSS and SDSS in all environments.)

Sl. No.	Design Temp. °C	Surface Preparation & Pre-erection/Shop Primer	Coating system		Total DFT Microns (min.)	Remarks
			Primer	Finish paint		
10.1	Carbon steel, LTCS and Alloy steel Piping, Storage tanks, Vessels, Equipment etc.					
10.1.1	-45 to 450	SSPC-SP-10; 1 coat of F-16 @ 125µ DFT/coat	None	1 coat F-16 @ 125µ DFT/coat	250	Note 1
10.2	Stainless Steel, Duplex Stainless steel, Super Duplex stainless steel & Piping, Tanks, Vessels & Equipment etc.					
10.2.1	-45 to 125	SSPC-SP-16; (15-25µ surface profile) 1 coat of F-15 @75 µ DFT/coat	None	2 coats of F-15 @75µ DFT/coat	225	Note 1
10.2.2	126 to 650	SSPC-SP-16; (15-25µ surface profile) 1 coat of F-16 @125µ DFT/coat	None	1 coat of F-16 @125µ DFT/coat	250	
10.3	Cyclic service of CS, LTCS, SS, DSS, SDSS & Alloy Steels (Note-1)					
10.3.1	-180 to 650	SSPC-SP-10 for CS, LTCS & Alloy steel. SSPC-SP-16 for SS (15-25µ surface profile) 1 coat of F-16 @ 125µ DFT/coat	None	1 coat of F-16 @ 125µ DFT/coat	250	

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Notes

1. Coating system for any other design temperature range not covered in Sr. No. 10.1 & Sr. No. 10.2 shall be as per Sr. No. 10.3.1.

General notes for TABLE-10:

1. "Cyclic Service" is characterized by rapid or periodical temperature fluctuation or temperature cycles or as defined in the process datasheet.
2. The blasting abrasives for SS and alloy steels shall be aluminum oxide or garnet only.
3. The coating system applicable for any other temperature range shall be reviewed if it is encountered.

TABLE-11: INTERNAL COATING SYSTEMS FOR WATER SIDE COMPONENTS OF CS, SS, DSS & NON-FERROUS HEAT EXCHANGERS

Sl. No.	Design Temp. in °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT in Microns (min.)	Remarks
			Primer	Finish paint		
11.1	Up to 80	SSPC-SP-10 for CS and SSPC-SP-16 for SS	1 coat of F-15 @ 80 µ DFT/coat	2 coats of F-15 @ 80 80 µ DFT/coat	240	-
11.2	81 to 200	SSPC-SP-10 for CS and SSPC-SP-16 for SS	-	2 coats of F-17@ 400µ/coat	800	-

Note for Table-11:

1. Coating systems are applicable as per requirement specified in the data sheets of the respective exchangers or equipment.

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TABLE-12: COATING SYSTEMS FOR CORROSIVE AREAS - BROWN FIELD PAINTING (REVAMP, REFURBISHMENT AND MAINTENANCE)

(For all existing un-insulated above ground CS, LTCS & Alloy steel piping, equipment, structures, valves, vessels & columns, furnace stacks etc.)

Sl. No.	Design Temp. °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT in Microns (min.)	Remarks
			Intermediate Coat	Finish Coat		
12.1	-45 to -15	SSPC-SP-3; 1coat of F-8 @ 125µ	-	-	125	-
12.2	-14 to 80	SSPC-SP-3; 1coat of F-8 @ 125µ DFT/ coat	2 coats of F-6B @ 100 µ DFT/coat	1 coat of F-2 @ 40µ DFT/coat	365	
12.3	81-650	SSPC-SP-3; 1 coat of F-16 @ 125 µ	-	1 coat of F-16 @ 125 µ	250-300	-

GENERAL NOTES FOR TABLE: 5 TO 12

1. For uninsulated or insulated items, scope of surface preparation, application of primers to finish coat including repair shall be as per applicable contractual documents like SOR, MR, and PR etc. The list of items is not exhaustive.

8.0 GUIDELINES FOR STORAGE & HANDLING

8.1 All paints and painting materials shall be stored in rooms only which are to be arranged by CONTRACTOR and approved by Engineer-In-Charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the word “PAINT STORAGE- NO NAKED LIGHT-HIGHLY INFLAMMABLE” shall be clearly displayed outside. Manufacturers’ recommendation /Materials safety datasheet shall be followed for storage and handling of paint materials.

Note: This specification doesn’t address all the safety concerns if any, associated with its use. It is responsibility of the user of this specification to establish appropriate safety and health practice and determine the applicability of regulatory limitations prior to use.

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9.0 COLOUR CODE

The colour coding system as per Annexure-2 of this specification shall be followed.

9.1 Identification

The system of colour coding consists of a ground colour and secondary colour bands superimposed over the ground colour. The ground colour identifies the basic nature of the service and secondary colour band over the ground colour distinguishes the particular service. The ground colour shall be applied over the entire length of the un-insulated pipes. For insulated lines, ground colour shall be provided as per specified length and interval to identify the basic nature of service and secondary colour bands to be painted on these specified length to identify the particular service. Above colour code is applicable for both unit and offsite pipelines.

9.2 Ground colour

On un-insulated pipes, the entire pipe has to be painted in ground colour. On metal cladded insulated lines, minimum 2 m long portion should be painted.

9.3 Colour bands

9.3.1. Location of colour bands:

a. At battery limits.
b. Intersection points & change of direction points in piping.
c. Midway of piping section, near valves, across culverts.
d. At 50 m interval on long stretch pipes.
e. At starting and termination points.

9.3.2. Minimum width:

NB	Width
3” and below	75 mm
Above 3” to 6”	NB X 25 mm
Above 6” to 12”	NB X 18 mm
Above 12”	NB X 15 mm

For insulated pipes, NB indicates OD of the insulation.

Sequence: Colour bands shall be arranged in sequence as shown above and the sequence follows the direction of flow. The width of the 1st Band to 2nd band is 4:1.
Wherever deemed required by process department or safety, pipes handling hazardous substances will be given hazard marking of 30 mm wide diagonal stripes of black and golden yellow.

9.4 Identification markings on equipment/piping

Equipment tag numbers shall be stenciled/neatly painted using normal ‘Arial’ lettering style on all equipment and piping (both insulated & un-insulated) after completion of all paint works. Lettering colour shall be either black or white, depending upon the background, so as to obtain good contrast.

Operations group shall specify the location of the marking.

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Size of the making shall be as follows:

Columns, vessels, heaters	: 150 mm
Pumps and other machinery	: 50 mm
Piping	: OD / 2 with maximum 100 mm
Storage tanks	: (as per drawings)

9.5 Colour coding for control valve

a)

Carbon steel body	:	Signal grey (RAL7004)
Alloy steel body	:	Golden yellow (RAL1004)
Stainless steel body	:	Natural

b) The actuator of the control valve shall be painted as:

Direct action (open on-air failure) valves : Traffic Green (RAL 6024)
Reverse acting (close on-air failure) valves: Traffic Red (RAL 3020)

The painting status shall be comprehensively updated every 6 months for compliance.

10.0 IDENTIFICATION OF VESSELS, PIPING ETC.

10.1 Equipment number shall be stenciled in black or white on each vessel, column, equipment & machinery (insulated or un-insulated) after painting. Line number in black or white shall be stenciled on all the piping of more than one location as directed by Engineer-In-Charge. Size of letter printed shall be as below:

Column & vessels	:	150 mm (high)
Pump, compressor & other machinery:		50 mm (high)
Piping	:	40-150 mm

10.2 Identification of storage tanks

The storage tanks shall be marked as detailed in the drawing.

11.0 PAINTING FOR CIVIL DEFENCE REQUIREMENTS

Painting for civil defense is a specific requirement and should be applicable as per instructions of OWNER and competent government authorities.

11.1 The following items shall be painted for camouflaging, if required by the client:

a. All columns
b. All tanks in offsite
c. Large vessels
d. Spheres

11.2 Two coats of selected finishing paint as per defense requirement shall be applied in a particular pattern as per clause 11.3 and as per the instructions of Engineer-In-Charge.

11.3 Method of camouflaging

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a. Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matte finish).

Dark Green		Light Green		Dark Medium Brown
5	:	3	:	2

b. The patches should be asymmetrical and irregular.
c. The patches should be inclined at 30º to 60º to the horizontal.
d. The patches should be continuous where two surfaces meet at an angle.
e. The patches should not coincide with the corners.
f. Slits and holes shall be painted in dark shades.
g. Width of patches should be 1 to 2 m.

12.0 QUALITY CONTROL, INSPECTION AND TESTING

12.1 All painting materials including primers and thinners brought to site by CONTRACTOR for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturers' test certificates. Paint formulations without certificates are not acceptable (see section 14.0 & 15.0).

12.2 The CONTRACTOR must produce test certificate from pre-qualified paint manufacturer for various tests as detailed out in section 15.0 of this document. The Engineer-In-Charge, in consultation with SMMS, shall have the right to test wet samples of paint at random for verifying quality of paint supplied. CONTRACTOR shall arrange to have such tests, as instructed, performed at his cost at any one of the NABL accredited laboratories under a TPI agency.

Samples for the test will be drawn at random in presence Engineer-In-Charge or his representations. Following tests to be carried out if called:

a. Specific Gravity
b. % solids by weight (% zinc content in case of inorganic or organic zinc primer)
c. Drying time (touch dry & full curing)
d. Adhesion test on a test panel prepared at the site (ASTM D 6677).

Test methods for above tests shall be as per relevant ASTM or ISO Standard.

12.3 The painting work shall be subject to inspection by Engineer-In-Charge at all times. In particular, following stage-wise inspection will be performed and CONTRACTOR shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

a. Surface preparation
b. Primer application
c. Each coat of paint

12.3.1 Following tests are to be carried out during surface preparation:

a. Test for presence of oil/grease and contamination

The steel substrate after degreasing as per SSPC-SP-1 shall be tested as per following procedure to validate absence of oil and grease contamination:

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- Visual inspection - continue degreasing until all visible signs of contamination are removed.
- Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination. Continue degreasing and inspection till test is passed.

b. **Tests for surface finish of blasted surface** shall be done by visual inspection using SSPC-VIS1. Clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on blasted surface. Checks shall be done on each component at least once per 200 m^2 of blasted surface and a minimum of 3 checks per shift.

c. **Test for presence of soluble salt** as per method ISO 8502-9. Maximum allowable salt content shall be considered 20 mg/m^2.Checks shall be done on each component at least once per 200 m^2 of blasted surface and minimum of 3 checks per shift. In case salt exceeds specified limit, the contaminated surface shall be cleaned by method as per Annexure-C of ISO 12944-4 (water cleaning). After cleaning, surface shall be retested for salt after drying.

d. **Blast Profile Measurement**: (In-Process testing during actual production before application coating). The angular profile depth measurement shall be done by profile tape as per method ASTM D 4417 method B (Profile depth gauge micrometer)/ calibrated Digital gauge meter. Spot measurement shall be carried out every 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 and average of measurements to be recorded and reported. If profile is less than specified range, blasting shall continue till greater specified depth profile is achieved.

e. **Tests for blasting media:** Blasting Media (For every fresh batch of media and one random test during blasting)**.** Blasting Media shall be visually inspected for absence of contamination and debris using 10 X magnification.

- Inspection for the absence of oil contamination shall be conducted using following procedure :
  - Fill a small clean 200 ml bottle half full of abrasive.
  - Fill the bottle with potable water, cap and shake the bottle.
  - Inspect water for oil film/slick. If present, the blasting media is not to be used.

- Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.

- Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

f. **Test for Blasting Air** (Once Daily before start of blasting and once at random during Blasting). The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

In addition to above, record should include type of shop primer already applied on equipment e.g. zinc silicate or zinc rich epoxy or zinc phosphate. Any defect noticed during the various stages of inspection shall be rectified by the CONTRACTOR to the entire satisfaction of Engineer-In-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, CONTRACTOR shall be responsible for rectifying any defects found during final inspection/guarantee period/defect liability period as defined in general conditions of the contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra

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coat of paint should be applied to make-up the DFT specified without any extra cost to OWNER, the extra coat should have prior approval of Engineer-in-charge.

12.4 Final inspection of finished coating shall consist of the following:

a. **Coating DFT & WFT check:** DFT measurement shall be as per ISO 2808. Type-II electronic gauge shall be used as described in ASTM D7091. DFT gauge calibration, adjustment of gauge coating thickness, frequency and number of coating thickness measurement shall be as per ASTM D7091 and SSPC-PA2. Measured DFT shall have a tolerance as per SSPC-PA-2 level-3 of the dry film thickness, specified in this specification. Once in every layer of coating application, spot checks of WFT shall be carried out during the coating application according to ISO 2808, Method No. 1A- comb gauge. This is to ensure that film thickness is being achieved as per the specification.

b. **Adhesion testing:** Adhesion of the primer to the steel substrate and inter-coat adhesion of the subsequent coat(s) after curing for at least a week after application of the topcoat shall be examined by a knife test in accordance with ASTM D6677. For the knife test, if the rating is better than 8, the adhesion is considered acceptable. The adhesion is destructive and tested areas shall be repaired afterward using the spot repair procedure. Alternatively, the applicator may perform the adhesion test on a steel panel coated using the same surface preparation and coating application procedure as the work piece. Adhesion testing shall be carried out for each component at least once per 200 m^2 of coated surface.

c. **Holiday detection check:** Holiday testing of non-conductive coatings shall be carried out in accordance with NACE SP0188. For immersion, buried & under insulation services, 100% of coated area shall be inspected for holidays. For atmospheric exposure, 10% of coated area which must include weld seams, corners and edges to be holiday tested. Voltage at which test is to be carried out will depend upon DFT of coating being tested and shall be as per NACE SP0188. Any holiday is unacceptable and should be marked and repaired immediately**.**

The CONTRACTOR shall arrange for spot checking of paint materials for specific gravity, glow time (ford cup) and spreading rate.

13.0 PAINT MATERIAL GUARANTEE CERTIFICATE

The CONTRACTOR shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work and shall submit necessary certificate of the paint material.

14.0 QUALIFICATION CRITERIA OF PAINTING CONTRACTOR/SUB-CONTRACTOR

Painting CONTRACTOR who is awarded any job for EIL, Projects under this specification must have necessary equipment, machinery, tools and tackles for surface preparation, paint application and inspection. The CONTRACTOR must have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The CONTRACTOR supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred in this specification.

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15.0 PRE-QUALIFICATION/ACCEPTANCE CRITERIA FOR PAINT COATING SYSTEM

15.1 Pre-qualification of paint coating manufacturer and their products

Paint manufacturer meeting the following requirements shall be considered by the CONTRACTOR for supply of the paint products.

a) Manufacturer should have been in continuous business of paint coating formulation and manufacturer for at least past 5 years.

b) Manufacturer should possess past experience of supplying his products to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms in the past 5 years.

c) Coating manufacturer should have supplied at least 10000 litre of an individual product to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms.

d) The manufacturer's manufacturing procedure & QA/QC system shall meet ISO 9001 requirements and preferably should possess ISO 14000 certificate.

e) The Quality control set up should be manned by qualified paint technologists whose biodata should be sent along with quality control organization chart.

The Past Track record of the manufacturers as mentioned above shall be substantiated by providing relevant documents to EIL-SMMS for their review and acceptance. This shall include Work Orders, Purchase orders and ISO 9001 certification covering all the requirements mentioned from bullets a) to e) above.

CONTRACTOR shall procure the paint materials from the qualified manufacturer meeting above requirements and after obtaining prequalification testing approval as per requirements mentioned in clause 15.2 below.

15.2 Pre-Qualification Testing procedure:

The paint manufacturer engaged by the mechanical contractor shall carry out the tests in NABL accredited government laboratories or in suggested list of laboratories below, as a part of qualification. Paint manufacturer shall provide the paint samples to laboratory for testing of the parameters mentioned in Table-2 (typical characteristics), Table-13 (tests on coating systems) and Table-13-Annexure-1 of this specification. The testing laboratory will confirm the compliance of the paint material with respect to the acceptance criteria mentioned in the respective tables. Colored photographs of coated test panels should be taken before and after the test and should be enclosed along with test report. Contractor shall furnish these test certificates along with all necessary supporting documents/information to EIL-SMMS for approval/ acceptance. The paint manufacturer will be qualified and approved by EIL-SMMS for supply of paints after review/assessment of the submissions made by the contractor. Test certificates which are more than 3 years old will not be considered. Paint manufacturers are advised to carryout pre-qualification testing accordingly for paints supply to EIL projects.

List of suggested laboratories:

1. National Test house – Kolkata
2. National Test house-Mumbai
3. HBTU- Kanpur
4. GIRDA (Gujarat Industrial Research & Development Agency)- Vadodara

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5. Indian institute of chemical technology – Hyderabad
6. RITES – Kolkata
7. ICT- Mumbai

TABLE-13: PRE-QUALIFICATION TESTING

SYSTEM No.	COATING SYSTEM	REFERENCE CLAUSE (from table-3 to 12)	TOTAL DFT µ (min)
1.	F-9+P6+F6B+F2	5.2	345
2.	F9+F12+F12	5.3	105
3.	F15+F15+F15	8.2.1	240
4.	F16+F16	7.3.1	250
5.	F17	8.3.3	400
6.	F8	3.1	125
7.	F20+F20	8.5.1	1100
8.	F6A+F6C	8.1.1	500
9.	F9+F7+F7+F7	7.2.1	515
10.	F15+F6A+F6A	8.9.1	280
11.	P2+F3-SYSTEM 11	Annexure-1	460

S. No.	TEST	FOR SYSTEM NUMBER	DURATION	ACCEPTANCE CRITERIA
1.	Cyclic Test Salt Spray : 72 hrs. Drying in air: 16 hrs. UV-A340 nm weather meter: 80 hrs. One cycle: 168 hrs. (25 cycles at 168 hrs. each cycle) (ASTM D5894)	1	4200 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling shall be observed.
2.	Chemical Resistance Test (ASTM D543)			
2a.	10% & 40% NaOH	3, 5, 7, 9 10, & 11	1000 hrs.	Shall pass. No cracking, discoloration, blistering, peeling or softening of film shall be observed.
2b.	5% H2SO4		168 hrs.	
2c.	Xylene		4 weeks	
2d.	Acetone		4 weeks	
2e.	Ethanol		4 weeks	
2f.	Kerosene		4 weeks	
2g.	Sea water		2000 hrs.	
3.	Immersion in DM/DI water @90^0 (ASTM C868)	3, 5, 7, 9 10, & 11	30 days	No softening, blistering or film damage.

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4.	Resistance to DM water using water immersion. (ASTM D870)	8	2000 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling.
5.	100% Humidity Test (ASTM D2247)	1 to 11 (except system-2)	1440 hrs.	Shall pass
6.	Thermal Shock Resistance Test; 5 cycles @ 30 minutes in furnace at 120 º C and 15 minutes in water after quenching in water for each cycle. (ASTM D2485 method A)	2, 3, 4, & 10 (For system-2, testing to be done after heating the panels at 400°C for 2 hrs.)	-	Shall pass
7.	Cathodic Disbondment Test (ASTM G42 @80°C)	3, 5, 9, 10 & 11	-	Diameter of cathodic Disbondment < 10 mm with 6 mm diameter artificial holiday.
8.	Assessment of Adhesion and artificial ageing as per ISO 19277	3, 4, 5, 9, 10 & 11	-	Shall Pass

Each coating product to be qualified shall be identified by the Specific gravity of base and curing agent (ISO 2811). The identification shall be carried out on the batch, which is used for the pre-qualification testing.

15.3 Information to be furnished during delivery of paint materials:

CONTRACTOR along with delivery of paint material has to furnish following information from paint manufacturer to EIL for acceptance/approval of products:

a) Batch test certificates:

Along with paint products delivery to site from the pre-qualified coating manufacturer, CONTRACTOR has to produce test certificate (from paint manufacturer) for each category of product for the following test items. All test results must mention clearly the batch no. and category of product tested. Tests to be conducted for following properties:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer) ~ ASTM D521.

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b) Product information sheet/ technical data sheet for each category of product.

The contractor shall be fully responsible for the quality of the paints products as per prequalification testing. After the paint materials are supplied to site, the supplier shall organize random sampling and testing in a NABL laboratory as per discretion of the Engineer-in-charge in consultation with SMMS. Failing to meet the specified quality requirements may cause rejection of the paint products.

16.0 METHOD OF SAMPLING & DISPATCH FOR LABORATORY TESTING

(Pre-Qualification tests (sec. 15.2), Batch testing (sec. 15.3) and Inspection testing (sec. 12.0))

16.1 Samples of coating materials should be submitted to the laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory.

16.2 All test panels should be prepared by testing laboratory. Surface preparation for a system shall be done in accordance with this specification. For individual products testing, minimum shall be Sa 2.5. Colour photographs of test panels should be taken before and after the test and should be enclosed along with test report. Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code.

16.3 Manufacturers should intimate EIL, details of sample submitted for testing, name of testing agency, date, and contact personnel of the testing agency.

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ANNEXURE-1

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SYSTEM 10:

Generic name of the coating	Thickness (mm)	Method of Application
Anti-Corrosive Tape (Coal Tar tape)	2 x 2 mm	Manual
Total DFT	4 mm	

Notes:

1. Carry out shot blasting of the surface to Sa 2.5 finish.
2. Apply one coat of synthetic primer conforming to AWWA 203/2003 and IS 15337/2003 standards. The primer shall be compatible with the hot applied tape.
3. Use 2 layers of 2 mm thick each hot applied anti-corrosive tape conforming to AWWA 203/2003 and IS 15337/2003 standards.
4. Both the primer and tape shall be of one manufacturer for compatibility.
5. Ensure that the tape is tightly wound on the pipe**.**
6. Spirally wrap the self-adhesive tape on the primed surface with 25 mm overlap.
7. The length of the tape shall be kept sufficiently extra to complete the length of the pipeline.
8. The spiral joint if any shall have 25 mm overlap.
9. The tape coated pipes and the field joint coated area shall be holiday tested using portable holiday tester using 12,000 volts.
10. Weld joints shall be coated only after hydro test.

SYSTEM 11:

Paint Type	Generic name of the coating	Thickness (mm)	Method of Application
P2	Epoxy red oxide zinc phosphate primer	1 x 60	Air / Airless Spray
F3	Epoxy Glass Flake (Amine Adduct)	2 x 200	Airless Spray
	Total DFT	460	

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Table-13-Coating system characteristics

Epoxy Red Oxide Zinc Phosphate Primer (P2)	
Color	Red
Finish	Semi-gloss
Application	Airless/Air spray/Brush
Pigment (main)	Zinc phosphate content minimum 5 – 10 % by weight of the total pigments
Type of epoxy	Condensation product of bisphenol – A and epichlorohydrin with terminal Epoxide groups.
Curing agent	Polyamide (amine value 210-230)
Volume solids	50 ± 2 %
DFT	60 - 70 microns
Area Coverage (Theoretical)	8 - 10 sq.m / litre
Surface dry	8 hrs.
Hard dry	24 hrs.
Recoatability	As per Manufacturer's PDS
Full cure	As per Manufacturer's PDS
Shelf life	As per Manufacturer's PDS

Epoxy Glass Flake Paint (Amine Adduct) for Buried pipelines (F3)	
Color	As desired
Finish	Semi-Glossy
Type	Two packs
Application	By brush or Airless spray
Volume solids	87 ± 3%
DFT	200– 210 µm
Area Coverage (Theoretical)	4 to 4. 5 sq.m/litre
Surface dry	8 hrs.
Hard dry	24 hrs.
Recoatability	As per Manufacturer's PDS
Full cure	As per Manufacturer's PDS
Overcoating	As per Manufacturer's PDS
Shelf life	As per Manufacturer's PDS

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ANNEXURE-2: COLOUR CODE

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SR. No.	SERVICE	RECOMMENDED COLOUR FOR PAINT SYSTEM	RAL COLOUR CODE	
			BASE COLOUR	BAND COLOUR
	HYDROCARBON LINES (UNINSULATED)			
1	CRUDE SOUR	Basalt Grey with 1 deep orange band	7012	2011
2	CRUDE SWEET	Basalt Grey with 1 signal red band	7012	3001
3	LUBE OILS	Basalt Grey with 1 grass green band	7012	6010
4	FLARE LINES	White Aluminum	9006	
5	LPG	Deep Orange with 1 oxide red band	2011	3009
6	PROPYLENE	Deep Orange with 2 Cobalt blue bands	2011	5013
7	NAPTHA	Deep Orange with 1 grass green band	2011	6010
8	M.S.	Deep Orange with 1 Basalt Grey band	2011	7012
9	AV.GASOLINE (96 RON)	Deep Orange with 1 band each of grass green, white and signal red bands	2011 / 6010	9010 / 3001
10	GASOLINE (regular, leaded)	Deep Orange with 1 Jet black band	2011	9005
11	GASOLINE (premium, leaded)	Deep Orange with 1 Cobalt blue band	2011	5013
12	GASOLINE (white)	Deep Orange with 1 white band	2011	9010
13	GASOLINE (Aviation 100/130)	Deep Orange with 1 signal red band	2011	3001
14	GASOLINE (Aviation 115/145)	Deep Orange with 1 traffic purple band	2011	4006
15	N-PENTANE	Deep Orange with 2 Cobalt blue bands	2011	5013
16	DIESEL OIL (White)	Oxide red with 1 white band	3009	9010
17	DIESEL OIL (Black)	Oxide red with 1 traffic yellow band	3009	1023
18	KEROSENE	Oxide red with 1 grass green band	3009	6010
19	HY.KEROSENE	Oxide red with 2 grass green bands	3009	6010
20	DISUFIDE OIL (EX-MEROX)	Oxide red with 1 jet black band	3009	9005
21	M.T.O	Oxide red with 3 grass green bands	3009	6010
22	DHPPA	Oxide red with 2 white bands	3009	9010
23	FLUSHING OIL	Oxide red with 2 jet black bands	3009	9005
24	LAB FS	Oxide red with 2 Basalt Grey bands	3009	7012
25	LAB RS	Oxide red with 3 Basalt Grey bands	3009	7012
26	LAB (Off. Spec)	Oxide red with 1 light grey band	3009	7035

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27	N-PARAFFIN	Oxide red with 1 Cobalt blue band	3009	5013
28	HEAVY ALKYLATE	Oxide red with signal red band	3009	3001
29	BLOW DOWN, VAPOR LINE	Off white / Aluminum with 1-Brown band	9006	8004
30	BLOWDOWN	Off white / Aluminum with 2 copper brown bands	9006	8004
31	A.T.F.	Clay Brown with 1 white band	8003	9010
32	TOULENE	Clay Brown with 1 traffic yellow band	8003	1023
33	BENZENE	Clay Brown with 1 grass green band	8003	6010
34	LAB PRODUCT	Clay Brown with 1 Cobalt blue band	8003	5013
35	FUEL OIL	Jet Black with 1 traffic yellow band	9005	1023
36	FULE OIL (Aromatic rich)	Jet Black with 2 traffic yellow bands	9005	1023
37	ASPHALT	Jet Black with 1 white band	9005	9010
38	SLOP AND WASTE OILS	Jet Black with 1 deep orange band	9005	2011
39	SLOP AROMATICS	Jet Black with 2 deep orange bands	9005	2011
CHEMICAL LINES				
40	TRI-SODIUM PHOSPHATE	Lemon Yellow with 1 violet blue band	1012	5000
41	CAUSTIC SODA	Lemon Yellow with 1 jet black band	1012	9005
42	SODIUM CHLORIDE	Lemon Yellow with 1 white band	1012	9010
43	AMMONIA	Lemon Yellow with 1 Cobalt blue band	1012	5013
44	CORROSION INHIBITOR	Lemon Yellow with 1 Aluminum band	1012	9006
45	HEXAMETA PHOSPHATE	Lemon Yellow with 2 jet black bands	1012	9005
46	ACID LINES	Golden Yellow with 1 signal red band	1004	3001
47	RICH AMINE	Lemon Yellow with 2 Cobalt blue bands	1012	5013
48	LEAN AMINE	Lemon Yellow with 3 Cobalt blue bands	1012	5013
49	SOLVENT	Lemon Yellow with 1 grass green band	1012	6010
50	LCS	Lemon Yellow with 1 Blue Grey	1012	7031
WATER LINES				
51	RAW WATER	Sky blue with 1 jet black band	5015	9005
52	INDUSTRIAL WATER	Sky blue with 2 signal red band	5015	3001
53	TREATED WATER	Sky blue with 1 oxide red band	5015	3009
54	DRINKING WATER	Sky blue with 1 grass green band	5015	6010

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55	COOLING WATER	Sky blue with 1 light brown band	5015	1011
56	SERVICE WATER	Sky blue with 1 signal red brown	5015	3001
57	TEMPERED WATER	Sky blue with 2 grass green bands	5015	6010
58	DM WATER	Sky blue with 1 aluminum band	5015	9006
59	DM WATER ABOVE 150°F	Sky blue with 2 jet black bands	5015	9005
60	SOUR WATER	Sky blue with 2 traffic yellow bands	5015	1023
61	STRIPPED WATER	Sky blue with 2 Cobalt blue bands	5015	5013
62	ETP TREATED WATER	Sky blue with 2 oxide red bands	5015	3009
FIRE PROTECTION SYSTEM (ABOVE GROUND)				
63	FIRE WATER FOAM & EXTINGUISHERS	Carmine Red	3002	
AIR & OTHER GAS LINES (UNINSULATED)				
64	SERVICE AIR	Yellow green with 1 signal red band	6018	3001
65	INSTRUMENT AIR	Yellow green with 1 jet black band	6018	9005
66	NITROGEN	Yellow green with 1 deep orange band	6018	2011
67	FREON	Yellow green with 1 traffic yellow band	6018	1023
68	CHLORINE	Lemon Yellow with 1 oxide red band	1012	3009
69	SO_2	Lemon Yellow with 2 white bands	1012	9010
70	H_2S	Deep Orange with 2 oxide red bands	2011	3009
71	GAS (Fuel)	Deep Orange with 1 aluminum band	2011	9006
72	GAS (Sour)	Deep Orange with 2 aluminum bands	2011	9006
73	GAS (Sweet)	Deep Orange with 2 signal red band	2011	3001
74	HYDROGEN	Deep Orange with 1 Pale green band	2011	6021
STEAM AND CONDENSATE LINES (UNINSULATED)				
75	HP STEAM	White Aluminum with 1 traffic yellow band	9006	1023
76	MP STEAM	White Aluminum with 1 signal red band	9006	3001
77	MLP STEAM	White Aluminum with 1 orange band	9006	2011
78	LP STEAM	White Aluminum with 1 light green band	9006	6021
79	CONDENSATE	Sky blue with 1 white band	5015	9010

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80	CONDENSATE ABOVE 150°F	Sky blue with 3 oxide red band	5015	3009
81	BFW	Sky blue with 2 signal red bands	5015	3001
Note: For all insulated steam lines, the colour coding shall be followed as given for un-insulated lines with the specified length of colour bands.				
INSULATED HYDROCARBON PIPING				
82	IFO SUPPLY	Jet Black ground colour with 1 traffic yellow band in centre	9005	1023
83	IFO RETURN	Jet Black ground colour with 1 grass green band in centre	9005	6010
84	HPS	Jet Black ground colour with 1 signal red band in centre	9005	3001
85	BITUMEN	Jet Black ground colour with 2 signal red bands in centre	9005	3001
86	CLO	Jet Black ground colour with 1 brown band in centre	9005	8004
87	VB TAR	Black ground colour with 2 copper brown bands in centre	9005	8004
88	VR AM (BITUMEN / VBU FEED)	Jet Black ground colour with 1 Cobalt blue band in centre	9005	5013
89	VR BH	Black ground colour with 2 Cobalt blue bands in centre	9005	5013
90	VAC. SLOP	Black ground colour with 1 white band in centre	9005	9010
91	SLOP	Black ground colour with 1 deep orange band in centre	9005	2011
92	CRUDE SWEET	Basalt Grey ground colour with 1 signal red band in centre	7012	3001
93	CRUDE OUR	Basalt Grey ground colour with 1 deep orange band in centre	7012	2011
94	VGO / HCU	Oxide red ground colour with 2 iron grey bands in centre	3009	7011
95	OHCU BOTOM / FCCU FEED	Oxide red ground colour with 2 iron grey bands in centre	3009	7011
UNINSULATED EQUIPMENT, TANKS AND STRUCTURES				
96	HEATER STRUCTURE	Iron grey	7011	
97	HEATER CASING	White Aluminum	9006	
98	VESSELS & COLUMNS	White Aluminum	9006	
99	HYDROGEN BULLETS	Antique Pink	3014	
100	LPG VESSELS	Oxide red	3009	
101	SO_2 VESSEL	Lemon Yellow	1012	
102	HEAT EXCHANGER	White Aluminum	9006	
103	FO TANK AND HOT TANKS	Jet Black	9005	

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104	ALL OTHER TANKS	White Aluminum	9006	
105	CAUSTIC / AMINE / ACID TANKS	Golden yellow	1004	
106	SOUR WATER	Sky Blue	5015	
107	OUTER SURFACE IN BOILER HOUSE	Aluminum	9006	
108	COMPRESSORS AND BLOWERS	Basalt Grey	7012	
109	PUMPS	Pigeon Blue	5014	
110	MOTORS & SWITCH GEAR	Pastel Blue	5024	
111	HAND RAILING	Signal red	3001	
112	STAIRCASE, LADDER AND WALKWAYS	Jet Black	9005	
113	LOAD LIFTING EQUIPMENT AND MONORAILS ETC	Clay Brown	8003	
114	GENERAL STRUCTURE	Jet Black	9005	
115	FLUE GAS STACK	Jet Black	9005	
	PIPES AND FITTINGS OF ALLOY STEEL AND SS MATERIAL IN STORE			
115	IBR	Signal red	3001	
116	9Cr-1Mo	Pale Green	6021	
117	5Cr-0.5Mo	Light Blue	5012	
118	$2_{1/4}$Cr-1 Mo	Luminous Yellow	1026	
119	$1_{1/4}$Cr-½ Mo	Traffic Yellow	1023	
120	SS-304	Grey Blue	5008	
121	SS-316	Blue Lilac	4005	
122	SS-321	Pigeon Blue	5014	
	SAFETY COLOUR SCHEMES			
123	DANGEROUS OBSTRUCTION	Jet Black and Bright Red Orange band	9005	2008
124	DANGEROUS OR EXPOSED PARTS OF MACHINERY	Bright Red Orange	2008	

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उपकेन्द्रीय पम्प के लिए मानक विनिर्देश (जल सेवा)

STANDARD SPECIFICATION FOR CENTRIFUGAL PUMPS (WATER SERVICE)

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	02/12/24	REVISED & ISSUED AS STANDARD SPECIFICATION	MK	JSD/TK	NK	MN
5	09/01/20	REVISED & ISSUED AS STANDARD SPECIFICATION	BBS	JSD	SM	RKT
4	06/04/11	REVISED & ISSUED AS STANDARD SPECIFICATION	SPS	DB	AKN	DM
3	20/03/08	REVISED & ISSUED AS STANDARD SPECIFICATION	NK	AKN	VKM	VC
2	04/09/02	REVISED & ISSUED AS STANDARD SPECIFICATION	NK	KDS	VJN	GRR

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Abbreviations:

ANSI	:	American National Standards Institute
ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
CG	:	Centre of Gravity
DCI	:	Document Control Index
EC	:	Experience Criteria
engDMS	:	Engineering Electronic Document Management System
GA	:	General Arrangement
IC	:	Internal Combustion
ISA	:	Instruments Society of America
MAWP	:	Maximum Allowable Working Pressure
MCF	:	Minimum Continuous Flow
MCR	:	Maximum Continuous Rating
MCS	:	Maximum Continuous Speed
NFPA	:	National Fire Protection Association
NPSH	:	Net Positive Suction Head
NPSHA	:	Net Positive Suction Head Available
NPSHR	:	Net Positive Suction Head Required
OD	:	Outside Diameter
P&ID	:	Piping and Instrumentation Diagram
PTR	:	Proven Track Record
VDM	:	Vendor Document Management
VDR	:	Vendor Data Requirements

Rotating Equipment Standards Committee

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SECTION 1 - GENERAL

1.1 SCOPE

i. This specification together with the attendant Data Sheets and other specifications/attachments to inquiry/order defines the minimum requirements for vertical and horizontal centrifugal pumps and their accessories/auxiliaries for use in clean, cold water service. Water injection pump, boiler feed water pumps and pumps for sea water services are not covered by this specification.

ii. Vendor shall comply with the requirement of this specification and other specifications/attachments to inquiry/order. No deviation or exception shall be permitted without the written approval of the purchaser.

iii. Compliance with this specification shall not relieve the vendor of the responsibility of furnishing equipment and accessories/auxiliaries of proper design, materials and workmanship to meet the specified start up and operating conditions.

In case the vendor considers requirement of additional instrumentation, controls, safety devices and any other accessories/auxiliaries essential for safe and satisfactory operation of the equipment, they shall recommend the same along with reasons in a separate section along with their proposal and include the same in their scope of supply.

1.2 CONFLICTING REQUIREMENTS

In case of conflict between this specification and the attendant data sheets, job specifications (if any) and other attached specification the following order of precedence shall govern:

1. Process Data Sheet / P&IDs / Process Package
2. Mechanical Data Sheets.
3. Job Specifications / Scope of Work (if any)
4. This specification
5. Other standards & specifications
6. Other referred codes and standards

The editions of referenced publication that are in effect at the time of inquiry or at a date specified in the inquiry documents shall be applicable.

In case of any ambiguity in the above documents, the vendor/supplier shall seek clarification from the owner/purchaser and the decision of the owner/purchaser shall be final and binding.

1.3 DEFINITION OF TERMS

1.3.1 The **Normal operating point** is the point at which usual operation is expected.

1.3.2 The **Rated operating point** is the point at which the vendor certifies that performance is within the tolerances stated in this specification.

1.3.3 **Maximum allowable working pressure (MAWP)** is the maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when the equipment is operating at the maximum allowable temperature.

1.3.4 **Maximum allowable temperature** is the maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified liquid at the specified pressure.

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1.3.5 **Minimum continuous stable flow** is the lowest flow at which the pump can operate continuously without exceeding the noise and vibration limits imposed by this specification.

1.3.6 The **Pressure casing** is the composite of all stationary pressure containing parts of the unit, including all nozzles, glands and other attached parts.

1.3.7 Unless otherwise specified, **Supplier / Vendor** shall be a manufacturer of centrifugal pumps (water service) having adequate design, engineering, manufacturing, packaging and testing facilities and shall have supplied complete centrifugal pumps (water service) package as a single point responsibility vendor. The vendor shall also be the manufacturer of the proposed centrifugal pumps (water service).

1.3.8 **Net positive suction head** (NPSH) is the total absolute suction head, in meters of liquid, determined at the suction nozzle and referred to the datum elevation minus the vapour pressure of the liquid in meters absolute. The datum elevation is the shaft centreline for horizontal pumps, the suction nozzle centreline for vertical in-line pumps and the top of foundation for other vertical pumps.

1.3.9 **Net positive suction head available** (NPSHA) is the NPSH in meters of liquid, determined by purchaser for pumping system with the liquid at the rated flow and normal pumping temperature.

1.3.10 **Net positive suction head required** (NPSHR) is the NPSH in meters, determined by vendor testing with water. NPSHR is measured at the suction flange and corrected to the datum elevation. NPSHR at rated and other capacities is equal to the NPSH that produces a 3 percent head drop (first stage head in multistage pumps) due to cavitation within the pump.

1.3.11 **Minimum Submergence required** is the liquid level with respect to pump suction flange face, in millimeters, determined by the vendor when testing with water for vertical pumps. This is the level required to prevent vortex formation/ingress of air/vapour into the pump suction resulting in loss of flow/head.

1.4 EXPERIENCE CRITERIA

1.4.1 The pump model offered shall be from the existing pump model series and shall be from the regular manufacturing range of the vendor (Prototypes are not acceptable).

The mechanical design as well as the hydraulic performance (including NPSHR) for the complete range of operation of the offered model shall have been established in the shop test. (Details to be furnished, if required).

The offered pump model with identical hydraulics and design shall be field proven (at least ONE unit) with minimum operating experience of one year for similar operating/design conditions, bearing span/column length, pumping liquid and material of construction supplied in the last Ten (10) years, from the proposed manufacturing plant, as on bid due date.
(Note: Similar operating/design conditions, bearing span/column length would mean approx. 80% or higher)

Multiple references can be furnished to justify the above.

1.4.2 The vendor shall complete the Experience Record Proforma enclosed with the inquiry document to amply prove that the offered pump meets the above criteria by furnishing references of flow, head, pressure & temperature, driver rating & speed, number of stages, bearing span / column length (as applicable), efficiencies, material of construction, bearing

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design & lubrication. In addition, manufacturer's catalogue and general reference list for centrifugal pump (water service) to be furnished along with the proposal.

SECTION 2 - BASIC DESIGN

2.1 GENERAL

2.1.1 The vendor shall have UNIT RESPONSIBILITY of complete centrifugal pump package & shall be responsible for complete design, engineering, manufacturing, packaging, testing, supply & supervision of erection & commissioning of total package as per specification requirements. Vendor's scope shall include but not limited to the responsibility for execution, coordination of all technical aspects of equipment and its auxiliary systems, their selection & integration into a complete package constituting total order. All drawings/documents pertaining to the order shall be duly approved by the vendor before onward submission.

2.1.2 Pumps with constant speed drivers shall be capable of at-least 5 percent head increase at rated condition and pump rated speed by replacing with a new impeller or impellers. Offered impeller shall in no case be less than the minimum diameter impeller.

2.1.3 Horizontal pumps of the close-coupled, the two stage overhung, or the single stage double suction overhung, type shall not be furnished.

2.1.4 Unless otherwise specified, Pumps where difference between NPSHA and NPSHR is 0.6 meter or less are not acceptable. The said NPSHR value shall correspond to the maximum value of NPSHR from rated flow down to the recommended minimum continuous stable flow specified by the vendor. However, for pumps having pump rated BKW up to 55 kW, pumps with margin between NPSHA & NPSHR less than or equal to 1 m are not acceptable.
For Pumps with open discharge valve/auto-start condition, the NPSHR at the 120% of Best Efficiency Point (BEP) flow shall not exceed the NPSHA.
Note: Actual datum for NPSHA (i.e. grade level, top of foundation level or any other level as defined in enquiry) shall be referred from the data sheets forming part of enquiry document.

Pumps fitted with inducers for reducing NPSHR are not acceptable.

2.1.5 Pumps shall have stable head/capacity curves (continuous head rise to shut-off). When parallel operation is specified, head rise shall be at least 10 percent of the head at the rated capacity. The shut off head shall not be more than 120 percent of the rated head in horizontal pumps and 140 percent in the case of vertical turbine pumps. In no case shutoff pressure shall exceed downstream design pressure. Unless otherwise specified, discharge orifice shall not be used to achieve required head rise to shut off, even in the case of parallel operation.

2.1.6 The best efficiency point for the furnished impeller is preferred between the rated point and the normal point. However the rated point shall be between 70 to 110 percent of the best efficiency point of the rated impeller except for intermittent duty applications and for pumps having rated BKW upto 22 kW.

2.1.7 Unless otherwise specified, the maximum permissible sound pressure level of the complete equipment (pump + driver) train shall not exceed 85 dBA measured at 1 meter from pump surface in any direction for the recommended range of operation at site.

2.1.8 For vertical pumps, not provided with non-reverse ratchet, vendor shall describe the precaution taken, to prevent damage due to reverse rotation.
Vertical pumps shall be provided with their own thrust bearing designed to carry rotor

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weight and pump generated axial forces and shall not transmit any thrust to the bearings of driver.

2.1.9 Pump-Driver train shall be designed to be suitable for outdoor installation without a roof.

2.1.10 Lifting lugs/eye hooks shall be provided for ease of lifting of complete pump as well as the heavy maintenance components of the pump (e.g. Top half casing cover of axially split pump).

2.1.11 The guaranteed parameters shall be demonstrated during shop test without any coating on impellers or casings.

LCWP (Horizontal/vertical) shall be internally coated after pump performance test to improve the pump efficiency to the extent possible. One pump per tag will be performance tested (testing procedure similar to pump tested without coating) after coating to witness the actual improvement in efficiency.

2.1.12 Pumps with variable speed drivers shall be capable of operating continuously upto 105 percent of rated speed as well as operating briefly upto driver trip speed.

2.1.13 Casing vents alongwith vent valves, as per manufacturer standards, for all pumps shall be provided. For all horizontal pumps, casing drain with isolation valve and flanged piping terminated at the skid edge shall be provided. Baseplate shall also be provided with flanged drain connection.

2.1.14 Horizontal between bearing pumps, pumps with rated flow above 500 m3/hr (horizontal) and pumps with rated flow above 100 m3/hr (vertical) shall be considered as Large Capacity Water Service (LCWS).

2.2 PRESSURE CASING DESIGN

2.2.1 Maximum allowable working pressure (MAWP) for all pressure containing parts e.g. casing, bowl, discharge head, discharge pipe, column pipe (in case of vertical turbine type pump), stuffing box etc. shall in no case be less than the maximum discharge pressure produced by the pump at shut-off (including tolerances), at the maximum suction pressure, for the rated impeller diameter and the maximum continuous speed.
Note: Shut-off pressure for vertical pumps shall be calculated at the delivery flange at the top of mounting plate in the same way bowl head is calculated, since the shut-off head corresponds to the rated impeller, at the Pump casing discharge flange.

MAWP shall also not be less than the specified downstream design pressure.

These pressure containing parts shall be suitable for hydrostatic test pressure of 1.5 times the MAWP.

Note: MAWP shall not be less than 10 kg/cm²g for pumps with 125# flanges (i.e. with Cast Iron casing) & 16 kg/cm²g for pumps with 150# flanges (i.e. with Carbon Steel or Alloy Steel casing).

2.2.2 Pumps shall have suction and discharge flanges designed for same rating. Unless otherwise stated, flanges shall be machined and drilled conforming to ASME B16.5 (up to NPS 24) and ASME B16.47 Series B (for above NPS 24).

2.2.3 Pumps shall be provided with Flanged nozzles.

2.2.4 Unless otherwise specified, all pumps shall be supplied with companion flanges with rating conforming to applicable specification of ASME B16.5 (up to NPS 24) and ASME B16.47 Series B (for above NPS 24), drilled and faced in accordance with pump suction

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and discharge flanges alongwith gaskets and fasteners.

For pumps with casing material as cast iron (CI), the companion flanges shall be of slip-on (SO) type [for flange sizes 50 mm (2 inches) & above] or socket welded (SW) type [for flanges of size 15 mm (0.5 inches) to 40 mm (1.5 inches)] with flat face (FF) & of carbon steel material. The gasket shall be of full face type.

For pumps with casing material other than cast iron, the companion flanges for pump suction and discharge connections shall be of weld neck (WN) type with raised face (RF) & of the material compatible with piping material.

2.3 IMPELLER, SHAFTS AND SHAFT SLEEVES

2.3.1 Impellers shall be cast as one piece.

2.3.2 Shaft shall be provided with sleeves under the packing/seal and shall be locked to the shaft. The material of sleeve shall be 12 percent chrome steel (hardened). Where the size of pump makes the use of shaft sleeve impracticable, the shaft shall be constructed of 12 percent chrome steel (hardened). For vertical pumps, shaft material shall be 12 percent chrome steel.

2.4 WEAR RINGS

Unless otherwise specified, renewable wear ring shall be furnished at least on the casings. Mating wear surfaces of hardenable materials shall have a difference in Brinell hardness number of at least 50. Integral impeller wear surfaces shall have higher hardness than that of the casing wear rings, when only casing wear rings are provided.

2.5 DYNAMICS

The following vibration limits shall be applied at rated speed and at flow of ±10 percent of rated flow.

2.5.1 **Horizontal Pumps**

Unfiltered vibration velocity (peak) for horizontal pumps upto 3000 rpm with antifriction bearing or sleeve bearings when measured at the bearing housing in horizontal or vertical direction shall not exceed 4.0 mm/sec (0.16 inch/sec).

Bearing housings shall be suitable to permit measurement of vibration.

2.5.2 **Vertical Pumps**

Unfiltered vibration velocity (peak) for vertical pumps with antifriction and or sleeve bearings when measured at the top bearing housing of pump or top bearing housing of motor or mounting flange for measuring points upto 3 meters above the mounting base shall not exceed the following limit:

Pumps greater than 1500 rpm	=	7.0 mm/sec (0.28 inch/sec)
Pumps upto & including 1500 rpm	=	5.1 mm/sec (0.2 inch/sec)

2.5.3 The vibration limits (peak) specified vide clause. 2.5.1 and 2.5.2 above shall be applied for pumps only. The vibration limits for the drivers shall be as per their respective applicable standards. Where respective applicable standards do not specify such limits for the associated drivers, the driver manufacturer's recommendation shall be applied for acceptance of the driver. Such acceptable limits shall be indicated by the vendor in their proposal.

2.6 MECHANICAL SEAL/PACKING

2.6.1 Unless otherwise specified, the pump shall be supplied with packings. Stuffing box shall

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have minimum five packing rings plus lantern ring. Packing ring size shall be 3/8" or larger.

2.6.2 The mechanical seal shall be of a make, duly approved by the purchaser.

2.6.3 Seal manufacturers specific recommendation shall be obtained and submitted alongwith the proposal.

2.6.4 All auxiliaries for flushing of mechanical seal shall be in vendor's scope of supply.

2.6.5 Large Capacity Water Service (LCWS) Pumps shall be provided with Non-API, balanced & horizontal split mechanical seals.

2.7 BEARINGS

2.7.1 Antifriction bearings shall be of standard type and shall meet minimum L-10 rating life of either 25000 hours with continuous operation at rated conditions or 16000 hours at maximum axial and radial loads and rated speed.

2.7.2 The rise in bearing grease/oil temperature with continuous running of the pump shall be within the allowable limits which shall not exceed 30°C for grease and 39°C for oil lubricated bearings above ambient. Cooling arrangements shall be provided if required. Bearings shall be equipped with constant level oilers, vent breather & drain point for oil lubricated arrangements.

2.7.3 Unless otherwise specified, for vertical pumps with open shaft, the intermediate bearings / bushings shall be suitable for operation without any lubrication during start / shut-down or during normal operation (i.e. bearing bush material shall be of self lubricating type). Details of line shaft bearings shall be furnished with the proposal.

2.7.4 Unless otherwise specified, for vertical pumps, thrust from the pump shall not be transferred to the electric motor.

2.8 MATERIALS

2.8.1 The material of construction of parts shall be as specified. Vendor shall furnish the equivalent material as per ASTM.

For impellers in cast iron or bronze construction, the tip speed shall be limited to 40 meters/sec. Unless otherwise specified, for tip speeds exceeding 40 meters/sec, the material of impellers shall be stainless steel.

2.8.2 Unless otherwise specified in the data sheet, material test certificates (chemical and mechanical properties) shall be supplied for impeller, shaft, shaft sleeve, wearing rings and casings.

2.8.3 The repair of pressure castings by peening, plugging, impregnating or by the use of plastic or cement compound is prohibited. The Inspector's prior approval shall be obtained for the repair of castings. When authorised, repair shall be carried out in accordance with applicable ASTM Specification. Weld repair of pressure containing parts of Cast Iron construction is not permitted.

2.9 PUMPS FOR FIRE WATER APPLICATION

Pumps for Fire Water Application shall also meet the following additional requirements:

2.9.1 Unless otherwise specified, Pumps shall meet the requirements of NFPA (National Fire

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Protection Association). Technical requirements specified in the data sheet are also to be met. The vendor shall also be responsible for obtaining the necessary approvals as specified in inquiry.

2.9.2 Pumps shall be direct-coupled except in the case of engine-driven vertical turbine pumps wherein gear drives through universal joint and cardan shaft shall be used. Belt driven pumps are not acceptable.

2.9.3 Parts of pumps like impeller, shaft sleeve, wearing ring etc. shall be of non-corrosive metal preferably brass or bronze unless the quality of water dictates the use of special metals/alloys which shall be insisted upon.

2.9.4 Pumps shall be capable of discharging not less than 150 percent of rated capacity at a head not less than 65 percent of the rated head.

2.9.5 Difference between NPSHA and NPSHR at 150 percent of the duty point shall not be less than 0.6 meters.

2.9.6 The electrical motor shall be of continuous rating type and the rating shall be 110 percent of the power at rated point or equal to maximum BKW rated impeller whichever is higher.

2.9.7 For Diesel engine drivers, the net continuous site power available after considering the deration due to site condition and power losses, due to other parasitic loads and engine driven auxiliaries shall be higher of the following two values:

(a) 20 percent in excess of the BKW required to drive the pump at rated condition.
(b) Maximum BKW rated impeller as indicated by the manufacturer in the pump data sheets.

SECTION 3 - ACCESSORIES

3.1 DRIVERS

3.1.1 Electric motor drivers shall have a maximum continuous rating (MCR) (i.e. service factor equal to 1) not lower than the following unless higher rating is dictated by the Note 1.

Pump Rated BKW *		**Motor MCR (% of Pump Rated BKW)**
Less than 22 kW	:	To suit maximum BKW indicated on pump data sheet or 125% of rated pump BKW, whichever is higher.
22 kW - 55 kW	:	115% of rated pump BKW.
Higher than 55 kW	:	110% of rated pump BKW.

Remark: * including all mechanical & transmission losses & with 0% +ve tolerance.

Note :

1. The motor nameplate rating for pumps under parallel operation shall not be less than the max. BKW indicated on pump data sheet (the power at End of the curve for the rated impeller) or shall have the specified margin as per this clause whichever is greater. The pump motors shall also be suitable for start-up under open discharge valve condition.

3.2 GEARS

The type of gears shall be as specified in the inquiry document.

Unless otherwise specified, gear box shall be selected with a minimum of AGMA service factor of 1.75 over the driver rating.

Wherever right angle gear box are required the same shall be supplied non-reversible

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ratchet and shall allow for vertical adjustment of the impeller. Further the gearbox shall be suitable for absorbing the maximum thrust under any case of operation.

3.3 COUPLING & GUARDS

3.3.1 Unless otherwise specified, connection between pump and driver shall be made by a flexible metallic coupling.

A spacer (127 mm minimum normal length), shall be used to permit the removal of coupling, bearings, seal and/or rotor as applicable without disturbing the driver, the suction and discharge piping, or the casing top cover, for all horizontal pumps.

It shall be the responsibility of the pump vendor to obtain purchaser's approval for the selected coupling, its make and rating.

3.3.2 Whether or not pump vendor is required to supply the driver, he shall still deliver the fully machined coupling assembly alongwith the pump. The driver shaft dimensions and tolerances shall be furnished by the Purchaser to the pump vendor.

3.3.3 Removable coupling guard shall be provided which shall be fabricated from non-sparking material, and shall be open at the bottom to permit manual shaft rotation. The guard shall be sufficiently rigid to withstand deflections as a result of bodily contact of nominally 100 kgs. Coupling guard shall have a hinge to open and Inspection window to see the healthiness of the coupling shims.

3.3.4 Coupling service factor shall not be less than 1.5 over driver rating. However, while selecting the coupling, it shall be ensured by pump vendor that the allowable shaft stresses of the pump train are not exceeded under any circumstances including any offset condition or conditions of maximum torque. For pump trains having gear-box, the coupling service factor shall not exceed the gear-box service factor.

3.4 BASEPLATE

3.4.1 Baseplates for Horizontal Pumps

3.4.1.1 Baseplate shall extend under the pump, gear box and motor/turbine driver and shall be fully machined for mounting the above equipment. All other projections of the equipment supplied shall fall within the maximum perimeter of the baseplate. Baseplate shall be steel fabricated and shall have sufficient rigidity to avoid vibration and distortion. Baseplate shall be so designed as to facilitate proper grouting (Vent holes where required shall be provided).Type of grout material and technical details shall be furnished by vendor in his proposal. Baseplate shall be cleaned (sand blasted) inside and outside and coated with suitable anticorrosion paint.

Drain Pan Type Baseplate surrounding the entire baseplate to be provided. Baseplate to be provided with minimum 2" flanged drain connection.

3.4.1.2 The baseplate shall be provided with lifting lugs for at-least a four point lift. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or machinery mounted on it.

3.4.1.3 For driver trains over 75 kW, alignment positioning screws shall be provided for each drive element to facilitate longitudinal and transverse horizontal adjustments. The lugs holding these positioning screws shall be attached to the baseplate so that they do not interfere with the installation or removal of the drive element.

3.4.1.4 Vertical leveling screws, spaced for stability shall be provided on the outside perimeter of

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the baseplate. These shall be numerous enough to carry the weight of the baseplate, pump, gear-box (if any) and driver without excessive deflection.

3.4.2 **Baseplate / Mounting Plate for Vertical Pumps**

3.4.2.1 Vertical pumps shall have the manufacturer's standard mounting arrangement.

3.4.2.2 Alignment positioning screws shall be provided for 18.5 kW and above and as per manufacturer's standard practice for lower ratings.

3.4.2.3 Unless otherwise specified, mounting plate for vertical pumps shall be having a minimum thickness of 48 mm and is to be made from IS:2062/IS:2002 plate material or can be of the same material as that of vessel / tank. Mounting plate shall be supplied with gaskets (as applicable) & fasteners.

3.4.2.4 Alignment positioning screws shall be provided for all motors.

3.5 STRAINERS

Unless otherwise specified, all vertical pumps shall be provided with suction strainers of SS-316 material.

SECTION 4 - INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 GENERAL

4.1.1 Unless otherwise specified, all pumps shall be inspected and all tests shall be witnessed by the Purchaser or by the Purchaser's authorised representative.

4.1.2 Purchaser's or their authorised representative shall have access to the plant including sub vendors plants where work on or testing of equipment is being performed.

4.1.3 No surfaces of parts of pumps are to be painted until the inspection is completed.

4.1.4 Vendor shall give to the purchaser at-least 15 days notice prior to commencement of testing. Vendor shall carry out all running tests and mechanical checks and satisfy himself prior to purchaser's arrival for inspection and shall maintain desired log of tests.

4.1.5 Acceptance of shop test shall not constitute a waiver of requirement to supply equipment as per specification and/or to meet field test under operating condition, nor does inspection relieve the manufacturer of his responsibility in any way whatsoever.

4.2 TESTS

As a minimum following tests shall be performed. The basic reference standard shall be the latest edition of Hydraulic Institute Standard or IS:5120.

4.2.1 **Hydrostatic Test**

4.2.1.1 Pressure casings including column pipe and discharge head shall be hydrostatically tested with water at ambient temperature at 1½ times the maximum allowable working pressure specified in the data sheet.

4.2.1.2 Jackets for bearing, stuffing box, coolers, etc, shall be tested at 1½ times the maximum allowable jacket working pressure.

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4.2.1.3 Hydrostatic test shall be maintained for a minimum period of 30 minutes. Shop test certificate is required.

4.2.2 **Performance Test**

4.2.2.1 Unless otherwise specified, performance test for Horizontal Pumps for General Water Service (GWS) shall be carried out as per the following:

Pumps with drivers upto 55 kW	Non witnessed. Only review of manufacturer's shop test reports are required.
Pumps with drivers from 55 kW to 160 kW	One pump per tag/Item no. to be witnessed
Pumps with drivers above 160 kW	All pump units in an item to be witnessed

However in case of vertical pumps and for pumps for Large Capacity Water Service (LCWS), all pumps in a tag needs to undergo witnessed performance test.

4.2.2.2 Unless specifically agreed upon, pump shall be tested at the rated speed specified in the data sheet with calibrated motors, at least for four hours. During the four hour run test, complete data including pressure, capacity, power, vibration levels, bearing temperatures and noise levels shall be recorded and guaranteed parameters verified.

Prior to start of test, manufacturer shall furnish the certificate of latest calibration / re-calibration of driver and measuring instruments. Unless electrical or mechanical failure occurs, driver used for shop testing need not be recalibrated and original calibration certificate shall remain valid. Duration of recalibration for all measuring instruments shall be as per the recommendations of HI Standards and/or relevant standards of the country of origin of the pump manufacturer.

4.2.2.3 The pump shall be tested with water at ambient temperature. Suitable rust inhibitor shall be added in the water used during any internal testing / performance testing of the pumps, to prevent rusting of pump internals.

4.2.2.4 The performance test for the pumps shall be in accordance with Indian Standard IS:5120 latest edition and the tolerance of the guaranteed parameters shall be as follows:

Rated head	:	Zero negative tolerance.
Shut-off head	:	Positive tolerance permitted as long as it does not exceed downstream design pressure. Negative tolerance permitted so long as the curve is continuously rising to shutoff without any drooping and minimum 110% head rise to shutoff shall be available for pumps in parallel operation.
Min. Submergence required (for vertical pumps)/ NPSH(R)	:	Zero Positive Tolerance.
Rated BKW	:	Zero positive tolerance (However pumps may be accepted upto 104 percent of Guaranteed BKW subject to Penalties as defined elsewhere)

As a minimum, data at Shut-off (no vibration data required), minimum continuous stable flow, midway between minimum and rated flow, rated flow and maximum allowable flow (as a minimum, 120% of best efficiency flow), shall be measured and recorded during tests. All the instruments used for conducting the tests shall be calibrated before tests and calibration certificates furnished from a recognised testing institution to the Inspector.

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4.2.2.5 For fire water application all engine driven horizontal and vertical pumps shall be subjected to a 4 hour complete unit string test at the pump vendor's works during which mechanical performance of the train shall be verified, in terms of vibration, bearing/oil temperature, engine parameters and controls.

In case multiple units are ordered, only one number of diesel engine and gear box unit (if used) may be brought to the pump vendor shop for complete unit (string) test for the fire water pump unit. For the remaining pumps, complete unit (string) need not be done. However, any modification required to be done on the first unit shall be uniformly done on the remaining units also for proper unitization of the same at site.

4.2.3 **NPSH Test / Min. Submergence Test**

Unless otherwise specified, NPSH test for Horizontal Pumps for General Water Services (GWS) shall be carried out as per following:

For pumps with driver rating upto 55 kW	Not Applicable
For Pumps with driver rating between 55 kW to 160 KW	One pump tag/item to be witnessed
For Pump with driver rating above 160 KW	All pump units to undergo witness test

Additionally, in case of vertical pumps, all pumps in tag needs to undergo minimum submergence test Testing for NPSH is not required for Vertical pumps.

Also for all pumps in LCWS, all pumps in a tag needs to undergo NPSH test if required as per specification.

Unless otherwise specified NPSH test shall be carried out where difference between NPSH available and NPSH required is 1 meter or less at the rated point, for pumps beyond 55 kW.

Test points shall be similar to those of Performance test.

4.2.4 **Vibration Measurement**

During performance test vibration shall be measured on the bearing housing for the capacity range from pump MCF to 110% of rated capacity. For checking the vibration, flat surface shall be provided on bearing housing by pump manufacturer. The vibrations shall be within the limits as specified in clause no. 2.5.

4.2.5 **Dismantling Inspection**

Dismantle inspection of pump after performance test shall be applicable only in case of abnormality in mechanical behaviour (such as excessive noise and vibration, bearing temperature rise etc.) during performance test.

If it is necessary to dismantle a pump after the performance test for the sole purpose of machining impellers to meet the tolerances for differential head, no re-test will be required unless the reduction in diameter exceeds 5 percent of the original diameter. The diameter of the impeller at the time of shop test, as well as the final diameter of the impeller, shall be recorded on a certified shop test curve that shows the operating characteristics after the diameter of the impeller has been reduced.

If it is necessary to dismantle a pump for some other correction, such as improvement of power, NPSH or mechanical operation, the initial test will not be acceptable and final performance test shall be run, after the correction is made.

4.2.6 **Final Inspection**

After the performance/dismantle test the pump and the job driver shall be unitised on the

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job base plate, aligned and coupled to make a complete unit except for engine driven vertical pumps. The pump will then be checked for visual inspection to confirm compliance to the GA drawings, nozzle dimension, elevations, anchor bold position, direction of rotation etc.

4.2.7 Prior to start of tests, vendor shall furnish the following:

1. Certificate of calibration of driver, which should be recalibrated after a period of every three years.
2. Certificate of calibration of measuring instruments, which should be recalibrated after a period of every one year. Magnetic flowmeters shall be recalibrated once in two years. Pressure gauges shall be calibrated prior to start of test and after completion of test.
3. Record of all running test and mechanical checks (including test curves and data) completed prior to purchaser's inspection.

4.3 PREPARATION FOR SHIPMENT

4.3.1 After all tests are completed and after inspection is made, all exposed mechanical surfaces and all internal parts shall be thoroughly coated with a rust preventive. All exterior parts of the unit except machined surfaces shall receive one prime coat and one coat of vendor's standard enamel.

4.3.2 All flanges, nozzles shall be blanked off. All untapped openings shall be provided with substantial wood or metal closure. The ends of small piping may be sealed with tape.

4.3.3 The pump shall be supplied with a nameplate containing the following information:

- Purchaser's Item No.
- Manufacturer's Name
- Type and Serial No
- Rated capacity in m3/hr.
- Differential head at rated capacity in m.
- Casing hydrostatic test pressure in kg/cm^2.
- Speed in rpm.

The nameplate shall be of stainless steel and relevant information shall be punched into the same.

4.3.4 All auxiliary, dismantled and packed separately shall be properly marked with the Item No. for which it is intended by means of metal tag.

4.3.5 Pump with auxiliary shall be suitably packed, fastened to avoid damage during transit and crated for shipment and storage for a period of 12 months. Lifting, unpacking and handling instructions shall be securely attached to the exterior of the largest packing in a well marked weather proof container. The upright position of lifting points, gross weights and dimensions be clearly marked on each package. Each package shall clearly identify the equipment contained therein. If any extra precaution is to be taken by the Purchaser for storage beyond 12 months the same shall be explicitly indicated in the operation and maintenance manuals.

SECTION 5 - VENDOR'S DATA

5.1 PROPOSALS

The vendor's proposals shall as a minimum include the following:

a) All data sheets, drawings and documents listed under "PRINTS WITH QUOTE" in the enclosed Vendor Data Requirement Form.
b) Vendor's confirmation/comments on post-order Vendor Data Requirements (Type of

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Documents, no. of prints and date needed) indicated in Vendor Data Requirement forms data sheets and specs.

c) List of recommended commissioning spares included in the offer.
d) List of mandatory spares (where specified by the purchaser) included in the offer.
e) List of Vendor's standard Spare Parts for Two Years Normal Operation
This list shall be made separately for each items including auxiliaries and drivers in the form of a table & shall show :
   i) Part name, description and number.
   ii) Quantity installed in one unit.
   iii) Quantity recommended per unit for 2 years normal operation.
   iv) Quantity recommended for number of units of an item as specified in the inquiry.
   v) Quantity recommended as insurance for the number of units of an item specified in the inquiry.
f) An itemised list of special tools included in the offer.
g) Any start-up, shutdown or operating restrictions required to protect the integrity of the equipment.
h) Any limitations of vendor's test-facility to carryout the specified tests.
i) A specific statement that the scope of supply, the offered equipment/systems and all its components are in strict accordance with the data sheets, job specifications, this specifications and all other attachments, except for specific deviations as listed in the proposal.

5.2 CONTRACT DATA

5.2.1 General

5.2.1.1 Drawings and data as required after purchase order has been specified in Vendor Data Requirement. Vendor to note that the drawing/document descriptions/titles as given in the Vendor Data Requirement are generic in nature. It is possible that against one drawing/document specified there are several drawings to be furnished by the vendor or vice versa.
Vendor shall complete & forward a document "DOCUMENT CONTROL INDEX (DCI)" to the purchaser (Destination & contact person as per order).

This document shall list out in consolidated form all drawings and documents required by purchaser (As specified in Data Sheets, Specifications and Vendor Data Requirement forms enclosed with the order).

Against each drawing/document vendor shall indicate the vendor's drawing numbers, titles, Rev. No., category (whether for information or approval) and schedule of submission.

This shall be the first document to be submitted by vendor within two weeks of order. **No drawing shall be taken up for review till the DCI for inquiry/order is finalized by vendor**. If specified, drawing review may be through VDM in soft as per the details provided elsewhere in the inquiry document.

5.2.1.2 All transmittal letters (covers), drawings and data shall have a title block (in addition to vendor's standard title block) which shall as a minimum contain the following contract information:
i) Purchaser's and Consultant's Corporate Name
ii) Project Name.
iii) Client / Customer's Name.
iv) Equipment Name and Item No.
v) Purchase Order No.
vi) Purchase Requisition No.
Title Block on drawings shall be placed on the lower right hand corner.

5.2.1.3 All vendor data/drawings/documents shall be in English Language and in Metric Systems.

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5.2.1.4 Data specified in the VDR is the minimum requirements of Purchaser. Any additional document/data required or requested by Purchaser for engineering or construction shall also be made available by the vendor.

5.2.1.5 Whether or not specified the vendor shall furnish the following, before shipment:

- As built running clearances and when applicable; thrust bearing, radial bearing and seal running clearances.
- A supplementary list of spare parts other than those included in his original proposal. The supplementary list shall include recommended spare parts, cross-sectional or assembly type drawings, parts numbers, materials, prices and delivery period. The vendor shall forward this supplementary list to the purchaser promptly after receipt of the reviewed drawings and in time to permit order and delivery of parts before field start-up.
- A parts list for all equipment supplied. The list shall include pattern, stock, or production drawing numbers and materials of construction. The list shall completely identify each part so that the purchaser may determine the interchangeability of the parts with other equipment furnished by the same manufacturer. Standard purchased items shall be identified by the original manufacturer's name and part number.
- At least 8 weeks before shipment, the vendor shall submit his preservation, packaging and shipping procedures to the purchaser's for his review.

5.2.2 **Co-ordination Meeting**

When specified, a co-ordination meeting shall be held at Purchaser's office, preferably within 4 weeks of order.
An agenda shall be prepared for this meeting and would include the following points related to technical aspects.

a. Any clarifications required by the vendor on purchaser's order.
b. Vendor Data Index & Schedule.
c. Vendor Data Review/approval modalities.
d. Sub-vendor lists proposed by vendor.
e. Utility requirements.
f. Preliminary General Arrangement & layout drawings & purchaser's interface drawings.

5.2.3 **Drawings**

5.2.3.1 The number of prints and/or reproducible required and the times within which these are to be submitted by vendor are specified in Purchaser's inquiry/order.

5.2.3.2 The purchaser's review of the vendor's drawings shall not constitute permission to deviate from any requirements in the purchase order/specifications unless specifically agreed upon in writing. After the drawings have been reviewed, the vendor shall furnish certified copies in the quantity specified. All drawings must be clearly legible and shall be folded to 216 mm x 279 mm (8½" x 11") size.

5.2.3.3 Drawings/documents with following titles shall contain as a minimum the following information:

a) **General Arrangement Drawing**
A general arrangement drawing shall indicate:

i) Outline dimensions (minimum three views) (All principal dimensions).
ii) Allowable forces and moments on suction and discharge nozzles.
iii) Location (in all three planes), size, type, rating and identification of all purchaser's interface connections including those of vents, drains lubricating oil, sealing fluid, cooling water, steam & Electrical/Instrumentation.
iv) Direction of rotation viewing from the driving end.
v) Weight of each assembly/component.
vi) The weight & location of center of gravity of the heaviest

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assembly/components that must be handled for erection.

vii) Identification and weight, dimensions of the heaviest assembly / subassembly / component required to be handled for maintenance.

viii) Maintenance clearances and dismantling clearances.

ix) Speeds of Driven Equipment and driver and driver rating. Location of driver terminal box (in case of Electric Driver)

x) Layout of auxiliary equipment and operating platform.

xi) Make, Type and Size of couplings and the location of guards and their coverage.

xii) A list of reference drawings if any.

xiii) A list of any special weather-protection and climatic features.

b) **Foundation Drawings**

A foundation drawing shall indicate complete information required for foundation design by purchase including the following:

i) Foundation bolt sizes, pipe sleeve details, pocket sizes and locations and also distance between the first/ nearest anchor bolt and pump suction and discharge nozzle centrelines.

ii) Grouting thickness and other necessary technical details.

iii) Static weight of each skid/independently grouted item and location of center of gravity of each of such skid/items in all three planes.

iv) Weight distribution for each bolt/subsole plate location and total static weight.

v) Dynamic loading caused due to various items grouted independently.

vi) The direction and magnitude of unbalance forces and moments generated by each such item at the worst operating condition and short circuit moments of motor drivers at the C.G. of the pump-motor baseplate.

vii) GD^2 value of each item resolved to driver speed.

viii) Maximum permissible amplitude of vibration on the foundation at base level.

ix) Total mass of rotating parts.

x) Total mass of reciprocating parts.

xi) Suggested dynamic factor and ratio of foundation weight to weight of skid/equipment as per vendor experience.

c) **Layout Drawing** (For multi-skid packages)

This drawing shall include atleast the following:

i) Layout of all skid/equipment and their auxiliaries, vessels, control panels, exchangers etc. Vendor shall furnish an optimised layout (considering the space allocated, site wind conditions, area classification, the type of equipment located in the vicinity etc.) indicating elevation and dimension of skids/equipment.

ii) Minimum spacing required between the various skids/equipment and between the skids and the walls/columns/roof for an easy accessibility and maintenance.

iii) Layout for water piping, trenches for water piping, cable tray/trenches layout.

iv) Piping arrangement and piping support arrangement/location for piping in vendor's scope.

v) Layout for auxiliary equipment and operating platform details.

vi) Specification for crane/mono rail (including suggested mono rail layout) recommended for maintenance and height of the lifting hook from the centerline of equipment.

d) **Field Alignment Diagram**

The diagram shall indicate the relative displacement to be kept between the centrelines of various equipments at the time of installation, so that under normal running conditions the equipments get fully aligned. This relative displacement should be decided on the basis of centerline temperature rise data of driver, gear box/transmission system, driven equipment.

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e) **Heat Exchanger Drawings**
Heat exchanger drawing and data shall include heat and mass balance data, details of provisions for separating and withdrawing the condensate, construction details, cross sections & general arrangement drawings of heat exchangers, vendors recommendations regarding provision for support and piping expansion.

5.2.3.4 **P&I Diagrams** (with Bill of Materials)
Vendor shall supply P&I Diagrams along with Bill of Materials of each system in the vendor's scope of supply or specified in the order. P&I Diagram shall indicate the system details, location of various auxiliaries, instruments, controls and safety devices as required. Line sizes, piping class, valve sizes and class shall be clearly marked on the P&ID. Vendor's scope and purchaser's scope shall be clearly demarcated. Each item shall be identified by an item No./item tag no., which shall correspond to the item no. shown on the bill of materials. The bill of materials shall include items number, normal value, set value, range, quantity per unit, make and other specifications as applicable.
Legends adopted shall be indicated either at the bottom of drawing or on a separate drawing. The legends shall be as per ISA.

5.2.3.5 **Cross-sectional Drawing** (with Bill of Materials)
The vendor shall supply cross-sectional or assembly type drawings for all equipment furnished showing all parts, design assembly and running clearances, and balancing data required for erection and maintenance. Each part shall be numbered which shall correspond to the part number on the bill of materials. The bill of materials shall include the part no., name of component, materials quantity installed per unit & sizes where applicable (say for bolts, nuts, rings, gaskets etc.). All boughtout items shall also be indicated with make and brief specifications.
A separate cross-sectional drawing showing installation and setting dimensions for the seals shall be furnished.

5.2.4 **Performance Characteristic Curves**

5.2.4.1 The vendor shall provide complete performance curves to encompass the map of operations, with any limitations indicated thereon.

5.2.4.2 All curves submitted prior to final performance testing shall be marked "PREDICTED". Any set of curves resulting from a test shall be marked "TESTED".

5.2.4.3 Certified test curves and data shall be submitted within 15 days after testing and shall include head, power recalculated to the proper specific gravity and efficiency plotted against capacity. If applicable, viscosity corrections shall be indicated. If NPSHR test is specified, the water NPSHR curve (drawn upto minimum continuous flow) shall also be included. The curve sheet shall include the maximum and minimum diameters of the impeller design supplied, the eye area of the first stage impeller, the identification number of the impeller or impellers and the pump serial number.

5.2.5 **Data Sheet**

5.2.5.1 The Vendor shall provide completely filled in data sheets, first for "as purchased" and then for "as built". This shall be done by the vendor correcting and filling out the data sheets and submitting copies to the purchaser.

5.2.6 **Technical Data Manual/Mechanical Catalogues**

5.2.6.1 Technical Data Manual/Mechanical Catalogue is a compilation of "as built" drawings and data, manufacturing and test records, installation, operating and maintenance instructions.

5.2.6.2 Not later than two weeks after successful completion of all specified tests, the vendor shall

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furnish the required number of Technical Data Manual/Mechanical Catalogues for the equipment, any auxiliaries and instruments that the vendor is providing. The Technical Data Manual/Mechanical Catalogue shall include the following documents as a minimum:

i) All drawings and data as listed in the vendor data index & schedule. (For drawings, where purchaser's approval is required, the final certified drawings shall be attached.) Sections shall be organised in a manner that data & drawings related to one subject is grouped together such as Mechanical, Electrical, Instrumentation etc.

ii) All manufacturing, inspection and test data and records.

iii) Installation and Instruction Manual

The vendor shall provide sufficient written instructions, including a cross-reference list of all drawings, to enable the purchaser to correctly install the equipment and prepare the equipment for start-up. It shall include any special information required for proper installation that is not on the drawings, special alignment or grouting procedures, utility specifications (including quantity) and all installation data. It shall also contain the following information:

(a) Instructions for erecting, piping, aligning (including the expected thermally induced shaft centerline shift between normal site ambient temperature position and that at normal equipment operating temperature).

(b) A description of rigging procedures, including the lifting of the assembled equipment, and methods of disassembly, repair, adjustment, inspection and reassembly of the equipment and auxiliaries.

(c) Pre-commissioning/commissioning/functional test procedures and acceptance criterion.

iv) Operation and Maintenance Manual

This manual shall provide sufficient written instructions and data to enable purchaser to correctly operate and maintain the equipment ordered. It shall include a section to cover special instructions for operation at extreme environmental and/or extreme operating conditions. The following shall be included in this manual:

(a) Instructions covering start-up, normal shutdown, emergency shutdown, operating limits and routine operational procedures.

(b) A description of equipment construction features and the functioning of component parts or systems (such as control, lubrication, sealing systems etc.).

(c) Outline and sectional drawings, schematics and illustrative sketches in sufficient details to identify all parts and clearly show the operation of all equipment and components and the methods of inspection and repair. Standardised sectional drawings are acceptable only if they represent the actual construction of the equipment.

(d) The following maintenance information:

i. Maximum and minimum bearing, labyrinth and seal clearances including any other clearance between moving and stationary parts of the equipment affecting proper running and maintenance of the equipment.

ii. Instructions for measuring and adjusting cold clearances, shaft runout, concentricity etc.

iii. Rotor float allowance.

iv. Interference fits on parts that are required to be removed or replaced for maintenance of normally consumable spares.

v. Balancing data with permissible tolerances.

vi. Lubricating schedules indicating recommended grades of oil, their properties, replacement period etc.

vii. Normal maintenance procedure.

viii. Preventive maintenance schedules and criterion for replacement of parts.

ix. Trouble - shooting procedures.

(e) The following reassembly information:

i. Bolting sequence and torque values for all bolts affecting equipment

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performance/integrity/safety.

ii. Reassembly sequences together with required inspection checks.

iii. Adjustment procedures to achieve required positions, clearances, float and so forth.

iv. Detailed procedures for pre-operational checks, including settings and adjustments.

v. Seals and coupling installation procedures.

vi. Parts list indicating cross-sectional drawings of various assemblies and sub-assemblies, part numbers, materials of construction (ASTM) etc.to facilitate identification of parts and for procurement of spares.

v) Following information shall also be included in the Technical Data Manual/Mechanical Catalogue:

a) Storage instructions for storing and preserving the equipment (including driver and all the auxiliary units) at the plant site before installation of the same.

b) Instructions for preserving the equipment after it has been installed. This is particularly required in cases where a long time gap is expected between equipment installation and commissioning.

c) Field performance test procedures and acceptance criterion.

5.2.6.3 Technical Data Manual/Mechanical Catalogue shall be in Hard board folder(s) of size 265 mm x 315 mm (10½" x 12½") and shall not be more than 90 mm thickness; it may be of several volumes and each volume shall have a volume number, index of volumes & index of contents of that particular volume.

5.2.6.4 Title sheet (Top sheet) of each volume of Technical Data Manual/Mechanical Catalogue shall contain the contract information as defined under 5.2.1.2 besides the volume number.

5.2.6.5 In case order contains more than one item, separate dedicated mechanical catalogues shall be submitted for each item.

5.2.6.6 Final documentation shall be submitted in hard copy and soft (CDs/ DVDs) in addition to submission through EIL VDM portal. The number of prints and/or reproducible required to be submitted by vendor are specified in Purchaser's inquiry/order.

5.2.6.7 All post order documents shall be submitted / approved through EIL VDM portal.

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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
6.	15.10.2013	REVISED & ISSUED AS STANDARD SPECIFICATION	VB	HK	UAP/JMS	SC
5.	28.04.2010	REVISED & ISSUED AS STANDARD SPECIFICATION	HK	SA	NS/JMS	ND
4.	03.03.2005	REVISED & ISSUED AS STANDARD SPECIFICATION	RM	AKT	AAN	SKG

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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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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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

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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.

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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.

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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.

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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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अग्निरोधक नियंत्रण स्टेशन के लिए विनिर्देश

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

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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

Electrical Standards Committee

Convenor: Ms. Sumita Anand

Members:
Mr. Parag Gupta
Mr. M. K. Sahu
Ms. Arvind N. P. Singh
Mr. Harish Kumar
Ms. Shalini Verma
Mr. Raman Sood
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Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

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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.

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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

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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.

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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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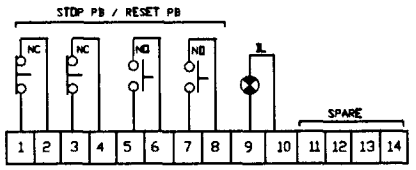
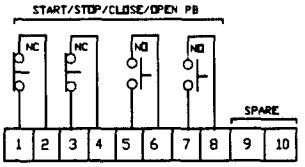
SKETCH-1

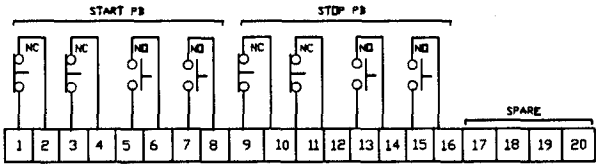
WIRING DETAILS OF LOCAL CONTROL STATIONS



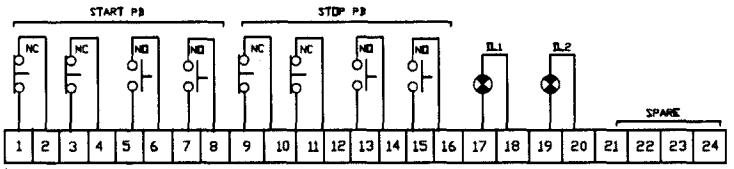
TYPE-A1 (STOP P.B. WITH LAMP)
OR
(RESET P.B. WITH LAMP)
(CABLE SIZE : 4Px2.5 Sq.mm)



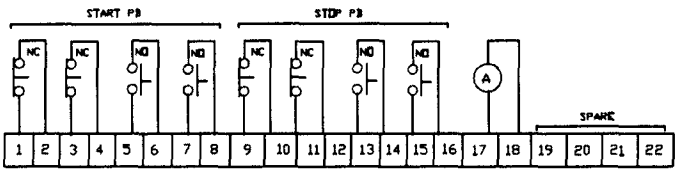
TYPE-A2
(START PB) OR (STOP PB) OR (CLOSE PB) OR (OPEN PB)
(CABLE SIZE : 2Px2.5 Sq.mm)



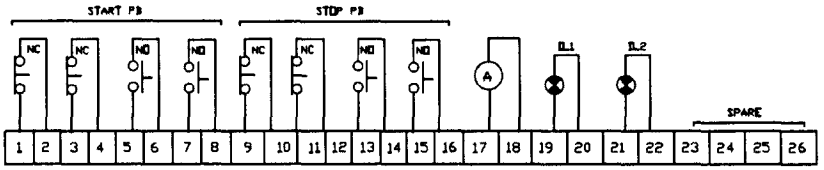
TYPE-B1 (WITH START & STOP PBs) OR (WITH CLOSE & OPEN PBs)
(CABLE SIZE : 4Px2.5 Sq.mm)



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)

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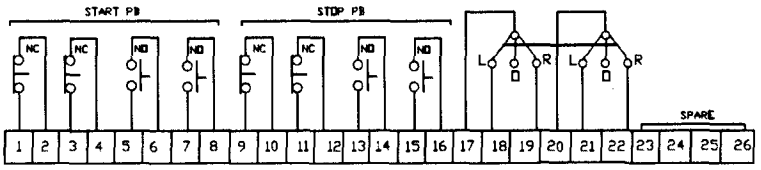
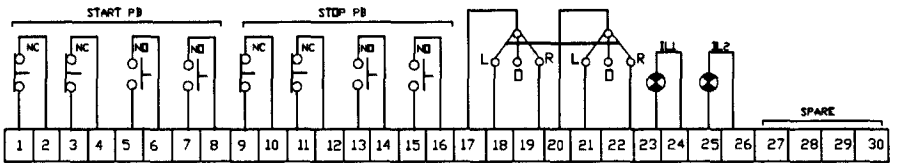
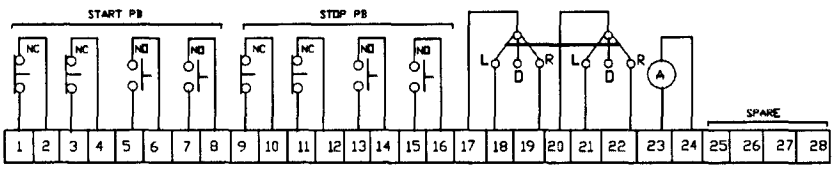


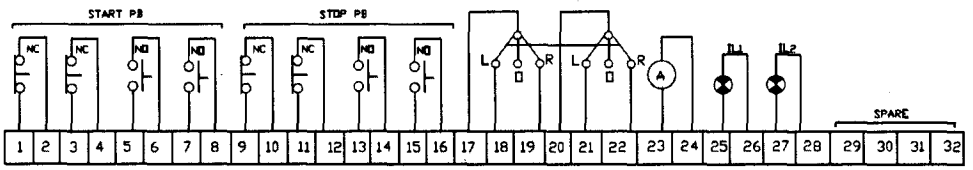
TYPE–D1 (WITH START & STOP PBs & L–O–R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm) (REFER NOTE–11)



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)

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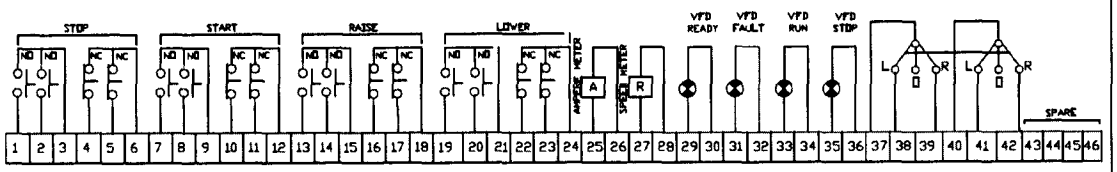
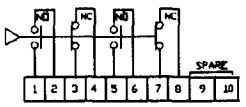
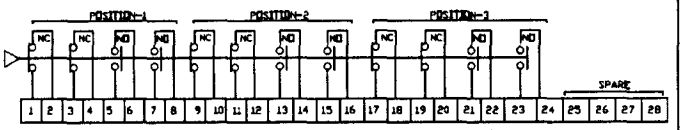


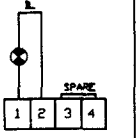
TYPE–F (WITH START & STOP PBs, RAISE & LOWER PBs, L–O–R SWITCH, AMPERE METER, SPEED METER & INDICATING LAMPS) (REFER NOTE–5,6,7)
(CABLE SIZE : 12Px2.5 Sq.mm)



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 SPECIFATION/TENDER.
9. LCS TYPE "I" ARE TYPICALLY FOR INSTRUMENTATION USE.
10. ALL PUSH BUTTON AND CONTROL SWITCH CONTACTS SHALL BE RATED FOR MINIMUM 5A 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.

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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	24.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

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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

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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.

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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.

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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

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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.

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पैकेज उपस्कर के निम्न वोल्टेज वाले फ़िक्स किस्म के स्विच बोर्ड के लिए विनिर्देश

SPECIFICATION
FOR
LV SWITCHBOARD FIXED TYPE
FOR PACKAGE EQUIPMENT

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	20.03.2025	REVISED AND REISSUED AS STANDARD SPECIFICATION	CA	SA	HK	MN
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

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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
CBCT	Core Balance Current Transformer
DC	Direct Current
DMPR	Digital Motor Protection Relay
DOL	Direct On Line
EIL	Engineers India Limited
ELR	Earth Leakage Relay
EPDM	Ethylene Propylene Diene Monomer
FRLS	Flame Retardant Low Smoke
HDPE	High-Density Polyethylene
HRC	High Rupture Capacity
Ics	Rated service short circuit current
Icu	Rated ultimate short circuit current
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
MFM	Multi-Function Meter
LV	Low Voltage
NO	Normally Open
NC	Normally Closed
PVC	Poly Vinyl Chloride
V	Volt
XLPE	Cross-linked polyethylene

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1.0 SCOPE

This specification covers the requirement of design, fabrication, testing, packing and supply of Low voltage fixed type switchboard in single front execution required for receipt, control and distribution of power to various low 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 : 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.

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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. The switchboard shall be completely type tested for the following tests (Short circuit, Temperature rise, Degree of Protection, Impulse withstand etc), as per IS/IEC standards. The switchboard shall also be completely Design Verified as per IS/IEC 61439-1 and Design Verification Report shall be submitted for the same.

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.

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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.

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5.22 The hot spot temperature of busbars, conductors including joints at design ambient temperature shall not exceed 130°C for Copper busbar and 120°C for Aluminium busbar. Temperature rise at all other locations shall be maintained in line with IS/IEC 61439.

5.23 Minimum clearance & creepage distances between live parts, between live parts/neutral to earth shall be as per IS/IEC 61439 for the selected material group and specified pollution degree.

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. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute.

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 upto and including 65 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.

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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/IE-4 type (as per job specification), 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/ IE-4 type (as per job specification) unless otherwise specified elsewhere. MCCB shall be suitable for Ics=Icu=100%.

6.8 For MCCB feeders other than those provided with DMPR or any other numerical relay, MCCBs shall be provided with a tripping device with inverse time characteristic for over load protection and instantaneous characteristics for short circuit protection and earth fault protection.

6.9 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 20.

6.10 All measuring AC instruments shall be moving iron, flush mounting type and of 72 x 72 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.

6.11 Multifunction meters/ Digital meters shall be provided, if specified in job specifications/datasheets. All MFM/ digital meters shall be highly reliable, accurate and compact. MFM/ Digital meter data shall be saved in case of power failure. Communicable type MFM/ Digital meter shall be provided if specified in datasheet/ job specification.

6.12 Digital motor protection relay shall be provided, if specified in job specifications/datasheets. All DMPR relay shall have Multi-Protection features like Motor protection (Overload, Overcurrent, Earth leakage Protection, Ground fault, Stalled Rotor, Loss of load, Phase unbalance, Negative phase sequence, Reverse connection), overcurrent, undercurrent & under voltage protection.

6.13 DMPR shall also have display and following features shall be provided in display like type of fault, three phase current, power, voltage, power factor and motor load (%) etc.

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6.14 CT ratio shall be settable in Digital MPR and communicable type DMPR shall be provided if specified in datasheet/ job specification.

6.15 CBCT with Earth Leakage Relay shall be provided if specified in job specifications/datasheets. ELR 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.

6.16 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.

6.17 Auxiliary relays/contactors shall generally be used for interlocking and multiplying contacts.

6.18 MCB shall have minimum breaking capacity of 9kA unless otherwise specified. Positive ON/OFF indication shall be provided.

6.19 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

6.20 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.

6.21 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.

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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.

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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

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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
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Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

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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).

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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.

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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.

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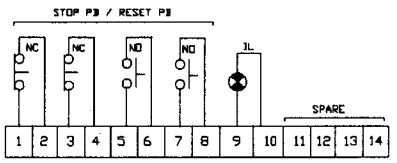
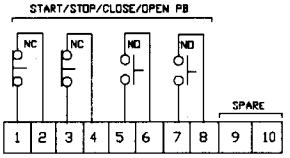
SKETCH–1

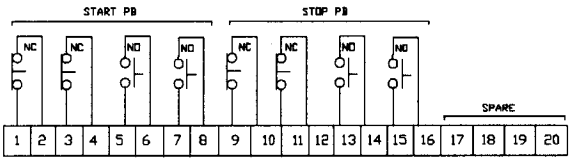
WIRING DETAILS OF CONTROL STATIONS



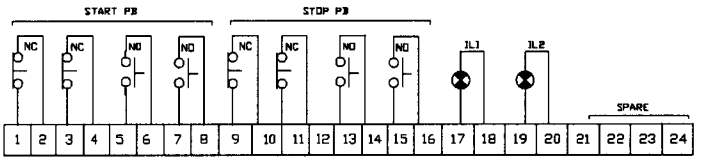
TYPE–A1 (STOP P.B. WITH LAMP)
OR
(RESET P.B. WITH LAMP)
(CABLE SIZE : 4Px2.5 Sq.mm)



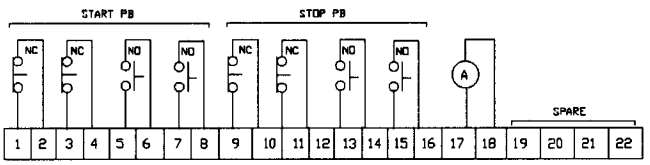
TYPE–A2
(START PB) OR (STOP PB) OR (CLOSE PB) OR (OPEN PB)
(CABLE SIZE : 2Px2.5 Sq.mm)



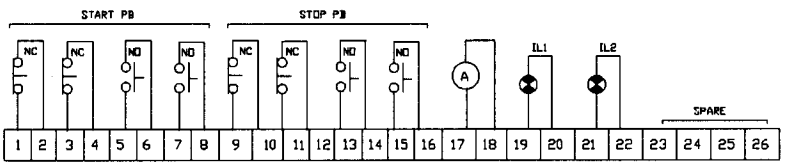
TYPE–B1 (WITH START & STOP PBs) OR (WITH CLOSE & OPEN PBs)
(CABLE SIZE : 4Px2.5 Sq.mm)



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)

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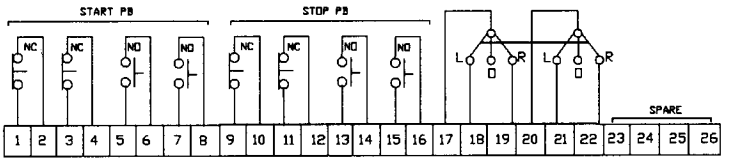
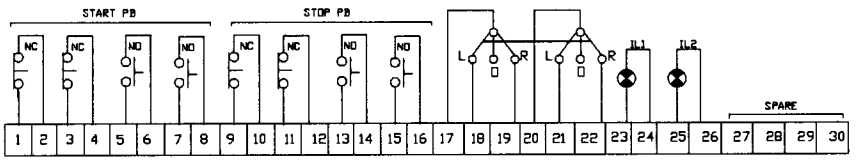
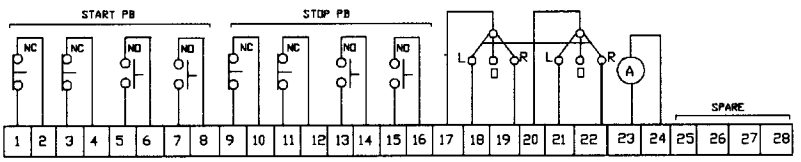


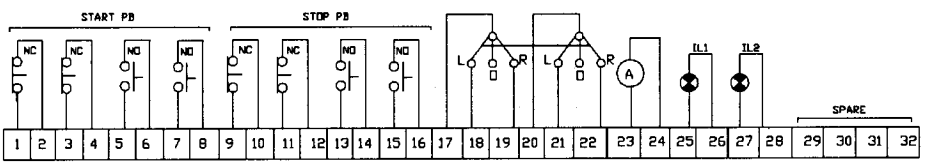
TYPE–D1 (WITH START & STOP PBs & L–O–R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm)



TYPE–D2 (WITH START & STOP PBs, L–O–R SELECTOR SWITCH & INDICATION LAMPS)
(CABLE SIZE : 12Px2.5 Sq.mm)



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)

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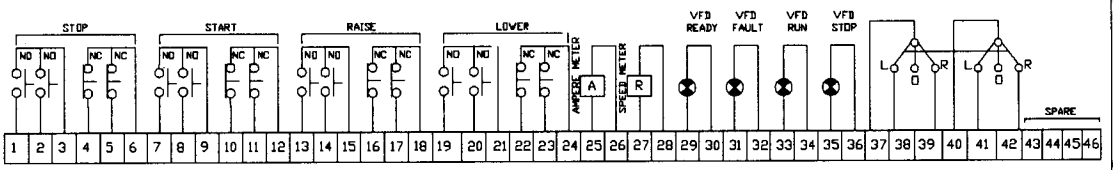
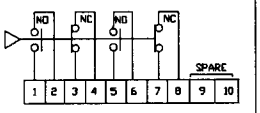
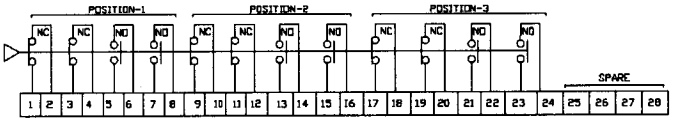


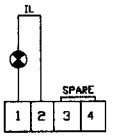
TYPE-F (WITH START & STOP PBs, RAISE & LOWER PBs, L-O-R SWITCH, AMPERE METER, SPEED METER & INDICATING LAMPS) (REFER NOTE-5,6,7)
(CABLE SIZE : 12Px2.5 Sq.mm)



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 5A AT 240V(AC-15) 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.

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अनइन्टरप्टेड पावर सप्लाई सिस्टम के लिए विनिर्देश

SPECIFICATION FOR UNINTERRUPTED POWER SUPPLY SYSTEM

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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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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.

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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

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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.

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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

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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

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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

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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.

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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-

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- 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

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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.

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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

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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.

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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.

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- 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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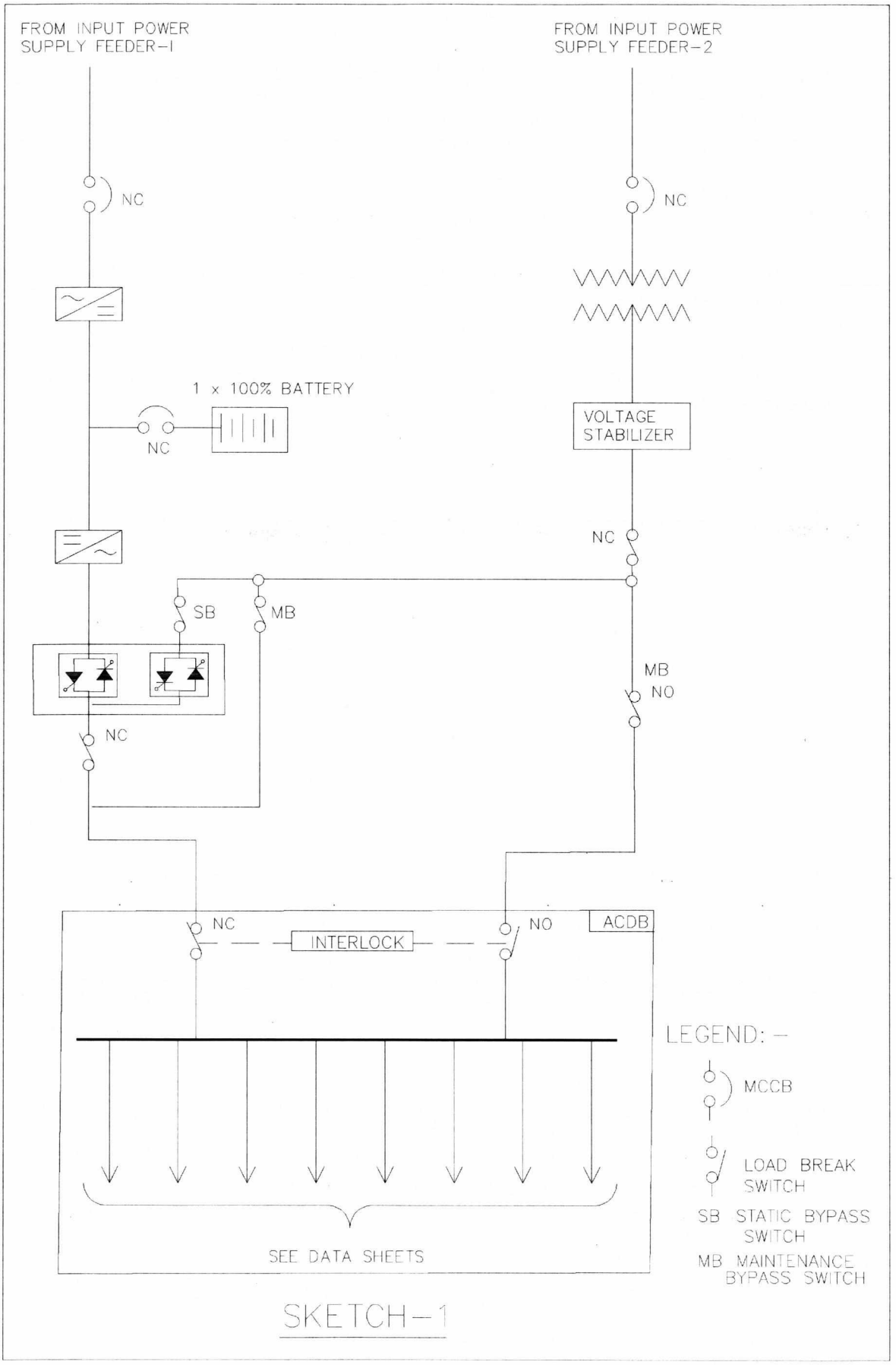

SKETCH-1

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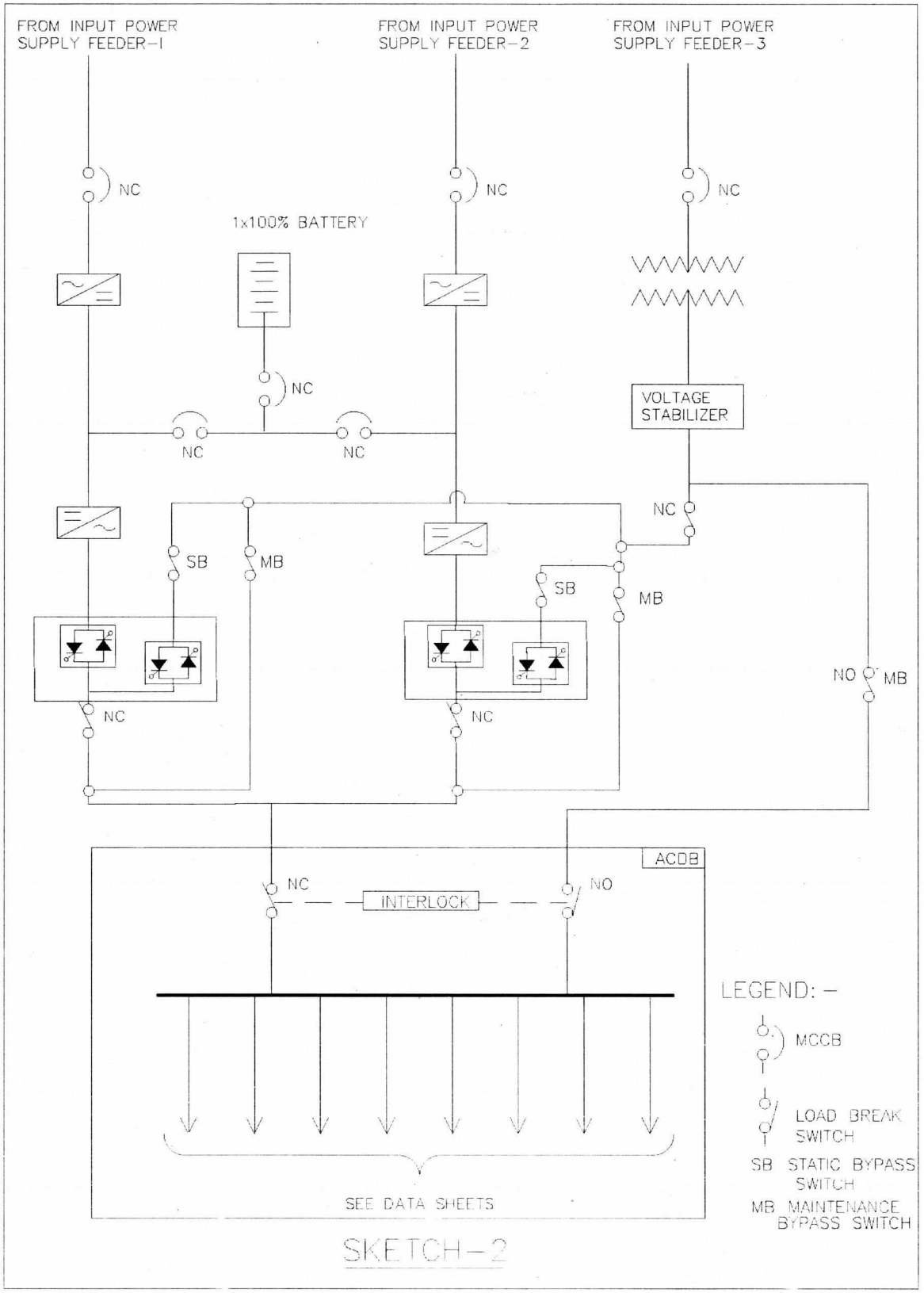

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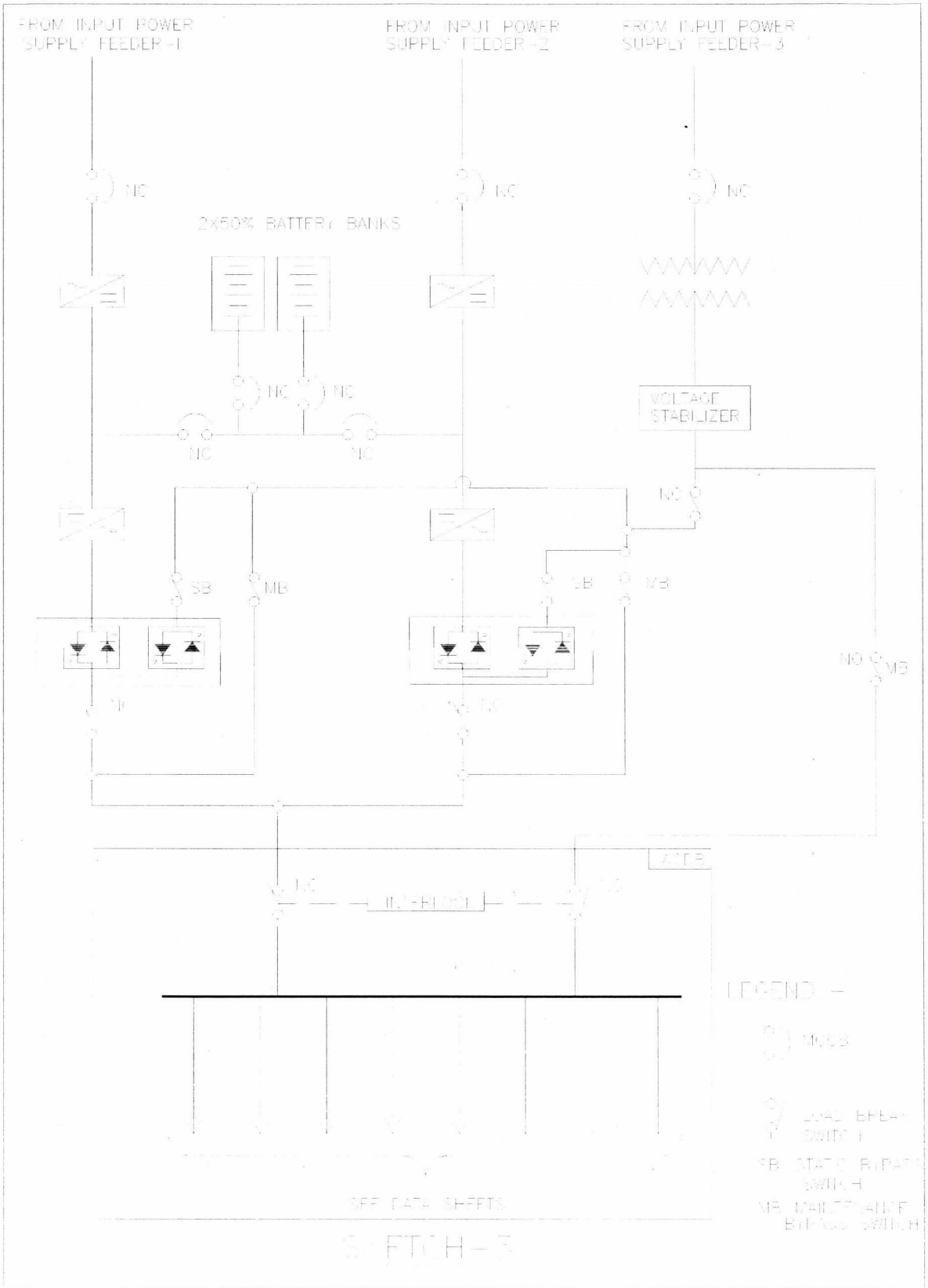

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निम्न वोल्टेज स्विच बोर्ड के लिए विनिर्देश

SPECIFICATION
FOR
LOW VOLTAGE SWITCHBOARD

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	20.03.2025	REVISED AND ISSUED AS STANDARD SPECIFICATION	CA	SA	HK	MN
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
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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

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Abbreviations:

A	:	Ampere	Icw	:	Rated short time withstand current
AC	:	Alternating Current	kA	:	kilo Amperes
ACB	:	Air Circuit Breaker	kVA	:	kilo Volt Ampere
ASB	:	Auxiliary Service Board	kW	:	kilo Watt
BIS	:	Bureau of Indian Standard	LDB	:	Lighting Distribution Board
CBCT	:	Core Balance Current Transformer	LED	:	Light Emitting Diode
			LOTO	:	Lock Out Tag Out
CEA	:	Central Electricity Authority	LV	:	Low Voltage
CPRI	:	Central Power Research Institute	mA	:	milli Ampere
			MCB	:	Miniature Circuit Breaker
CRCA	:	Cold Rolled Cold Annealed	MCC	:	Motor Control Center
CT	:	Current Transformer	MCCB	:	Moulded Case Circuit Breaker
DC	:	Direct Current	MFM	:	Multi-Function Meter
DMPR		Digital Motor Protection Relay	NC	:	Normally Closed
EIL	:	Engineers India Limited	NO	:	Normally Open
EPDM	:	Ethylene Propylene Diene Monomer	OTMS	:	Online Temperature Monitoring System
ELR	:	Earth Leakage Relay	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
iMCC	:	Intelligent Motor Control Center	V	:	Volt
IP	:	Ingress Protection	VA	:	Volt Ampere
IS	:	Indian Standard	XLPE	:	Cross Linked Poly Ethylene
Ics	:	Rated service short circuit current			
Icu	:	Rated ultimate short circuit current			

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1.0 SCOPE

1.1 This specification covers the requirements of design, manufacture, testing, packing and supply of fixed and draw out type low 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 1	:	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 TR 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.

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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 Low voltage switchboard shall be metal enclosed fully draw out or fixed, as specified in datasheet/ job specification, free standing, floor mounting, compartmentalized, 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 completely type tested for the following tests (Short circuit, Temperature rise, Degree of Protection, Internal Arc, Impulse withstand and breaker duty cycle etc), as per IS/IEC standards. The switchboard shall also be completely Design Verified as per IS/IEC 61439-1 and Design Verification Report shall be submitted for the same.

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.

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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.

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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 TR 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 TR 61641. However where the circuit is protected by a current limiting device, then duration shall be 0.2 second (minimum) as per IEC TR 61641. In addition to this, internal arc protection system shall also be provided if specified in job specification/ datasheet. Internal arc protection system shall be supplied complete along with requisite quantity of arc sensors and associated arc flash protection relay.

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 Switchboard shall be provided with online wired/ wireless temperature monitoring facility if specified in job specifications/datasheet. The passive sensor shall be battery less, dielectrically safe, robust to suitable 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.

5.31 If specified in job specification/ datasheet, all drawout modules shall be suitable for closed door operation i.e. Module racking operation should be possible with module door closed. The design shall be such that the degree of protection (IP) remains the same in all three positions of the feeder i.e. service, test and isolated.

5.32 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.

5.33 Auxiliary Bus Bars

5.33.1 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.

5.33.2 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.

5.33.3 Provision for hook up of external AC space heater/ DC control supply to be provided either in bus PT panel or bus coupler panel.

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5.34 Bus Bar

5.34.1 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.

5.34.2 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.

5.34.3 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.

5.34.4 Only zinc passivated or chromium plated high tensile strength steel bolts, nuts and washers shall be used for all bus bar joints and supports.

5.34.5 The hot spot temperature of busbars, conductors including joints at design ambient temperature shall not exceed 130°C for Copper busbar and 120°C for Aluminium busbar. Temperature rise at all other locations shall be maintained in line with IS/IEC 61439.

5.34.6 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.

5.34.7 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.

5.34.8 Minimum clearance & creepage distances between live parts, between live parts/neutral to earth shall be as per IS/IEC 61439 for the selected material group and specified pollution degree.

5.34.9 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.

5.35 Wiring and Terminals

5.35.1 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.

5.35.2 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.

5.35.3 Shorting links/suitable arrangement for shorting CT secondary shall be provided.

5.35.4 Each wire shall be identified at both ends by PVC ferrules.

5.35.5 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.

5.35.6 A minimum of 10% spare terminals shall be provided on each terminal block.

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5.35.7 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.

5.35.8 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).

5.36 Earthing

5.36.1 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.

5.36.2 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 for fault level upto and including 65 kA.

5.36.3 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.

5.36.4 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.

5.37 Nameplate

5.37.1 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.

5.37.2 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.

5.37.3 Blank nameplates shall be provided for all spare and vacant modules.

5.37.4 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.

5.37.5 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.

5.37.6 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.

5.38 Painting

5.38.1 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.

5.38.2 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.

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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.
- "Isolated" Position - both power and control circuits shall be disconnected in this position.

6.6.5 The circuit breaker shall be lockable in "service" and "test" positions. Safety shutters shall be provided when the breaker is in Isolated 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.

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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

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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. The requirement shall be complied for all feeders with remote start/ stop provision. In addition to that, resistor shall be provided in series of contactor to dissipate the residual capacitive voltage

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

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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/IE4 (as per job specification) 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.

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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.

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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/IE-4 motor as per job specification/ datasheet.

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 For MCCB feeders other than those provided with DMPR or any other numerical relay, MCCBs shall be provided with a tripping device with inverse time characteristic for over load protection and instantaneous characteristics for short circuit protection and earth fault protection.

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/IE4 type (as per job specification) 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 CBCT with Earth Leakage Relay shall be provided if specified in job specifications/datasheets. 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 [illegible] relays as required to avoid spurious tripping.

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