



**ANNEXURE- TECHNICAL QUALIFYING
CRITERION**

MCDERMOTT

EPCC-03 - 220KV GIS AND ASSOCIATED WORKS

Page 6 of 21

EXPERIENCE CRITERIA (TECHNICAL)

4.1 Technical Requirements for Bidders (Bidder shall meet the following qualification criteria):

4.1.1 The bidder shall be a manufacturer of Gas Insulated Switchboard with SF6 Circuit Breaker of rating 220 kV (minimum) and shall have successfully executed at least One (01) order of EHV indoor, double bus GIS (with single breaker/ one and half breaker/ double breaker execution) of voltage rating 220 kV or above with SF6 circuit breaker having minimum bus rating of 2000A, 50kA for 3 sec. and total 6 nos. of circuit breaker bays having same model of EHV GIS and SF6 circuit breaker as being offered, including design, detail engineering, procurement, supply, fabrication, construction/ construction management, installation, testing and commissioning in the last Twelve(12) years and the reference job must have completed a period of minimum one (1) year after commissioning **as on scheduled date of original technical bid opening.**

OR

~~**4.1.2** The bidder should have executed at least one EPC/EPCC/ LSTK Contract, having Supply, Construction/ construction management, installation, testing and commissioning of a Gas Insulated Switchboard with SF6 Circuit Breaker of rating 220 kV (minimum) and the bidder engages a GIS manufacturer as a subcontractor (hereinafter called a GIS manufacturer) for this job who has executed at least One (1) order for EHV indoor, double bus GIS (with single breaker/ one and half breaker/ double breaker execution) of voltage rating 220 kV or above with SF6 circuit breaker having minimum bus rating of 2000A, 50kA for 3 sec. and total 6 nos. of circuit breaker bays having same model of EHV GIS & SF6 circuit breaker as being offered, including design, detail engineering, procurement, supply, fabrication, along with either testing and commissioning or supervision of testing and commissioning. The reference EPC/LSTK job and GIS manufacturer reference job must have been completed and commissioned in the last Twelve (12) years and must have completed a period of minimum one (01) year after commissioning, ending on the last day of the month immediately preceding the month in which the last date of bid submission falls (in case of extended bid submission date, original bid submission date shall be considered).~~

~~**4.1.3** For above case of 4.1.2, the bidder along with the bid, shall submit Memorandum of Understanding (MoU) / Agreement and a clear scope / responsibility matrix (activity wise) with the GIS manufacturer to be engaged as sub-contractor based on the experiences mentioned in EHV GIS manufacturer qualifying reference, which shall be binding on the bidder, shall not to be changed thereafter and shall remain in force at least for 5 years or till the defect liability period whichever is later~~

~~The minimum scope of the bidder in MoU shall include but not limited to~~

~~i) Overall Project management,~~



NOTICE INVITING TENDER (NIT)

MCDERMOTT

EPCC-03 - 220KV GIS AND ASSOCIATED WORKS

Page 7 of 21

- ii) ~~Planning, monitoring, scheduling and reporting,~~
- iii) ~~Procurement of critical hardware,~~
- iv) ~~Participation in Progress review meeting~~
- v) ~~Commissioning.~~

~~The MOU / Agreement shall be converted into definite contract agreement between successful bidder & EHV GIS manufacturer after award of job and before signing of contract with IOCL which shall be done within one month from the date of award to EPC Contractor and this agreement must remain in force for at least 5 years or till the defect liability period whichever is later.~~

4.1.4 220 kV Gas Insulated Switchboard shall be supplied from the manufacturer's same unit/ works from which GIS switchboards meeting the criteria specified at 4.1.1 above have been supplied for the referenced jobs/ past projects.

4.2 The reference units provided by the bidder with respect to their experience as mentioned in Clause Nos. 4.1 above must be Non Captive units and bidder is required to declare the same upfront in the bid.

- a) In case of EPC/EPCC/LSTK contract Non Captive shall mean, other than units executed and completed for their own use, i.e., other than In-house units.
- b) Experience of any, Revamp of GIS System shall not be considered for qualification.

4.3 The unit(s) as referred in Clause Nos. 4.1 & 4.2 above, should have been commissioned and should have completed operation for at least one (1) year after commissioning, within the last 12 (Twelve) years ending on last day of the month immediately preceding the month in which bid due date falls, (in case of extended bid due date, original bid due date shall be considered).

4.4 In case bidder has executed contract(s) comprising of multiple process units/multiple facilities/installations (including associated offsite facilities/ utilities) under single contract, such contracts shall be considered as completed for the purpose of qualification provided all the units/facilities/ installations (including associated offsite facilities/ utilities) covered under the scope of the referred contract meets the criteria given in under Clause No.4.1.

4.5 In case bidder has executed contract(s) where the scope includes operation/ maintenance & maintenance/post warranty maintenance, the completion of only EPC/EPCC/LSTK portion of the scope shall be considered for the purpose of qualification in case that meets Clause Nos. 4.1 to 4.2.

4.6 GENERAL REQUIREMENTS

- I. For qualifying against the Technical experience criteria and Commercial Experience criteria, Bidder (Parent Company), bidding as Sole bidder, shall be allowed to use the credential of its Subsidiary Company (either fully owned or where the parent company has a controlling interest of over 50% of the equity shares and over 50% of voting rights of the given subsidiary company and controls the composition of Board of Directors of the Subsidiary company). However, it would be necessary for a bidder to show that it has the relevant experience either on its own or in the name of such subsidiary.
- II. Any agency who has offered services as a GIS manufacturer under clause no- 4.1.2 of BQC above, to any bidder shall not be permitted to participate either in an individual capacity as a sole bidder. However, the agency is not barred from offering services as a GIS manufacturer to more than one bidder.



NOTICE INVITING TENDER (NIT)

MCDERMOTT

EPCC-03 - 220KV GIS AND ASSOCIATED WORKS

Page 8 of 21

- III. The Bidder shall ensure submission of complete authentic information / documentation along with the Bid.
- IV. Wherever specific compliance to the relevant documentation from bidder in support of the criterion mentioned under Clause No. 4.0 is required post Bid submission, Owner/Consultant reserves the right to directly interact with the Bidder's Owner/Consultants to verify the relevant documentation and the Bidder will render assistance in facilitating that.
- V. Bidder shall also render assistance in facilitating visit to the reference unit, if so, considered necessary by Owner/Consultant. Cost of visit shall not be to the bidder's account.
- VI. If the bidder cites any reference of a job executed for IOCL or executed for some client through Consultant and the bidder is not able to furnish documentary evidence, the internal records of IOCL or CB&I (as the case may be) shall be considered.
- VII. In case bidder has executed a contract as an EPC/EPCC/LSTK contractor meeting the requirements under clause no. 4.1.2 of BQC as a leader of a consortium/ JV, the experience is acceptable for the purpose of qualification.
- VIII. In case bidder has executed a contract as an EPC/EPCC/LSTK contractor meeting the requirements under clause no. 4.1.2 of BQC as one of the members/ partners of a consortium/ JV, the experience is acceptable for the purpose of qualification provided the bidder has done at least project management for such reference contract.
- IX. Whenever a contractor had worked as a sub-contractor to main contractor, their experience also can be considered. With regard to Sub-Contracted work order, the bidder in addition to documents mentioned at clause no. 4.9.1 and 4.9.2 above has to submit a Certificate from the end user / Owner / Consultant of the Owner stating that the main contractor has intimated them about the engagement of sub-contracting OR have been allowed/ permitted as a sub-contractor.

COPYRIGHT & CONFIDENTIAL The information in this document is the property of BHARAT HEAVY ELECTRICALS LIMITED. This must not be used directly or indirectly in anyway detrimental to the interest of the company.	 BHARAT HEAVY ELECTRICALS LIMITED TRANSMISSION BUSINESS ENGINEERING MANAGEMENT NOIDA						
	DOCUMENT NO.	TB-PBTU-IOCL Panipat-GIS		Rev 00	Prepared	Checked	Approved
	TYPE OF DOC.	TECHNICAL SPECIFICATION		NAME	BY	DKS	VK
	TITLE 220kV Gas Insulated Switchgear (GIS) with its accessories			SIGN	-sd-	-sd-	-sd-
				DATE	15.07.2024	15.07.2024	15.07.2024
				GROUP	TBEM		
				WO No.			
	CUSTOMER	IOCL					
	PROJECT	Pre-Bid Tie up for, EPCC 03 Package 220KV GIS AND ASSOCIATED WORKS for Maleic Anhydride Project at Panipat Refinery Petrochemical Complex of M/s. Indian Oil Corporation Limited.					
	Contents						
	Section No.	Description				No of Pages	
	Section-1	Scope, Project Specific Technical Requirements & Bill of Quantities Annexure- BOQ_ IOCL				'--	
	Section-2	Equipment Specification under scope of Supplies				'--	
	Section-3	Project details and general technical requirements (For all equipment under the Project)				'--	
	Section-4	Annexures Annexure- A: Compliance Certificate to Technical Specification Annexure- B: Deviation/ Change Request to Technical Specification Annexure- C: Guaranteed Technical Particulars				'--	
Remarks: Bidder to note that data and details of Guaranteed Technical Particulars shall not be reviewed during Technical Evaluation/ Review, hence compliance of Guaranteed Technical Particulars in line with Technical Specification has to be ensured by the bidder.							
Rev. No.	Date	Altered	Checked	Approved			
Distribution				To			
				Copies			

SECTION 1: CHECKLIST FOR TECHNICAL EVALUATION

Along with the technical offer/ bids, the bidder should submit this checklist confirming the inclusion of the enclosures as listed below,

Sl. No.	Documents to be enclosed	Bidder to confirm (Please tick "Confirmed")
1.	Supporting documents for compliance of Technical Qualifying Requirement.	Confirmed
2.	Unpriced BOQ duly mentioning "Quoted" for all the items, signed and sealed.	Confirmed
3.	Annexure-A & B duly filled, signed and sealed.	Confirmed

Note: Any bidder not meeting the above requirement is liable for non-evaluation.
The above checklist is reviewed and verified for,

NIT Reference No.:

Name of Bidder:

Name of Project:

Date:

Bidder's Stamp & Signature

Contents

SECTION 1:.....	2
SCOPE, PROJECT SPECIFIC TECHNICAL REQUIREMENTS & BILL OF QUANTITIES.....	2
1. Scope.....	2
2. Codes & Standards.....	4
3. Specific Technical Requirements	4
4. Other General Requirements.....	6
5. Earthing of GIS	7
6. Modular Design & Future extensions	7
7. Maintenance and Repair of Circuit Breaker	9
8. Interchangeability & Future Extension	9
9. Bill of Quantities.....	10
10. Drawings / Documents required for Engineering Manufacturing Clearance	10
11. Type Testing	10
12. Quality Plan	11
13. Inspection & Testing.....	12
14. Field Testing & Commissioning	12
15. Makes of Equipment/ Components	12
16. Packing and Dispatch.....	12
17. Abbreviations Used	13
18. Definitions Used	14
19. List of Documents/ Drawings	14

SECTION 1:
SCOPE, PROJECT SPECIFIC TECHNICAL REQUIREMENTS & BILL OF QUANTITIES

1. Scope

This technical specification covers the requirements of design, engineering, fabrication, manufacturing, shop assembly, inspection and testing at manufacturer's works before supply, proper packing and delivery to project site, supervision of unloading & storage at site, and supervision of installation/ erection, site testing & commissioning, putting into successful operation complete with all materials, support structures, anchoring bolts, accessories, commissioning spares & maintenance spares, special spanners, tools & tackles, any specific required ancillary services, SF6 gas for first filling & spare etc. including training of Customer/ BHEL personnel for 220kV GIS with LCC & its Accessories complete in all respects for efficient & trouble-free operation mentioned under this specification.

Hence, the electrical scope of work under this requisition shall include but not be limited to basic and detailed engineering, as required, manufacturing, supply, transportation to site, inspection at manufacturer's work, supervision of installation, commissioning including site testing along with necessary equipment, training to Customer/ BHEL personnel, Insulation coordination studies, supply of all mandatory spares, commissioning spares, special tools and tackles as defined in the equipment datasheet, drawings, standard specifications, standards etc. attached or referred with technical specification.

This section covers the specific technical requirements of 220kV GIS with LCC & its Accessories. This constitutes minimum technical parameters for the above item as specified by the BHEL/ Customer. The offered 220kV GIS with LCC & its Accessories shall also comply with the Section-3 (Project Details and General technical requirements for all equipment under the Project) of this specification.

The specification comprises of following sections:

Section-1	:	Scope, Project Specific Technical Requirements & Bill of Quantities
Section-2	:	Equipment Specification under scope of Supplies
Section-3	:	Project Details & General Technical Requirements (For All Equipment under the Project)
Section-4	:	Annexures
		Annexure A- Compliance Certificate
		Annexure B- Schedule of Technical Deviations
		Annexure C- Guaranteed Technical Particulars

The following order of priority shall be followed. In case of conflict between requirements specified in various documents, the more stringent one shall be followed. BHEL/Customer concurrence shall, however, be obtained before taking a final decision in such matters.

1. Statutory Regulations

- In particular, the latest version of the following statutory regulations, as applicable, shall be followed for system,
- o Indian Electricity Act
 - o CEA regulations

- o The Factory Act
 - o The Petroleum Rules
 - o OISD standards
 - o Requirements of other statutory bodies as applicable, e.g. CEA, CCE, LPCB.
2. Section-1
 3. Section-2
 4. Section-3
 5. Codes & Standards

Bidder shall furnish list of conflicts/ ambiguities/ deviations, if any, along with their technical offer and also furnish the basis that is considered for submitting technical offer. BHEL/Customer will resolve listed conflicts prior to award. In case of ambiguity, bidder shall inform BHEL/Customer of their interpretation. In case bidder fails to convey the same prior to award, BHEL/ Customer decision on interpretation shall be considered final if need arises during the execution. No additional cost or extra time on account of conflicts/ ambiguities/ deviations shall be admissible.

The 220kV GIS being supplied shall be with double bus bar arrangement integrated LCC (Local control center). Due integration of outdoor 220 KV facilities and transformer system shall be in the bidder's scope. The scope includes supply of a minimum of following items also,

- (a) The incoming line bays will have Gas insulated bus duct/ cable connectivity with the overhead line.
- (b) The termination of incoming conductors with Gas Insulated Bus-duct shall be through proper AIS-GIS bushing complete with all accessories.
- (c) The connectivity of transformer bays with outdoor transformer shall also be through Gas insulated Bus-duct/ cable. The connectivity with GIB and Transformer HV bushing shall also be through proper AIS-GIS bushing system complete with all accessories. Any intermediate conductors or connectors required for GIB to Transformer connectivity shall also be in bidder's scope.

220KV GIS - 1 No., 220KV GIS, 2000A, 50KA (3 sec.) Double Bus bar Gas Insulated Switchgear with Local Control Cubicle. 220KV Gas Insulated switchgear to be placed in 220KV GIS building with required number of bays. GIS shall be provided with Online temperature monitoring system and Partial Discharge system.

GIS shall be designed in such a way that transfer from one bus isolator to another bus isolator shall be possible in energized condition without any break in supply to the loads.

In general, no deviation from the requirements specified in various clauses of this specification shall be allowed and hence, a certificate to this effect shall have to be furnished along with the offer (Annexure-B), however bidder shall furnish list of conflicts/ ambiguities/ deviations (Annexure-A), if any. Any conflicts/ ambiguities/ deviations mentioned elsewhere in technical offer shall not be reviewed.

The equipment is required for the following project:

Name of the Customer : **Indian Oil Corporation Limited (IOCL)**

Name of Consultant	: CB&I India Private Limited
Name of Main Contractor	: Bharat Heavy Electricals Limited
Name of the Project	: EPCC 03 Package 220KV GIS AND ASSOCIATED WORKS for Maleic Anhydride Project at Panipat Refinery Petrochemical Complex of M/s. Indian Oil Corporation Limited

The scope of supplies shall be as per commercial terms and conditions enclosed separately with the notice inviting tender/ enquiry.

2. Codes & Standards

The performance, testing and rating of the switchgear shall conform to the latest edition of the following IEC / IS publications,

IEC 60694	Common clauses for High Voltage Switchgear & Control Gear
IEC 62271-203	Gas Insulated metal-enclosed Switchgear for rated voltages above 52kV
IEC 62271-207	Seismic Qualification for Gas-insulated Switchgear Assemblies for rated voltages above 52kV
IEC 60376	New Sulphur Hexafluoride
IEC 62271-100	High Voltage Alternating Current Circuit Breakers
IEC 62271-1	Common Clauses for High Voltage Switchgear and Control-Gear Standards
IEC 62271-102	Alternating Current Disconnections (Isolators) and Earthing Switches
IEC 60044-1	Current Transformers
IEC 60044-2	Voltage Transformers
IEC 60137	Bushings for Alternating Voltages above 1000V
IEC 62271-209	Cable Connections for Gas-insulated Switchgear
IEC 60480	Guide to Checking of Sulphur Hexafluoride taken from Electrical Equipment
IEC 60099-1/4	Non-linear Resistor type Arresters for AC Systems
IEC 60439	Factory-built Assemblies of Low-voltage Switchgear and Control Gear.
IEEE 80 (2000)	IEEE Guide for Safety in AC Substation Grounding.
CIGRE-44	Earthing of GIS- An Application Guide. (Electra no. 151, Dec'93).
IEC 61639	Direct connection between Power Transformers and Gas-insulated metal-enclosed Switchgear for Rated Voltage 72.5kV and above

These are only indicative list and hence any other codes & standards, if applicable shall be complied by bidder.

3. Specific Technical Requirements

Specific technical requirements 220kV GIS with LCC & its Accessories shall be as follows,

Sl. No.	Technical Parameters	Unit	Particulars
	Type of GIS		Indoor Type, phase

			segregated/ phase encapsulated
	Installation		Indoor with outdoor GIB duct connection
	Meteorological data		
1.1	Design ambient temperature	°C	46.6
1.2	Site ambient temperature range: min. to max.	°C	(-)0.7 (min.), 46.6 (max.)
1.3	Altitude (above MSL)	Mtrs	< 1000 Mtrs
1.4	Relative humidity	%	95
1.5	Seismic zone	Zone	IV (IS - 1893)
1.6	Site environment		Tropical, humid and corrosive atmosphere
1.7	Location of installation		Indoor
1.8	Area classification		Unclassified safe
	Switchgear Design Data		
2.1	System voltage, frequency, phases	kV/ Hz/ Ø	220kV, 50 Hz, 3Ø
2.2	Voltage variation	%	±6
2.3	Frequency variation	%	±3
2.4	System grounding		Solidly earthed
2.5	Fault level	kA/ sec	50/3
2.6	Maximum Service Voltage	kV	245
2.7	Rated Insulation Level		
	- at power frequency 1 min	kV	460
	- at lightning impulse (1.2/50 µs wave)	kV	1050
2.8	Rated service current (min.)		
	- Bus bar		
	- Input Feeder bay		Refer SLD for 220kV GIS
	- Transformer bay		Refer SLD for 220kV GIS
	- Bus coupling bay		Refer SLD for 220kV GIS
	- Sectionalizer bay		Refer SLD for 220kV GIS
2.9	Rated short time withstand current (Symm.)		Refer SLD for 220kV GIS
	- Duration		Refer SLD for 220kV GIS
2.10	Internal fault withstand time without burn Through		as per IEC-62271-203
2.11	Temperature rise at rated service current (indicative)		
	- Conductor		°C as per IEC-60694
	- Enclosure		°C
2.12	Rated SF6 gauge pressure at 20°C		
	- Circuit breaker		as per standard
	- Switchgear		as per standard

2.13	Enclosure design pressure		
	- Circuit breaker		as per standard
	- Switchgear		as per standard
2.14	Leakage rate of SF6 per annum for the whole substation		< 0.5 %
2.15	Maximum partial discharge level		≤ 5 pC
2.16	Factory Dielectric routine test 50Hz		
2.17	Site dielectric test		
2.18	Painting of switchgear		
	- Coating design and execution		RAL as per detailed Specification/ Standard.
	- Top coat colour		RAL as per detailed Specification/ Standard.
2.19	Surface protection of steel frames		Hot-dip Galvanizing with Zinc with 610gm/ square meter
2.20	Degree of Protection		IP42

All current carrying components of the equipment specified shall be capable of continuous operation at the specified rated current without exceeding the maximum temperature rise specified in the relevant IEC standards. Thermal calculations shall be based on the climatic conditions mentioned elsewhere in specification.

4. Other General Requirements

Other general requirements 220kV GIS with LCC & its Accessories shall be as follows,

1. Storage shall be provided by BHEL/ its contractor. However, bidder shall provide their tentative space requirement for covered and/ or open store area during tender stage only. In addition to this, bidder shall submit their standard storage instruction manual specifically specifying the item detailed with details of type of storage.
2. Bidder shall submit list of consumables with shelf life of less than six months and same shall be dispatched just before the erection and only after specific clearance from BHEL/ Customer.
3. Project Site is located in petrochemical/ process industry, which is highly corrosive & abundance of hydrocarbon area. Hence, GIS should be compatible with above requirements during design, material selection and construction of GIS & its accessories and all equipment, accessories and wiring shall have tropical protection, involving special treatment of metal and insulation against fungus, insects and corrosion.
4. Packing of GIS & its accessories shall be suitable for long term storage without any deterioration in quality and performance (minimum 1 years, if required).
5. Bidder shall offer their latest type tested compact model to accommodate the specified & allocated space as per attached layout drawing of GIS. Bidder to note that if bidder fails to meet above requirement, its technical offer is liable for non-evaluation.
6. Bidder shall conduct insulation co-ordination studies in line with IEC:60071 for establishing surge arrester rating, quantity and any other requirement for successful operation of GIS.
7. Bidder shall be required to submit 3D OGA Drawing compatible with Primtech for complete GIS & its accessories.

8. Bidder shall check and ensure adequacy of system protection for successful operation of GIS. After checking of system by bidder, GIS shall be installed and if any failure, malfunction of any part occurs after/ during commissioning, same shall be replaced immediately without any extra cost.
9. The 220kV GIS building shall comprise an EOT (Electric overhead travel) crane of minimum capacity Ten (10) Ton or as per GIS OEM/ bidder recommendation, whichever is higher for lifting of any components of GIS switchgear EOT crane shall be provided for GIS. However, EOT crane for GIS is not envisaged in bidder's scope but bidder shall provide all the calculations basis for sizing of EOT crane during tender stage only. EOT cranes for GIS hall shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements & lifting assemblies for erection & maintenance of GIS equipment.
1. CT/VT parameters mentioned in CT VT parameter document is indicative only. Bidder has to ensure correctness of CT/VT sizing for GIS during contact stage / detailed Engineering stage.
2. Any change in bay pitch (distance between bays) as per civil requirement for during detailed engineering stage shall be incorporated by the bidder without any cost and delivery implication to BHEL.
3. Bidder shall include painting and marking of all buses, individual incomers, all outgoing feeders etc. with details such as tag no., feeder rating, sending end source reference etc. for all switchboards.
4. The GIS shall be designed in such a way that suitable walkways are provided all around the switchgears so that the operators will be able to have free access to all the operating mechanism.
5. The GIS Equipment shall be complete with all necessary supports, ladders, galleries, staircases, catwalks, movable platforms or walkways (for accessing the equipment above two meters for maintenance and operation), mechanism cabinets, internal cable raceways etc for each bay and it shall be of modular construction and extendable design. All structures, galleries, staircases and walkways shall conform to the relevant Occupational Safety and Health Administration (OSHA).
6. Special tools & tackles for installation and testing kits for testing & commissioning shall be in bidder's scope, however, it shall be brought at site on returnable basis only.
7. Bidder shall provide list of general tools, tackles, slings, spanners, gauges and other lifting devices, drills, instruments, testing kits and appliances necessary for the complete assembly, installation, gas filling, maintenance, site testing of the GIS, however, the same shall be arranged by BHEL.

5. Earthing of GIS

Bidder to submit detailed calculations and layout drawings for earthing system during detailed engineering stage based on technical specification Section-2 of technical specification, bidder's design philosophy, IS/IEC requirement as applicable. Bidder to provide the bill of quantity of entire items required for the earthing of the GIS. However, supply of 40mm MS ROD, 75X12/50x6mm GI Flat shall be done by BHEL. Any other earthing material, as per design/BOQ, shall be in bidder's scope of supply only. Erection of earthing will be done by BHEL team under the supervision of bidder/manufacturer, as per manufacturer's design.

6. Modular Design & Future extensions

1. The GIS switch gear shall be of modular design offering high degree of flexibility. Each module shall be complete with SF6 gas circuit breaker, disconnectors, Maintenance Grounding

- switches, fast Earthing switches, voltage transformers, Current transformers, bus & elbow sections, Gas Insulated Bus-duct, local control cubicle and all necessary components required for safe & reliable operation and maintenance.
2. The GIS shall be of either single-phase enclosure type or three-phase enclosure type for voltage levels of 220kV.
 3. In those design where bus bar is continuous, provision is to be made available for isolation of individual bay without disturbing adjacent bay.
 4. The switchgear shall be of the freestanding, self-supporting dead-front design, with all high-voltage equipment installed inside gas-insulated, metallic grounded enclosures, and suitably sub-divided into individual arc and gas proof compartments, preferably for:
 - (1) Bus bars
 - (2) Intermediate compartment
 - (3) Circuit breakers
 - (4) Line dis-connectors
 - (5) Voltage transformers
 - (6) Gas Insulated bus duct section between GIS and,
 - (7) Gas insulated bus section between GIS and oil filled transformer.
 - (8) Current Transformers.
 5. The bus enclosure shall be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus.
 6. Arc faults caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. In case of any internal arc fault in a busbar, busbar disconnector or circuit breaker, of double bus system, repair works must be possible without shutting down complete substation and at least one busbar and the undisturbed bays must remain in operation.
 7. The busbar system shall be sectionalized for each bay and contained in individual SF6 gas tight bus compartments to prevent contamination of the gas of the whole bus bar due to fault in one bay zone and refill lesser quantity of SF6 gas.
 8. Where bus Coupler is specified and in case of any internal arc fault in a busbar, busbar disconnector or sectionaliser, repair work must be possible without shutting down the complete substation and at least one half of the substation must remain in operation.
 9. Documents indicating sequence of repair work steps and description of necessary restrictions during work shall be submitted with the technical manual during as built drawing submission.
 10. Each bay module should be equipped with suitable arrangement for easy dismantling and refitting during maintenance without disturbing other units.
 11. Bus duct lengths shall be taken from the end of bay equipment (VT, LA etc.) to end equipment (SF6 to air bushing, SF6 to oil bushing/ connection etc.)
 12. Material clearance certificate shall be issued after demonstration of the functionality of maintenance equipment.
 13. Structure Materials for support of GIS, Bus Ducts, SF6 to oil bushing/ connection and SF6 to air bushing/ connection including Foundation Bolts, Embedded Items, Rails and/ or other items structural items required. All steel structure members shall be hot-dip galvanized after fabrication. Unless otherwise specified, minimum mass of zinc coating for Galvanizing shall be 610 gm/square meter. All field assembly joints shall be bolted. Field welding shall not be acceptable. Noncorrosive metal or plated steel shall be used for bolts and nuts throughout the

work. Manufacturer shall provide suitable foundation channels and anchor bolts to support the switchgear assemblies. All mounting bolts, nuts and washers shall be provided to fasten the switchgear base frames to the foundation channels.

7. Maintenance and Repair of Circuit Breaker

1. The positioning of the circuit breaker in the GIS shall be such that it shall be possible to access the circuit breaker of any feeder from the front side for routine inspection, maintenance and repair without interfering with the operation of the adjacent feeders.
2. The GIS shall be so designed that any component of the GIS can be removed easily. With minimum flexibility in the layout arrangement it shall be possible to remove the circuit breaker with both busbars remaining in service and it shall be possible to remove the disconnectors of the busbars, with one bus bar remaining in service. For achieving this requirement, adequate number of intermediate compartments, if required, shall be provided to ensure equipment & operating personnel's safety.
3. The bidder shall be required to demonstrate clearly in his submitted documents the suitability of the switchgear design in this respect. The arrangement shall be such that expansion of the original installation can be accomplished with minimum GIS down time.
4. In case of extension, the interface shall incorporate facilities for installation and testing of extension to limit the part of the existing GIS to be re-tested and to allow for connection to the existing GIS without further dielectric testing.
5. All the elements shall be accessible without removing support structures for routine inspections and possible repairs.

8. Interchangeability & Future Extension

1. As much as possible, all the parts shall be of standard manufacturer with similar parts and assemblies being interchangeable.
2. The GIS system shall be suitable for future extension on either end by the addition of extra feeders, bus couplers, bus-bars, circuit breakers, dis-connectors, and other switch gear components. The arrangement of gas sections or compartments shall be such as to facilitate future extension without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays
3. The layout shall ensure that GIS bus link section is provided for future extension of the GIS buses to avoid de-gassing and modification of the existing bus.
4. The physical layout shall ensure free movement of the SF6 Gas Cart and easy access to all components of the GIS for maintenance purposes.

9. Online Partial Discharge (PD) monitoring system for GIS, if applicable

The equipment shall be used for detecting different types of defects in Gas Insulated Switchgear (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.

It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect

partial discharges in cable joints and terminations.

Detection and measurement of PD and bouncing particles shall be displayed on provided HMI for the system and the measurement shall be stored in the PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc. Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed on the provided HMI by the contractor.

Measurement shall be possible in the charged substation/ switchyard in the presence of EMI/EMC

10. Bill of Quantities

Quantities for supply and services for 220kV GIS with LCC & its Accessories shall be as per Annexure- BOQ_IOCL. However, the scope broadly covers the following requirements,

11. Drawings / Documents required for Engineering Manufacturing Clearance

The drawings/ documents, as follows shall be used for providing technical clearance for manufacturing of GIS and furthermore, it shall be used for delay analysis, if any, from bidder. The first drawing submission will be counted from the date of submitting reasonably correct drawings.

Sl. No.	Overall Drawings approval required in Cat I /Cat II
1	220KV GIS- Gas Schematics with Single Line Diagram (Including CT VT Parameters)
2	220KV GIS- Guaranteed Technical Particulars (Including all GIS equipment
3	220KV GIS- Layout Plan & Section
4	220KV GIS- Interfacing Drawings for Cable Connection Module, SF6 to Air Bushing, SF6 to Oil Module with Guaranteed Technical Particulars
5	220KV GIS- Equipment Layout with Earthing philosophy
6	220KV GIS- Type Test Reports (Including all GIS equipment)
7	220KV GIS- Secondary Engineering Base Design
8	220KV GIS- Control Schematics for GIS and Local Control Cabinet
9	220KV GIS- Maintenance Equipment Catalogue with Guaranteed Technical Particulars
10	220KV GIS- Quality Assurance Plan & Inspection Test Schedule
11	220KV GIS- Civil Design Specification with Foundation Loading Diagram (Including interfacing details)
12	220KV GIS- Quantification for main Items, Spares, Consumables

12. Type Testing

Bidder shall ensure that 220kV GIS with LCC & its Accessories, being procured should have valid type test certificates as per specified in IEC standard 62271 – 203 & 62271-100 (amended up to date) at any ISO/IEC accredited laboratories.

Type test certificates shall not be more than fifteen (15) years old as on original scheduled date of technical bid opening. In those cases, where type test certificates are more than fifteen (15) years old from original scheduled date of technical bid opening, OEM/ bidder shall carry out the type

tests at any ISO/IEC accredited laboratories prior to dispatch of equipment with no commercial implication to BHEL/Customer.

In case any of Type tests have not been conducted on the offered design or there has been a change in the design after the type tests. The requisite tests shall be conducted by bidder on the offered design without any extra cost and delivery impact to BHEL/ Customer.

Type test should have been carried out as per relevant IEC standards at the type test must have been carried out at any ISO/IEC accredited laboratories. The following type test certificates, as specified in IEC standard 62271 – 203 & 62271-100 (amended up to date) shall be required for verification as evidence of successful completion of type tests.

1. Tests to verify the insulation level (Lightning impulse, switching impulse and ac withstand test with PD) test on each GIS device (CB, Disconnecter, bus, etc).
2. Dielectric tests on auxiliary circuits.
3. Tests to prove the radio interference voltage (RIV) level.
4. Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit.
5. Tests to prove the ability of the main and earthing circuits to carry the rated peak and the rated short time withstand current.
6. Tests to verify the making and breaking capacity of the included switching devices.
7. Tests to prove the satisfactory operation of the included switching devices.
8. Tests to prove the strength of enclosures.
9. Verification of the degree of protection of the enclosure.
10. Gas tightness tests
11. Electromagnetic compatibility tests (EMC).
12. Additional tests on auxiliary and control circuits.
13. Tests on partitions.
14. Tests to prove the satisfactory operation at limit temperatures.
15. Tests to prove performance under thermal cycling and gas tightness tests on insulators.
16. Corrosion test on earthing connections (if applicable).
17. Tests to assess the effects of arcing due to an internal fault.
18. Tests on solid dielectric components (operating rods, spacers, etc)
19. Seismic test
20. Test on Auxiliary switches (Electrical & Mechanical Endurance, Heat run, IR & HV test)

13. Quality Plan

The successful bidder shall submit Quality Assurance Plan for major components such as breakers, disconnecting switches, lightning arrestors, earth switches, etc. with in-process inspection methods, tests, records, etc. for BHEL/ Customer approval. Customer hold points will also be included in the plan, which shall be mutually agreed by the BHEL/ Customer and Bidder and approved. In case bidder has reference Quality Assurance Plan agreed with BHEL/Customer, same shall be submitted for specific project to BHEL/ Customer approval. There shall be no commercial implication to BHEL/ Customer on account of Quality Plan approval.

Superior quality control system shall be adopted to assure high product quality. Raw materials of

the best commercial grade quality and high reliability shall be used in the manufacture of GIS. High reliability of materials shall be ensured so as to keep maintenance work to a minimum. All materials shall be procured, manufactured, inspected and tested by vendor/ sub-vendor as per approved quality plan. The supplier shall perform all tests necessary to ensure that the material and workmanship conform to the relevant standards and comply with the requirements of the specification. Charges for all these tests for all the equipment & components shall be deemed to be included in bidder's scope.

14. Inspection & Testing

1. GIS and its associated materials shall be subject to inspection by BHEL/ Customer or authorized representative at bidder/manufacturers' works. Hence, Bidder shall furnish all necessary information concerning the supply to BHEL/ Customer.
2. During fabrication, the equipment shall be subject to inspection by BHEL/ Customer or by an agency authorized by BHEL/ Customer to assess the progress of work as well as to ascertain that only quality raw material is used.
3. Bidder shall ensure that the hazardous area equipment provided shall have the necessary test certificates and valid CCOE approval certificates.
4. Bidder shall also furnish factory acceptance test (FAT) from manufacturers for BHEL/ customer approval in line with specific requirements mentioned in Section-2.

15. Field Testing & Commissioning

1. Bidder shall carry out the supervision of installation, field testing and commissioning of 220kV GIS with LCC & its Accessories. Further appropriate test and commissioning reports and as-built documentation as necessary be submitted.
2. Field testing and commissioning of 220kV GIS with LCC & its Accessories shall be done by Bidder/OEM only.
3. Bidder shall also submit site acceptance testing (SAT) procedures and get them approved from BHEL/ Customer before carrying out the site testing at site.
4. All switchboard protection shall be subject to primary injection test before commissioning.
5. Bidder/ OEM shall coordinate with manufacturers of other equipment wherever required and shall freely and readily supply all technical information for this purpose as and when called for.
6. All electrical equipment shall be said to be installed and mechanically complete after circuit testing, primary and secondary injection testing and loop simulation is complete. Due care and consideration shall be given to the installation of 220kV GIS with LCC & its Accessories.

16. Makes of Equipment/ Components

Bidder/ vendor while ordering shall ensure the availability of spare parts and maintenance support services for the offered equipment at least for 15 years from the date of supply. Bidder/ OEM shall give a notice of at least one year to the BHEL/ Customer before phasing out the products/spares to enable the owner for placement of order for spares and services.

17. Packing and Dispatch

1. The equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and for any damage during transportation, transit and storage. Packing of the equipment shall be suitable for long storage (minimum 1

- year).
2. The SF6 equipment shall be shipped in the largest factory assembled units within transport and loading limitations and considering handling facilities on site to reduce the erection and installation work on site to a minimum. Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner.
 3. Each individual piece to be shipped, whether crate, container or large unit, shall be marked special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., and other details as per purchase order.
 4. 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.
 5. Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment.
 6. All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided. Any seals, gaskets, 'O' rings, etc. that will be used as part of the arrangement for sealing off gas sections for shipment of site, shall not be used in the final installation of the equipment at site. Vendor to provide quantity of components accordingly considering permanent installation and commissioning.

18. Abbreviations Used

The following terminology/ acronym hereunder and elsewhere in the technical specification used and their grammatical variations shall unless repugnant to the subject or context thereof, have the following full form hereunder respectively assigned to them, namely,

GIS:	Gas Insulated Switchgear
LCC:	Local Control Centre
CT:	Current Transformer
DC:	Direct Current
HV:	High Voltage
EHV:	Extra High Voltage
kV:	Kilovolt
Hz:	Hertz
IP:	Ingress Protection
SAT:	Site Acceptance Testing
CCOE:	Chief Controller of Explosives
OEM:	Original Equipment Manufacturer
ANSI:	American National Standards Institute
ASTM:	American Society for Testing and Materials
BIS:	Bureau of Indian Standards
BS:	British Standard
IEC:	International Electro Technical Commission

IEEE:	Institute of Electrical & Electronics Engineers
IS:	Indian Standards
NEMA:	National Electrical Manufactures Association
CEA:	Central Electricity Authority
DIN:	Deutsches Institiut fur Normung
CCE:	Continuous and Comprehensive Evaluation
LPCB:	Loss Prevention Certification Board
BHEL:	Bharat Heavy Electricals Limited
OISD:	Oil Industry Safety Directorate
IOCL:	Indian Oil Corporation Limited
LSTK:	Lump sum Turnkey
QAP:	Quality Assurance Plan
BOQ:	Bill of Quantities

19. Definitions Used

The following expressions hereunder and elsewhere in the technical specification used and their grammatical variations shall unless repugnant to the subject or context thereof, have the following meanings hereunder respectively assigned to them, namely:

2. Bid/Bidding Documents: The totality of the documents comprising the Bidding Document for the notice inviting tender.
3. Contract: The totality of agreement between Customer/ Purchaser/ Owner/IOCL and the Contractor/ LSTK Contractor/ BHEL as derived from the contract documents.
4. Contractor/ LSTK contractor: The bidder selected by the Customer/ Purchaser/ Owner/IOCL for the performance of the work and supply of materials. In this case, it is BHEL.
5. Customer/ Purchaser/ Owner: Indian Oil Corporation Limited.
6. Consultant: Any person(s)/ Firm nominated/ assigned by the Contractor/ LSTK Contractor/ BHEL for providing the engineering consultant services. In this case, it is CB&I INDIA PRIVATE LIMITED.
7. Bidder/ vendor: The bidder selected for this intended work shall be known as vendor.

20. List of Documents/ Drawings

1. As attached.

Sl. No.	Item Description	Unit	Qty.	Remarks
1.0	SUPPLY- GIS: 220KV, 50KA FOR 3S, GAS INSULATED SWITCHGEAR (GIS) AS PER TS (Two/ Double bus scheme)			
1.01	GIS SUPPLY: 220KV, 2000A, 50kA, SF6 GIS BUS BAR MODULE (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS) AS PER TS	SET	4	
1.02	GIS SUPPLY: 220KV, 50kA, SF6 BUS PT/ VT BAY MODULE WITH BUS EARTH SWITCH (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS) AS PER TS	SET	4	220kV PT/ VT BAY MODULE shall include following but not limited to, (a) 1 SET- 1 NO x3 phase Disconnecter, complete with operating mechanism. (b) 1 SET- 1 NO x3 phase Maintenance Grounding Switch, complete with operating mechanism (c) 1 SET- 1 NO x3 phase High Speed make proof Earthing Switch, complete with operating mechanism. (d) 3 NO- 1 phase multi winding Voltage Transformer In addition to above, Gas device, UHF sensors, Pressure Switches, Expansion joints/ Flexible connections, Insulators etc. as applicable shall be included, however, Online PD Monitoring System, Local Control Cubicle and End Terminations, if applicable shall be covered separately. GIS shall be complete with all necessary terminal boxes, inspection windows, SF6 gas, grounding connection, pipings for gas monitoring system, trays, support structures with mounting hardware, walkways, interconnecting cables with glands, ferrules, lugs etc. 220kV INCOMING GIS LINE FEEDER BAY MODULE shall include following but not limited to, (a) 1 SET- 1 NO x3 phase Circuit Breaker, compatible for Controlled Switching Facility (if applicable), complete with operating mechanism (b) 3 SET- 1 NO x3 phase Disconnecter, complete with operating mechanism. (c) 2 SET- 1 NO x3 phase Maintenance Grounding Switch, complete with operating mechanism. (d) 1 SET- 1 NO x3 phase High Speed make proof Earthing Switch, complete with operating mechanism. (e) 6 NO- 1 phase multi ratio Current Transformer In addition to above, Gas device, UHF sensors, Pressure Switches, Expansion joints/ Flexible connections, Insulators etc. as applicable, however, Controlled Switching Device (CSD), Online PD Monitoring System, Local Control Cubicle and End Terminations, if applicable shall be covered separately. GIS shall be complete with all necessary terminal boxes, inspection windows, SF6 gas, grounding connection, pipings for gas monitoring system, trays, support structures with mounting hardware, walkways, interconnecting cables with glands, ferrules, lugs etc. Please refer section-2 (TS for 220kV GIS)- Technical Specification
1.03	GIS BAY SUPPLY: 220kV, 2000A, 50 kA, SF6 INCOMING GIS LINE FEEDER BAY MODULE (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS) AS PER TS	SET	2	220kV GIS BUS COUPLER BAY MODULE shall include following but not limited to, (a) 1 SET- 1 NO x3 phase Circuit Breaker, compatible for Controlled Switching Facility (if applicable), complete with operating mechanism (b) 2 SET- 1 NO x3 phase Disconnecter, complete with operating mechanism. (c) 2 SET- 1 NO x3 phase Maintenance Grounding Switch, complete with operating mechanism. (d) 6 NO- 1 phase multi ratio Current Transformer In addition to above, Gas device, UHF sensors, Pressure Switches, Expansion joints/ Flexible connections, Insulators etc. as applicable, however, Controlled Switching Device (CSD), Online PD Monitoring System (OPMS), Local Control Cubicle (LCC) and End Terminations, if applicable shall be covered separately. GIS shall be complete with all necessary terminal boxes, inspection windows, SF6 gas, grounding connection, pipings for gas monitoring system, trays, support structures with mounting hardware, walkways, interconnecting cables with glands, ferrules, lugs etc. Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.04	GIS BAY SUPPLY: 220kV, 2000A, 50kA, SF6 GIS BUS COUPLER BAY MODULE (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS) AS PER TS	SET	2	220kV GIS BUS SECTIONALIZAER BAY MODULE shall include following but not limited to, (a) 1 SET- 1 NO x3 phase Circuit Breaker, compatible for Controlled Switching Facility (if applicable), complete with operating mechanism (b) 2 SET- 1 NO x3 phase Disconnecter, complete with operating mechanism. (c) 2 SET- 1 NO x3 phase Maintenance Grounding Switch, complete with operating mechanism. (d) 6 NO- 1 phase multi ratio Current Transformer In addition to above, Gas device, UHF sensors, Pressure Switches, Expansion joints/ Flexible connections, Insulators etc. as applicable, however, Controlled Switching Device (CSD), Online PD Monitoring System (OPMS), Local Control Cubicle (LCC) and End Terminations, if applicable shall be covered separately. GIS shall be complete with all necessary terminal boxes, inspection windows, SF6 gas, grounding connection, pipings for gas monitoring system, trays, support structures with mounting hardware, walkways, interconnecting cables with glands, ferrules, lugs etc. Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.05	GIS BAY SUPPLY: 220kV, 2000A, 50kA, SF6 GIS BUS SECTIONALISER BAY MODULE (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS) AS PER TS	SET	2	220kV GIS BUS SECTIONALIZAER BAY MODULE shall include following but not limited to, (a) 1 SET- 1 NO x3 phase Circuit Breaker, compatible for Controlled Switching Facility (if applicable), complete with operating mechanism (b) 2 SET- 1 NO x3 phase Disconnecter, complete with operating mechanism. (c) 2 SET- 1 NO x3 phase Maintenance Grounding Switch, complete with operating mechanism. (d) 6 NO- 1 phase multi ratio Current Transformer In addition to above, Gas device, UHF sensors, Pressure Switches, Expansion joints/ Flexible connections, Insulators etc. as applicable, however, Controlled Switching Device (CSD), Online PD Monitoring System (OPMS), Local Control Cubicle (LCC) and End Terminations, if applicable shall be covered separately. GIS shall be complete with all necessary terminal boxes, inspection windows, SF6 gas, grounding connection, pipings for gas monitoring system, trays, support structures with mounting hardware, walkways, interconnecting cables with glands, ferrules, lugs etc. Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.06	GIS BAY SUPPLY: 220kV, 2000A, 50 kA, SF6 OUTGOING GIS TRANSFORMER FEEDER BAY MODULE (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS) AS PER TS	SET	8	220kV GIS LINE FEEDER BAY MODULE shall include following but not limited to, (a) 1 SET- 1 NO x3 phase Circuit Breaker, compatible for Controlled Switching Facility (if applicable), complete with operating mechanism (b) 3 SET- 1 NO x3 phase Disconnecter, complete with operating mechanism. (c) 2 SET- 1 NO x3 phase Maintenance Grounding Switch, complete with operating mechanism. (d) 1 SET- 1 NO x3 phase High Speed make proof Earthing Switch, complete with operating mechanism. (e) 6 NO- 1 phase multi ratio Current Transformer In addition to above, Gas device, UHF sensors, Pressure Switches, Expansion joints/ Flexible connections, Insulators etc. as applicable, however, Controlled Switching Device (CSD), Online PD Monitoring System, Local Control Cubicle and End Terminations, if applicable shall be covered separately. GIS shall be complete with all necessary terminal boxes, inspection windows, SF6 gas, grounding connection, pipings for gas monitoring system, trays, support structures with mounting hardware, walkways, interconnecting cables with glands, ferrules, lugs etc. Please refer section-2 (TS for 220kV GIS)- Technical Specification.

Sl. No.	Item Description	Unit	Qty.	Remarks
1.07	GIS BAY SUPPLY: 220kV, 2000A, 50kA, SF6 OUTGOING GIS SPARE FEEDER BAY (FULLY EQUIPPED) MODULE (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS) AS PER TS	SET	2	220kV OUTGOING GIS SPARE FEEDER BAY MODULE shall include following but not limited to, (a) 1 SET- 1 NO x3 phase Circuit Breaker, compatible for Controlled Switching Facility (if applicable), complete with operating mechanism (b) 3 SET- 1 NO x3 phase Disconnector, complete with operating mechanism. (c) 2 SET- 1 NO x3 phase Maintenance Grounding Switch, complete with operating mechanism. (d) 1 SET- 1 NO x3 phase High Speed make proof Earthing Switch, complete with operating mechanism. (e) 6 NO- 1 phase multi ratio Current Transformer In addition to above, Gas device, UHF sensors, Pressure Switches, Expansion joints/ Flexible connections, Insulators etc. as applicable, however, Controlled Switching Device (CSD), Online PD Monitoring System, Local Control Cubicle and End Terminations, if applicable shall be covered separately. GIS shall be complete with all necessary terminal boxes, inspection windows, SF6 gas, grounding connection, pipings for gas monitoring system, trays, support structures with mounting hardware, walkways, interconnecting cables with glands, ferrules, lugs etc. <u>Please refer section-2 (TS for 220kV GIS)- Technical Specification</u>
1.08	GIS BAY SUPPLY: ONLINE TEMPERATURE MONITORING & PARTIAL DISCHARGE SYSTEM	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.09	GIS SUPPLY: 220KV, CONTROLLED SWITCHING DEVICE (CSD) FOR 220KV, 3- PH CIRCUIT BREAKER	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.10	SUPPLY- GIS : 220KV, 2000A, 1 PHASE GAS INSULATED BUS DUCT (INCLUDING SF6 GAS, STRUCTURE WITH HARDWARES AND EARTHING MATERIALS)	MTRS	800	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.11	GIS SUPPLY: 220KV, 2000A, 1 PHASE SF6 TO AIR BUSHING (POLYMER) (INCLUDING SF6 GAS, STRUCTURE WITH HARDWARES AND EARTHING MATERIALS)	NO	6	Please refer section-2 (TS for 220kV GIS)- Technical Specification. It is considered for INCOMING BAYS only.
1.12	GIS SUPPLY: 390KV, 1 PHASE SURGE ARRESTER WITH SURGE COUNTER (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS)	NO	42	Please refer section-2 (TS for 220kV GIS)- Technical Specification. It is considered for ALL OUTGOING BAYS & BUS BAR MODULE only.
1.13	GIS SUPPLY: 220KV, 2000A, 1 PHASE SF6 TO OIL BUSHING (POLYMER) (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS)	NO	30	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.14	GIS SUPPLY: 220KV, 1 PHASE VOLTAGE TRANSFORMER (INCLUDING SF6 GAS, STRUCTURE, HARDWARES & EARTHING MATERIALS)	NO	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
1.15	GIS SUPPLY: LOCAL CONTROL CUBICLES	SET	16	Please refer section-2 (TS for 220kV GIS)- Technical Specification. It is considered for ALL BAYS only.
2.0	SUPPLY- GIS: SPECIAL TOOLS AND TESTING & MAINTENANCE INSTRUMENTS AS PER TS			
2.01	GIS SUPPLY: SF6 GAS LEAKAGE DETECTOR	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
2.02	GIS SUPPLY: SF6 GAS FILLING AND EVACUATING PLANT	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
2.03	GIS SUPPLY: SF6 GAS ANALYSER	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
2.04	GIS SUPPLY: PORTABLE PARTIAL DISCHARGE MEASUREMENT SET	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
2.05	GIS SUPPLY: SF6 TOPPING SYSTEM	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
2.06	GIS SUPPLY: SF6 GAS HANDLING PLANT/ SERVICE CART	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
2.07	GIS SUPPLY: PORTABLE LADDER WITH ADJUSTABLE HEIGHT	SET	1	Please refer section-2 (TS for 220kV GIS)- Technical Specification.
3	SPARES- GIS: 220KV, 50KA FOR 3S, GAS INSULATED SWITCHGEAR (GIS) AS PER TS			
3.01	GIS SPARES: NUMERICAL RELAYS	NO.	2	Each type and rating
3.02	GIS SPARES: CT/ PT/ CONMTROL TRANSFORMER (ALL TYPES AND RATINGS)	NO.	3	Each type and rating
3.03	GIS SPARES: POWER & CONTROL FUSES	NO.	10	Each rating
3.04	GIS SPARES: SF6 GAS LEAKAGE DETECTOR	SET	1	Each type and rating

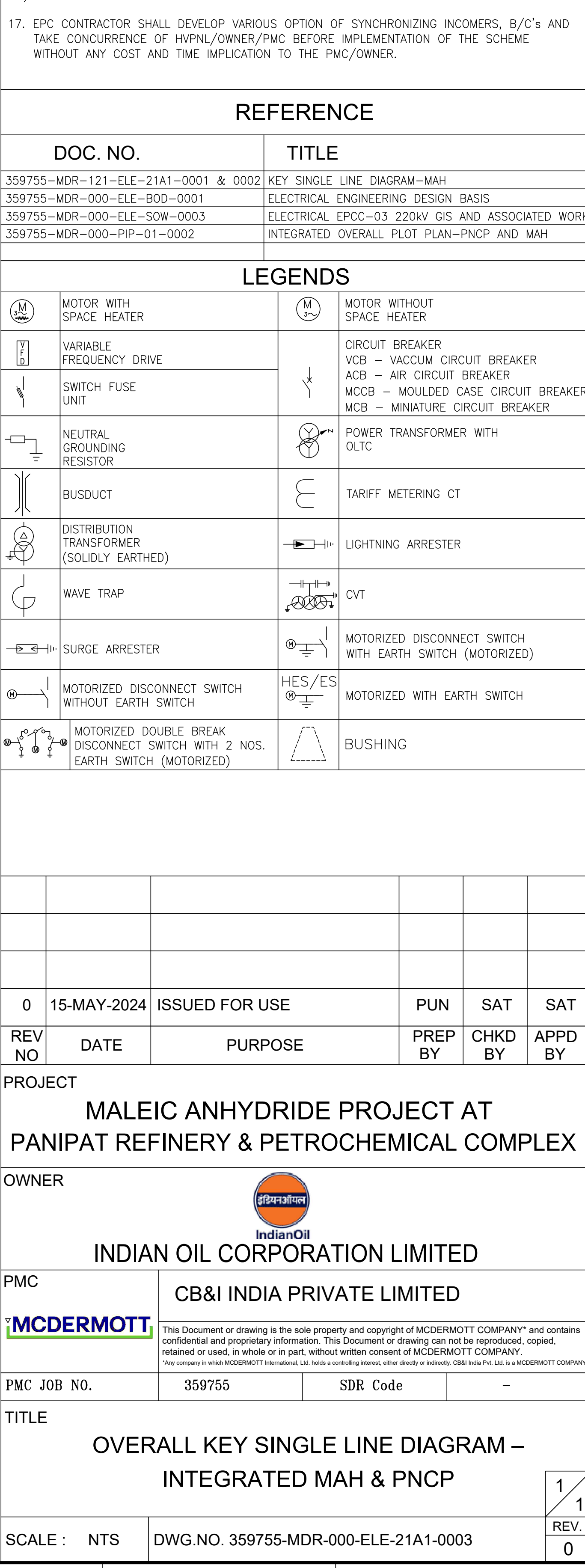
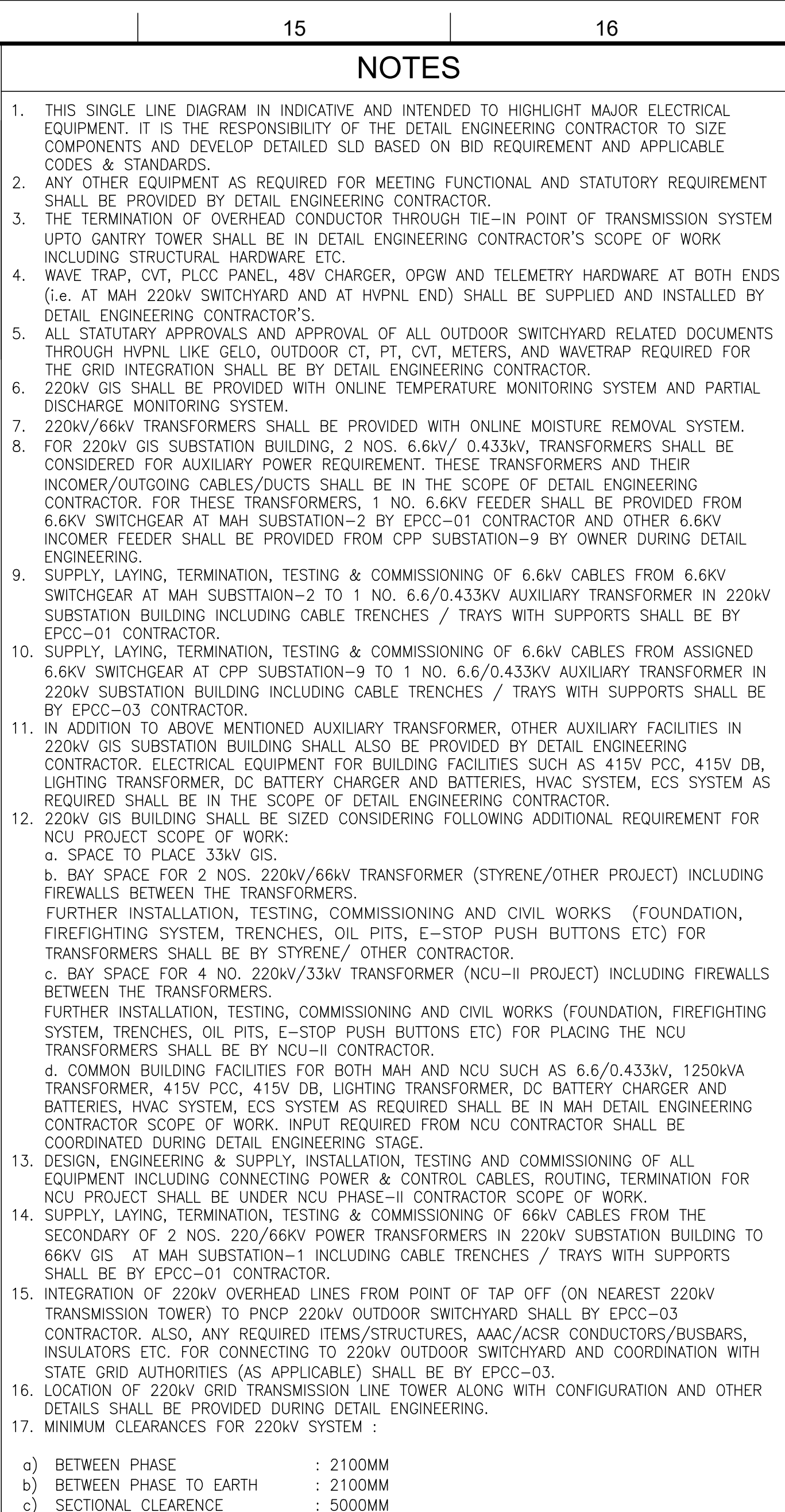
Sl. No.	Item Description	Unit	Qty.	Remarks
3.05	GIS SPARES: DIGITAL MULTIFUNCTION METERS	NO.	1	Each bus
3.06	GIS SPARES: INDICATING LAMPS	NO.	5	Each colour
4.0	SPARES- GIS: REFERENCE UNIT PRICE FOR ADDITION/ DELETION OF SUPPLY ITEMS (Unit Prices of Individual Equipment included here or in mandatory spares are required for any Addition/Deletion of Equipment and replacement of damaged items. Bidder to ensure that the unit prices have a logical relationship with prices of assemblies in main items. Quoting for unit prices is mandatory and shall be considered for evaluation)			
4.01	SUPPLY- GIS: SPARES: 220KV, OPERATING MECHANISM FOR CIRCUIT BREAKER COMPLETE IN ALL RESPECT	Set	1	
4.02	SUPPLY- GIS: SPARES: 220KV, OPERATING MECHANISM FOR DISCONNECTOR COMPLETE IN ALL RESPECT	Set	1	
4.03	SUPPLY- GIS: SPARES: 220KV, OPERATING MECHANISM FOR MAINTENANCE EARTHING SWITCH COMPLETE IN ALL RESPECT	Set	1	
4.04	SUPPLY- GIS: SPARES: 220KV, OPERATING MECHANISM FOR FAST ACTING/ HIGH SPEED GROUNDING SWITCH COMPLETE IN ALL RESPECT	Set	1	
4.05	SUPPLY- GIS: SPARES: 220KV, MAINTENANCE EARTHING SWITCH COMPLETE IN ALL RESPECT	Set	1	
4.06	SUPPLY- GIS: SPARES: 220KV, FAST ACTING/ HIGH SPEED GROUNDING SWITCH COMPLETE IN ALL RESPECT	Set	1	
4.07	SUPPLY- GIS: SPARES: 220KV, SINGLE PHASE BUS BAR	Mtrs	1	Complete in all respect.
4.08	SUPPLY- GIS: SPARES: 220KV, GIS METALLIC ENCLOSURE	Kgs	50	
4.09	SUPPLY- GIS: SPARES: 220KV, EXPANSION JOINTS	Set	1	1set= 1 nos. of each type and each rating.
4.10	SUPPLY- GIS: SPARES: 220KV, FLEXIBLE CONNECTIONS	Set	1	1set= 1 nos. of each type and each rating.
4.11	SUPPLY- GIS: SPARES: 220KV, BARRIER INSULATOR	Set	1	1set= 1 nos. of each type and each rating.
4.12	SUPPLY- GIS: SPARES: 220KV, NON-BARRIER INSULATOR	Set	1	1set= 1 nos. of each type and each rating.
4.13	SUPPLY- GIS: SPARES: 220KV, GAS SEALS	Set	1	1set= 1 nos. of each type and each rating.
4.14	SUPPLY- GIS: SPARES: 220KV, GAS DENSITY MONITOR SWITCH	Set	1	1set= 1 nos. of each type and each rating.
4.15	SUPPLY- GIS: SPARES: 220KV, GAS PRESSURE SWITCH	Set	1	1set= 1 nos. of each type and each rating.
4.16	SUPPLY- GIS: SPARES: 220KV, TEE BEND	Set	1	1set= 1 nos. of each type and each rating.
4.17	SUPPLY- GIS: SPARES: 220KV, ANGLE BEND	Set	1	1set= 1 nos. of each type and each rating.
4.18	SUPPLY- GIS: SPARES: 220KV, L-BEND	Set	1	1set= 1 nos. of each type and each rating.
4.19	SUPPLY- GIS: SPARES: 220KV, VOLATGE DETECTORS	Set	1	1set= 1 nos. of each type and each rating.

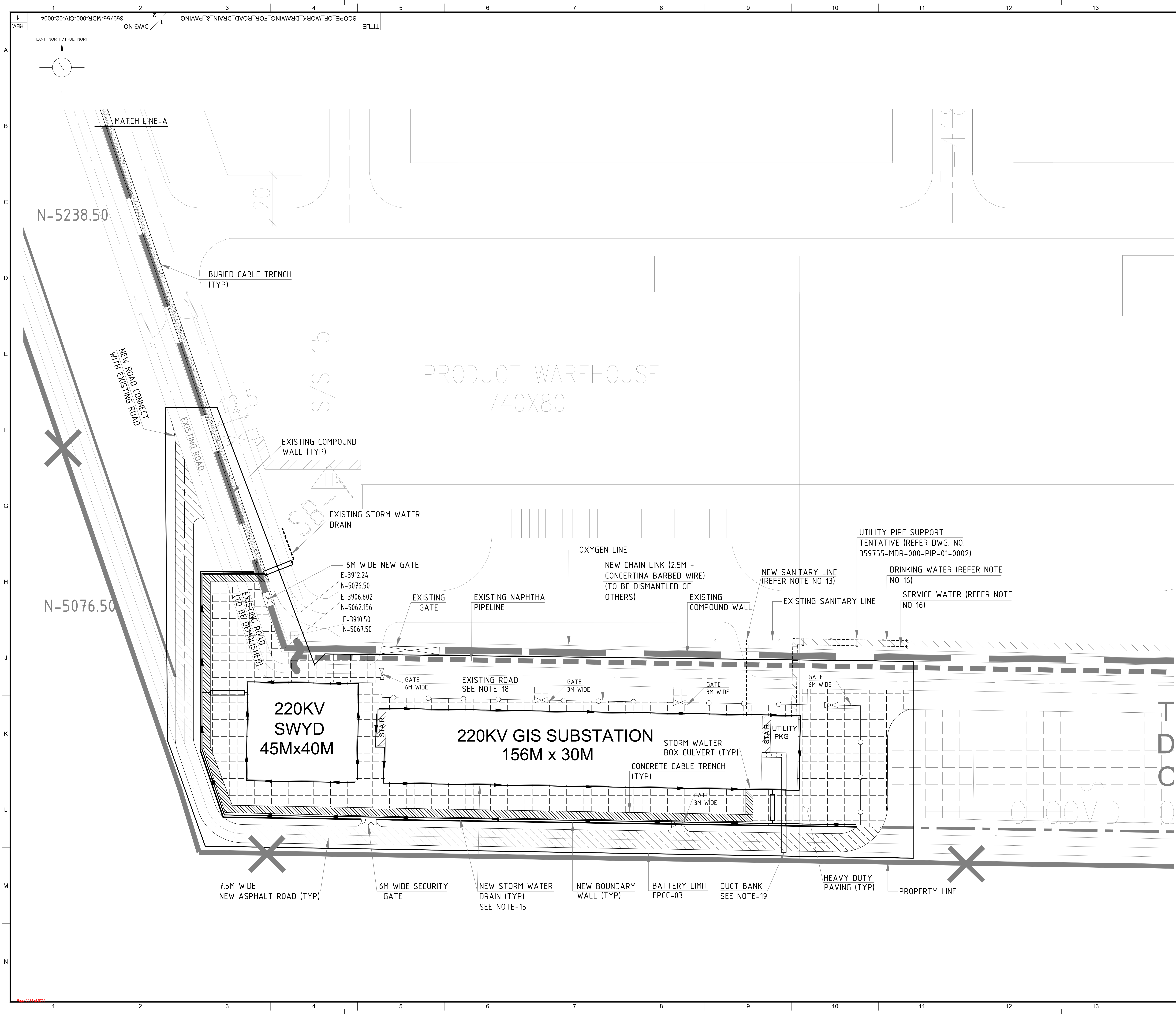
ANNEXURE BOQ_220kV GIS_SERVICE_IOCL PANIPAT
REV No: 01

DATE: 15.07.2024

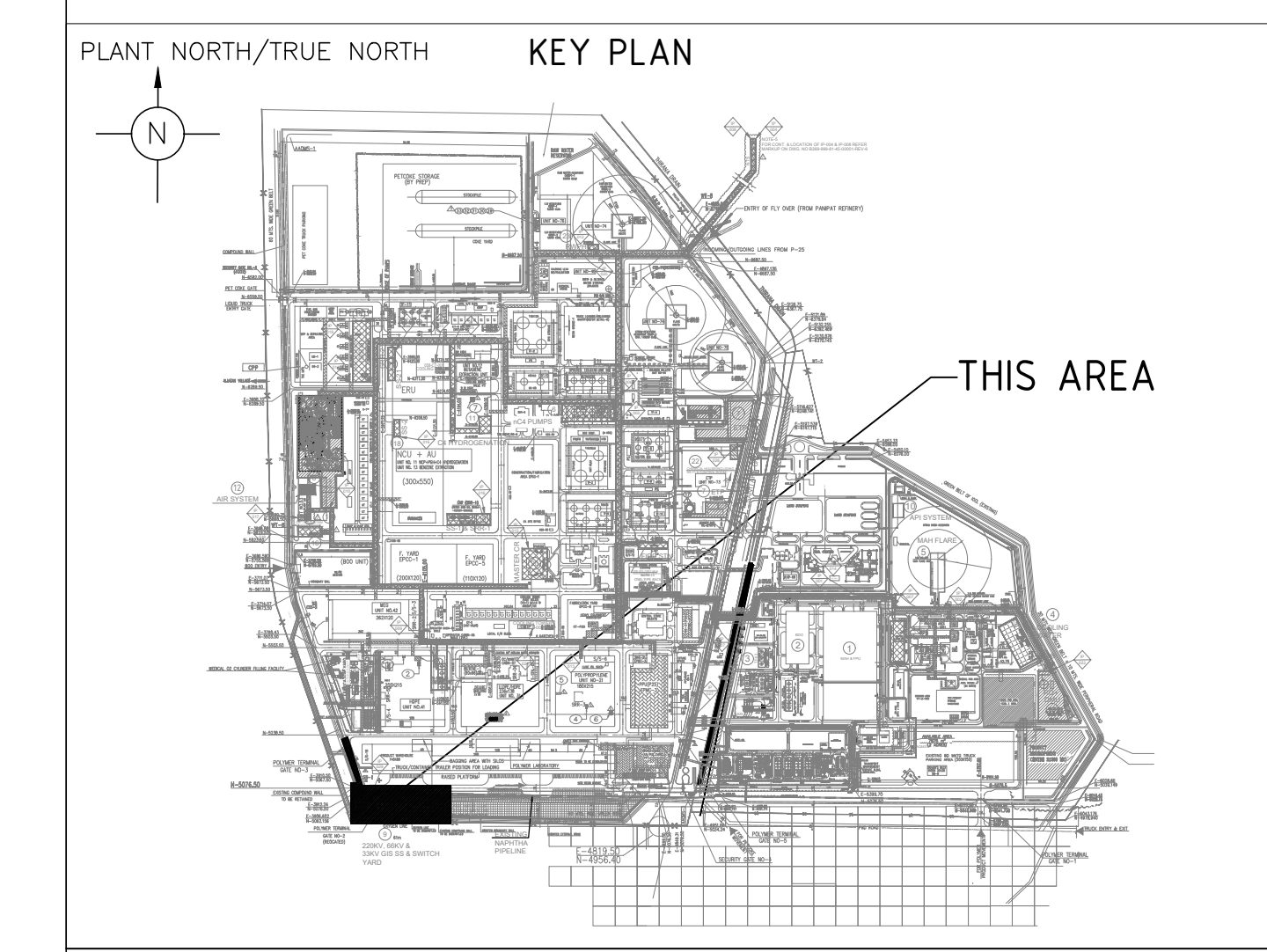
Sl. No.	Description	Unit	Quantity	Remarks
5.0	SERVICES- GIS : 220KV, 50KA FOR 3S, GAS INSULATED SWITCHGEAR (GIS) AS PER TS			
5.01	SERVICES- 220kV GIS: SUPERVISION OF ERECTION OF GIS	Bays	16	Supervision of erection of GIS with main bus, complete as per TS in all respect including LCC and its accessories. It also includes verification of materials for proper storage at site for final storage. Earthing, SF6 Gas Filing works, Internal Cabling from GIS to LCC, including Structure Works are covered under this item. GIS Bus Duct, SF6 to Air Bushing (SAB)/ SF6 to Oil Bushing (SOB), Surge Arrester, VT are not covered in this BOQ item.
5.02	SERVICES- 220kV GIS: SUPERVISION OF ERECTION OF 1-PHASE GAS INSULATED BUS DUCT	MTR	800	Supervision of erection of GIB complete as per TS in all respect. GIB shall be considered from first equipment of GIS. Earthing, SF6 Gas Filing works, Internal Cabling with tray work including Structure Works are covered under this item.
5.03	SERVICES- 220kV GIS: SUPERVISION OF ERECTION OF 1 PHASE SF6 TO AIR BUSHING	SET	6	Supervision of erection of SF6 to Air Bushing complete as per TS in all respect. Earthing, SF6 Gas Filing works, Internal Cabling with tray work, including Structure Works are covered under this item.
5.04	SERVICES- 220kV GIS: SUPERVISION OF ERECTION OF 1 PHASE SF6 TO OIL BUSHING (POLYMER)	SET	30	Supervision of erection of SF6 to Oil Bushing complete as per TS in all respect. Earthing, SF6 Gas Filing works, Internal Cabling with tray work, including Structure Works are covered under this item.
5.05	SERVICES- 220kV GIS: SUPERVISION OF ERECTION OF 1 PHASE SURGE ARRESTER WITH SURGE COUNTER	SET	42	Supervision of erection of Surge Arrester complete as per TS in all respect. Earthing, SF6 Gas Filing works, Internal Cabling with tray work, including Structure Works are covered under this item.
5.06	SERVICES- 220kV GIS: SUPERVISION OF ERECTION OF 1 PHASE VOLTAGE TRANSFORMER	SET	1	Supervision of erection of Voltage Transformer complete as per TS in all respect. Earthing, SF6 Gas Filing works, Internal Cabling with tray work, including Structure Works are covered under this item.
5.07	SERVICES- 220kV GIS: TESTING & COMMISSIONING OF GIS	Bays	16	Testing and commissioning of complete GIS system including main bus, LCC and associated system (LA, VT, CSD etc.) is to be executed by bidder. All the special testing instruments, kits, T&P etc. are to be arranged by bidder on returnable basis. Please refer relevant section of technical specification for details.
5.08	SERVICES- 220kV GIS : TESTING & COMMISSIONING OF GAS INSULATED BUS DUCT	MTR	800	Testing and commissioning of GIB complete as per TS in all respect. GIB shall be considered from first equipment of GIS. All the special testing instruments, kits, T&P etc. are to be arranged by bidder on returnable basis. Please refer relevant section of technical specification for details.
5.09	SERVICES- 220kV GIS : FINAL SUCCESSFUL HV/ POWER FREQUENCY TESTING OF GIS INCLUDING ARRANGING OF HV TEST KIT ALONG WITH OPERATOR	Bays	16	Carrying out successful HV/ Power Frequency Testing of GIS as per IEC including Arrangement of HV Test kit with operator (on returnable basis) shall be in scope of bidder, which includes charges of HV test kit with operator, accessories & tools required for completion of HV testing. The quoted price shall include GIS bays including Main Bus, GIB, SAB/SOB and other common items as per TS complete in all respect. In this BOQ item, mobilization and demobilization for HV test kit is considered for once. In case of more, for reasons not attributable to bidder, same shall be paid extra as per BOQ Item.
5.10	SERVICES- 220kV GIS : 3D MODEL FOR 220KV GIS	LOT	1	Please refer TS.

Sl. No.	Description	Unit	Quantity	Remarks
5.11	SERVICES- 220kV GIS : INSULATION CO-ORDINATION STUDIES FOR GIS SYSTEM	LOT	1	1 Lot means Complete study report as per technical specification, Including VFTO report.
5.11	SERVICES- 220kV GIS : TRAINING FOR GIS AT SITE	DAY	7	Training of ten OWNER's personnel & two BHEL's personnel for a period of at least Seven days at site
5.12	SERVICES- 220kV GIS : TRAINING FOR GIS AT MANUFACTURER WORKS	DAY	7	Training of two OWNER's personnel & two BHEL's personnel for a period of at least Seven days at manufacturer's works
6.0	SERVICES- GIS : REFERENCE UNIT PRICE FOR ADDITION / DELETION OF SERVICES: (UNIT PRICES OF INDIVIDUAL SERVICES INCLUDED HERE ARE REQUIRED FOR ANY ADDITION/DELETION OF EQUIPMENT AND REPLACEMENT OF DAMAGED ITEMS. VENDOR TO ENSURE THAT THE UNIT PRICES HAVE A LOGICAL RELATIONSHIP WITH PRICES OF ASSEMBLIES IN MAIN ITEMS. QUOTING FOR UNIT PRICES IS MANDATORY AND SHALL BE CONSIDERED FOR			
6.01	SERVICES- 220kV GIS: REF. UNIT PRICE OF GIS INDIVIDUAL ITEM/ EQUIPMENT - SERVICES FOR SUPERVISION OF ERECTION OF GIS	MANDAY	10	Charges for repetition of services - (if required due to reasons not attributed to the bidder) This item will be executed only if repetition of services is required by BHEL.
6.02	SERVICES- 220kV GIS: REF. UNIT PRICE OF GIS INDIVIDUAL ITEM/ EQUIPMENT - SERVICES FOR TESTING & COMMISSIONING OF GIS	MANDAY	10	Charges for repetition of services - (if required due to reasons not attributed to the bidder) This item will be executed only if repetition of services is required by BHEL.
	DEMOBILIZATION AND REMOBILIZATION CHARGES			
6.03	SERVICES- 220kV GIS: DEMOBILIZATION AND REMOBILIZATION CHARGES FOR GIS ERECTION SUPERVISION TEAM	Set	2	THIS BOQ ITEM SHALL BE PAYABLE IF REQUIRED FOR REASONS NOT ATTRIBUTABLE TO BIDDER.
6.04	SERVICES- 220kV GIS: DEMOBILIZATION AND REMOBILIZATION CHARGES FOR GIS TESTING & COMMISSIONING TEAM	Set	2	BOQ ITEM SHALL BE PAYABLE IF REQUIRED FOR REASONS NOT ATTRIBUTE TO BIDDER. HV TESTING IS NOT PART OF THIS ITEM
6.05	SERVICES- 220kV GIS: DEMOBILIZATION & REMOBILIZATION CHARGES OF HV TEST KIT ALONG WITH OPERATOR	Lot	1	In this BOQ item, mobilization and demobilization chages for HV test kit is considered for second time or more , for reasons not attributable to bidder. HV testing charges shall be paid per bay basis as per main





- NOTES:
1. ALL DIMENSIONS ARE IN MM & CO-ORDINATES ARE IN METERS.
 2. HPP EL. 100.000 CORRESPONDS TO RL 238.72M ABOVE MSL.
 3. REFER INTEGRATED OVERALL PLOT PLAN PNCP & MAH FOR MORE DETAILS OF BATTERY LIMIT CONDITIONS AND PLOT DETAILS.
 4. THIS DRAWING SHALL BE REFERRED AS SCHEMATIC LAYOUT TO UNDERSTAND THE SCOPE OF WORK FOR ROADS, DRAINS AND PAVING. CONTRACTOR TO DEVELOP DETAIL CONSTRUCTION DRAWINGS.
 5. TIE-IN LOCATIONS SHOWN IN THE DRAWING ARE INDICATIVE AND SAME SHALL BE FINALIZED BY CONTRACTOR DURING DETAIL ENGINEERING IN CONSULTATION WITH OWNER/PMC.
 6. FOLLOWING LOCATIONS SHALL BE FINALIZED BY CONTRACTOR:
A) HARD STAND FOR ERECTION OF HEAVY EQUIPMENTS.
B) SAFETY SHOWER & EYE WASH LOCATION.
C) APPROACH ROAD/EXIT/ EMERGENCY ROAD AS PER REQUIREMENT AND STATUTORY REGULATION .
 7. PAVING UP TO EDGE OF ROAD SIDE DRAIN IS IN THE SCOPE OF CONTRACTOR (TYP).
 8. APPROACH ROADS/ACCESS WAYS SHOWN ARE INDICATIVE. CONTRACTOR SHALL PROVIDE SUFFICIENT HEAVY DUTY APPROACHES BETWEEN FACILITIES AND ROADS SURROUNDING FACILITIES WHEREVER REQUIRED FROM ERECTION / MAINTENANCE / OPERATION POINT OF VIEW AS WELL AS LOADING / UNLOADING AREA.
 9. CONTRACTOR SHALL CHECK SUITABILITY OF EXISTING ROADS FOR CRANE MOVEMENT & STRENGTHEN THE SAME AS REQUIRED.
 10. RCC CULVERTS, SUITABLE FOR ENVISAGED VEHICULAR TRAFFIC LOADS SHALL BE PROVIDED WHERE STORM WATER DRAINS CROSS MAIN / APPROACH ROADS. CULVERTS SHALL BE EXTENDED AT LEAST 1000 MM BEYOND THE WIDTH OF THE ROADS, INCLUDING TURNING RADIUS WHEREVER APPLICABLE BY CONTRACTOR.
 11. CONTRACTOR SHALL BE PROVIDED WHERE ELECTRICAL / INSTRUMENTATION CABLE CROSS MAIN / APPROACH ROADS ALONG WITH CABLE PULLING PITS.
 12. CONTRACTOR SHALL SUBMIT DETAILED SCHEME FOR GENERAL CIVIL FACILITIES FOR PMC / OWNER FOR APPROVAL BEFORE PROCEEDING WITH ANY WORK.
 13. SANITARY SEWER FROM 220KV SUBSTATION SHALL BE TIE-IN TO THE EXISTING SANITARY SEWER NETWORK. APPROX 300M DISTANCE FROM GIS SHALL BE CONSIDERED FOR THE TIE-IN LOCATION. THE SCOPE SHALL ALSO INCLUDE CHECKING OF ANY U/G HINDRANCE AND RECTIFICATION OF THE SAME.
 14. THE STORM WATER DRAIN LAYOUT IS TENTATIVE AND TO BE CONNECTED TO NEAREST EXISTING STORM WATER DRAIN (MAX. TENTATIVELY 200M) EXACT TIE IN SHALL BE FINALIZED BY THE DETAIL ENGINEERING CONTRACTOR DURING DETAIL ENGINEERING.
 15. STORM WATER DRAIN SIZE / LOCATION / ROUTING ETC & SHALL BE FINALIZED BY EPCC CONTRACTOR AS PER BUILDING DOCUMENT.
 16. DRINKING AND SERVICE WATER SHALL BE LAID ABOVE / UNDERGROUND TO SUIT SITE CONDITION AND TIE IN WALL BE AROUND (450M APPROXIMATE) NEAR EPCC-03 AREA.
 17. RAIN HARVESTING FACILITY SHALL BE CONSIDERED FOR THE BUILDING.
 18. NO OF EXIT / GATE ETC ARE TENTATIVELY SHOWN AND IT IS EPCC CONSTRUCTOR RESPONSIBILITY TO FINALIZE THE LOCATION / NO AS PER STATUARY REGULATION.
 19. EPCC CONTRACTOR SHALL CONSIDER CONSTRUCTION OF CULVERT ELECTRICAL ROAD CROSSING (4m x 6m x 200mm HDPE CASING) (MIN. 3M WIDE/2M DEPTH) FOR LAYOUT OF CABLE BY OTHERS IN ISBL OF EPCC-3



REFERENCE DRAWINGS	
359755-MDR-000-PIP-01-0002	INTEGRATED OVERALL PLOT PLAN PNCP & MAH

LEGEND	
	BATTERY LIMIT
	HEAVY DUTY PAVING (TYPE - II)
	ASPHALT ROAD
	NEW STORM WATER DRAIN
	BOX CULVERT
	DUCT BANK
	CONCRETE CABLE TRENCH
	BURIED CABLE TRENCH
	MANHOLE
	NEW SANITARY LINE
	FENCING

REV NO	DATE	PURPOSE	PREP BY	CHKD BY	APPD BY
1	08-MAY-24	ISSUED FOR USE	TAB	JAN	YOK
0	12-JAN-24	ISSUED FOR USE	SHS	SUP	DKS

PROJECT
MALEIC ANHYDRIDE PROJECT AT
PANIPAT REFINERY & PETROCHEMICAL COMPLEX

OWNER

INDIAN OIL CORPORATION LIMITED

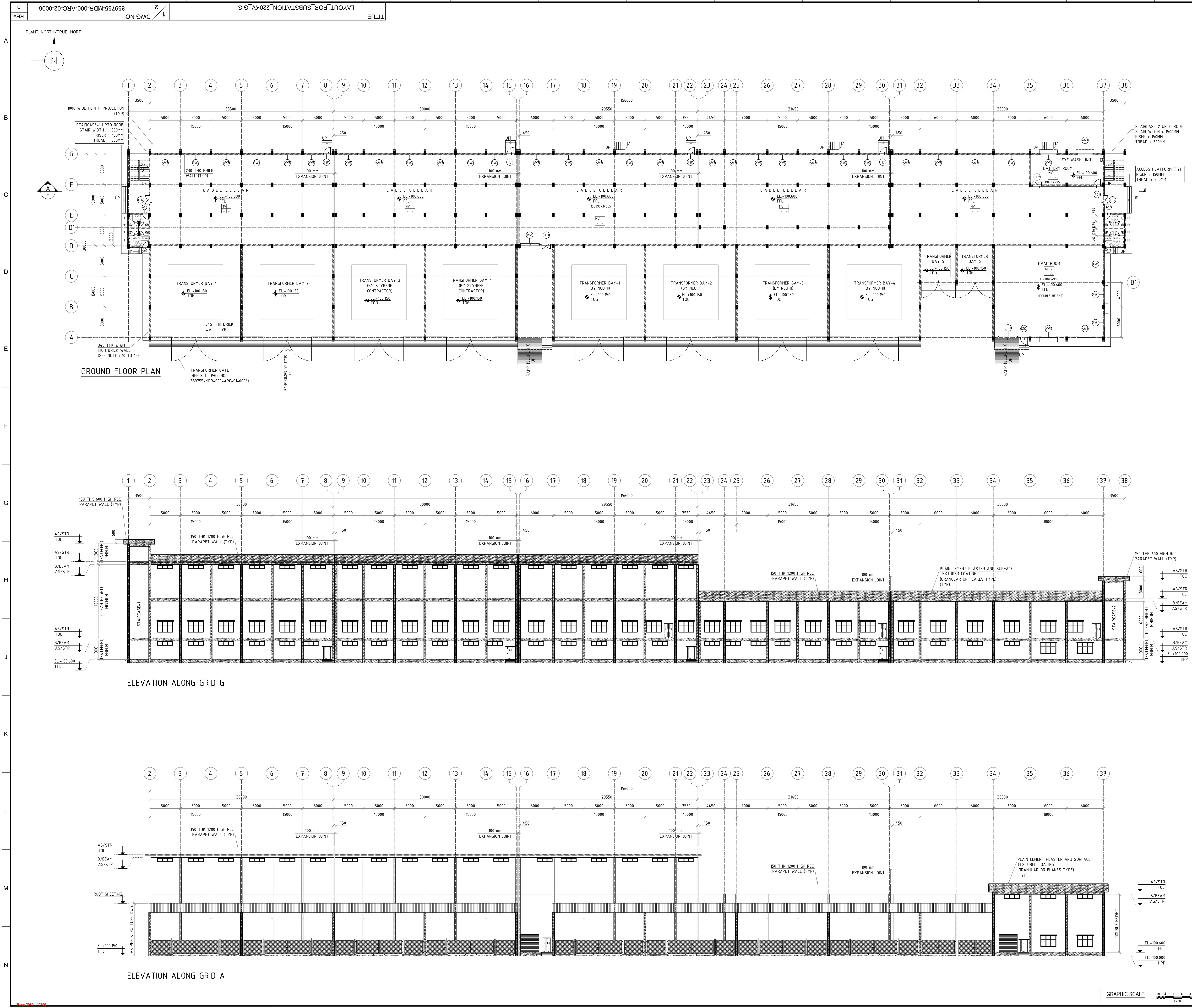
PMC

CB&I INDIA PRIVATE LIMITED

PMC JOB NO. 359755 SDR Code -

TITLE
SCOPE OF WORK DRAWING
FOR ROADS, DRAIN & PAVING

SCALE : 1:500 DWG.NO. 359755-MDR-000-CIV-02-0004



NOTES:

- ALL THE DIMENSIONS ARE IN MM & ELEVATIONS ARE IN METER UNLESS OTHERWISE NOTED.
- DO NOT SCALE DRAWING ONLY WRITTEN DIMENSIONS TO BE FOLLOWED.
- HIGHEST PAVEMENT LEVEL (HPP) 100.00M OF PROCESS UNIT CORRESPONDS TO LEVEL 238M ABOVE MS.
- THIS DRAWING SHALL IN CONJUNCTION WITH ARCHITECTURAL DESIGN BASIS DOC NO: 359755-MDR-000-ARC-000-0001.
- ALL EXTERNAL WALLS SHALL BE 230mm BRICK MASONRY WALLS UNO.
- WATER LOGGING AREAS SUCH AS TOILET, PANTRY, DRINKING WATER AREA, ENTRANCE LOBBY, PLATFORM SHALL BE SUNKEN WITH 12mm TILE DROP.
- ALL TERRACES SHALL HAVE WATERPROOFING AS PER SPECIFICATIONS.
- ELEVATIONS & SIZE OF THE BUILDING IS INDICATIVE ONLY, CONTRACTOR TO VERIFY AND CONFIRM DURING DETAIL ENGINEERING.
- THIS DRAWING IS GUIDE DRAWING IN NATURE AND INDICATIVE OF BROAD REQUIREMENT SUCH AS SPACE REQUIREMENT, SIZE AND LAYOUT.
- HEIGHT OF FIRE WALL SHALL BE 1.0M ABOVE TOP OF TRANSFORMER.
- LOWEST LEVEL OF SHELTER (EAVE LEVEL) SHALL BE 21M ABOVE TOP OF TRANSFORMER.
- ANY REARRANGEMENT WITHIN GIVEN SPACE SHALL BE FINALIZED DURING DETAIL ENGINEERING STAGE.
- SHELTER AS ON TRANSFORMER SHALL BE REMOVABLE TYPE FOR MAINTENANCE OF TRANSFORMER.
- THE WALL CUTOUTS FOR ENTRY OF BUS DUCT, CABLE TRAYS, HVAC ARE NOT SHOWN HERE. SUITABLE CUTOUT AS REQUIRED SHALL BE SHOWN DURING DETAIL ENGINEERING.
- HEIGHT OF THE TRANSFORMER SHED SHOWN HERE IS FOR REFERENCE ONLY. FINAL SHED HEIGHT TO BE PROVIDED SHALL BE DECIDED DURING DETAIL ENGINEERING STAGE.

LEGEND / ABBREVIATION--

HPP - HIGH POINT PAVEMENT
FFL - FINISHED FLOOR LEVEL
FGL - FINISHED GROUND LEVEL
TYP - TYPICAL
RWP - RAIN WATER PIPE
TOC - TOP OF CONCRETE
TOG - TOP OF GRAVEL
SS - STAINLESS STEEL

AC - AIR CONDITIONING
FC - FALSE CEILING
UI - UNDER DECK INSULATION
FF - FALSE FLOORING
MV - MECHANICAL VENTILATION
10MM FLOOR/ TILE DROP

KEY PLAN

PLANT NORTH/TRUE NORTH

REFERENCE DRAWINGS

359755-MDR-000-PIP-01-001	MAH OVERALL PLOT PLAN
359755-MDR-000-ELE-51A1-0002	SUBSTATION LAYOUT - 220KV

0	04-MAY-24	ISSUED FOR USE	TAB	JAN	YOK
REV NO	DATE	PURPOSE	PREP BY	CHKD BY	APPD BY

PROJECT
MALEIC ANHYDRIDE PROJECT AT PANIPAT REFINERY & PETROCHEMICAL COMPLEX

OWNER

INDIAN OIL CORPORATION LIMITED

PMC

CB&I INDIA PRIVATE LIMITED

This Document or drawing is the sole property and copyright of MCDERMOTT COMPANY and contains confidential and proprietary information. This Document or drawing can not be reproduced, copied, related or used, in whole or in part, without written consent of MCDERMOTT COMPANY.
The Company is MCDERMOTT International, US, which is a wholly owned subsidiary of MCDERMOTT COMPANY.

PMC JOB NO.	359755	SDR Code	-
-------------	--------	----------	---

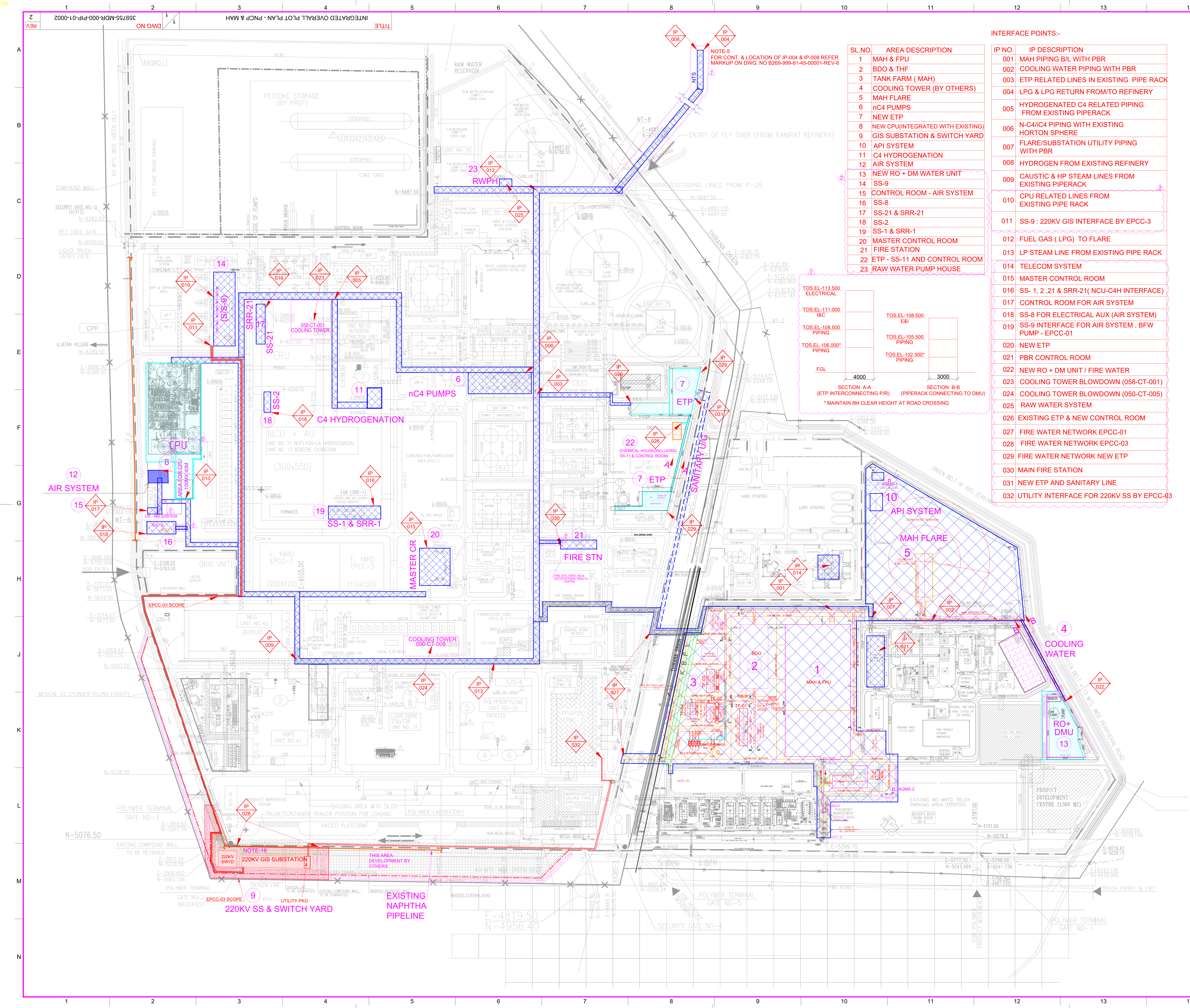
TITLE
LAYOUT FOR SUBSTATION - 220KV GIS

GRAPHIC SCALE
0m 2 4 6 8 10
1:200

1	2
REV.	REV.



0	04-MAY-24	ISSUED FOR USE	TAB	JAN	YOK				
REV NO	DATE	PURPOSE	PREP BY	CHKD BY	APPD BY				
PROJECT									
MALEIC ANHYDRIDE PROJECT AT PANIPAT REFINERY & PETROCHEMICAL COMPLEX OWNER Indian Oil INDIAN OIL CORPORATION LIMITED									
PMC			CB&I INDIA PRIVATE LIMITED						
			This Document or drawing is the sole property and copyright of MCDERMOTT COMPANY** and contains confidential and proprietary information. This Document or drawing can not be reproduced, copied, retained or used, in whole or in part, without written consent of MCDERMOTT COMPANY. *In company in which MCDERMOTT International, Ltd. holds a controlling interest, either directly or indirectly. CB&I India Pvt. Ltd. is a MCDERMOTT COMPANY.						
PMC JOB NO.			359755		SDR Code		--		
TITLE LAYOUT FOR SUBSTATION-220kV GIS									
SCALE : 1:200			DWG.NO. 359755-MDR-000-ARC-02-0006						



SL.NO.	AREA DESCRIPTION
1	MAH & FPU
2	BDO & THF
3	TANK FARM (MAH)
4	COOLING TOWER (BY OTHERS)
5	MAH FLARE
6	nC4 PUMPS
7	NEW ETP
8	NEW CPU(INTEGRATED WITH EXISTING)
9	GIS SUBSTATION & SWITCH YARD
10	API SYSTEM
11	C4 HYDROGENATION
12	AIR SYSTEM
13	NEW RO + DM WATER UNIT
14	SS-9
15	CONTROL ROOM - AIR SYSTEM
16	SS-8
17	SS-21 & SRR-21
18	SS-2
19	SS-1 & SRR-1
20	MASTER CONTROL ROOM
21	FIRE STATION
22	ETP - SS-11 AND CONTROL ROOM
23	RAW WATER PUMP HOUSE

INTERFACE POINTS:-	
IP NO.	IP DESCRIPTION
001	MAH PIPING B/L WITH PBR
002	COOLING WATER PIPING WITH PBR
003	ETP RELATED LINES IN EXISTING PIPE RACK
004	LPG & LPG RETURN FROM TO REFINERY
005	HYDROGENATED C4 RELATED PIPING FROM EXISTING PIPERACK
006	N-C4/C4 PIPING WITH EXISTING HORTON SPHERE
007	FLARE/SUBSTATION UTILITY PIPING WITH PBR
008	HYDROGEN FROM EXISTING REFINERY
009	CAUSTIC & HP STEAM LINES FROM EXISTING PIPERACK
010	CPU RELATED LINES FROM EXISTING PIPE RACK
011	SS-9 : 220KV GIS INTERFACE BY EPCC-3
012	FUEL GAS (LPG) TO FLARE
013	LP STEAM LINE FROM EXISTING PIPE RACK
014	TELECOM SYSTEM
015	MASTER CONTROL ROOM
016	SS- 1, 2 ,21 & SRR-21(NCU-C4H INTERFACE)
017	CONTROL ROOM FOR AIR SYSTEM
018	SS-8 FOR ELECTRICAL AUX (AIR SYSTEM)
019	SS-9 INTERFACE FOR AIR SYSTEM , BFW PUMP - EPCC-01
020	NEW ETP
021	PBR CONTROL ROOM
022	NEW RO + DM UNIT / FIRE WATER
023	COOLING TOWER BLOWDOWN (058-CT-001)
024	COOLING TOWER BLOWDOWN (050-CT-005)
025	RAW WATER SYSTEM
026	EXISTING ETP & NEW CONTROL ROOM
027	FIRE WATER NETWORK EPCC-01
028	FIRE WATER NETWORK EPCC-03
029	FIRE WATER NETWORK NEW ETP
030	MAIN FIRE STATION
031	NEW ETP AND SANITARY LINE
032	UTILITY INTERFACE FOR 220KV SS BY EPCC-03

PLANT NORTH/TRUE NORTH

WIND FROM

ANNUAL WIND DIRECTION ROSE FOR KARNAL.

DOC. NO.	TITLE
359755-MDR-000-PIP-01-0001	OVERALL PLOT PLAN - MAH BLOCK
359755-MDR-121-PIP-03-0001	EQUIPMENT LAYOUT PLAN MAH & FPU UNIT
359755-MDR-122-PIP-03-0001	EQUIPMENT LAYOUT PLAN BDO & THF UNIT
203168C-000-DW-0051-0001 (REV.4)	PLOT PLAN OFFSITE FACILITIES -OVERALL (PBR)
6714-LAY-000-LD-0002 (REV-0)	OVERALL PLOT PLAN - PNCP COMPLEX

NOTES

- LOCATION OF ALL FACILITIES SHALL BE FINALIZED BY EPC CONTRACTOR IN CONSULTATION WITH ENGINEER. IN-CHARGE AND THIS PLOT PLAN SHALL BE READ WITH SCOPE, DRAWINGS AND SPECIFICATIONS DEFINED IN THE BIDDING DOCUMENT.
- DETAILED LAYOUT OF EACH FACILITY SHALL BE DEVELOPED BY EPC CONTRACTOR BASED ON DETAIL ENGINEERING AND VENDOR / PKG / SUPPLIER INPUT
- INTERFACE POINTS ARE INDICATIVE. LSTK CONTRACTOR TO VERIFY THE LOCATIONS INLINE WITH P&IDS, S&W AND FINALIZE THE LOCATIONS DURING DETAIL ENGINEERING.
- FOR CIVIL RELATED BATTERY LIMIT INTERFACE, REFER DRAWING NO. 359755-MDR-000-CIV-02-0003 - SCOPE DRAWINGS FOR ROADS AND DRAINAGE (EPC 1).
- THIS INTERFACE POINT (IP004/IP008) SHALL BE AT EXISTING PANIPAT REFINERY. THESE LINES MIGHT TRAVEL APPROX. 7KM (7KM IS INDICATIVE AND FINAL DISTANCE SHALL BE ESTIMATED BY EPC CONTRACTOR AND TO BE INCLUDED IN THE PROPOSAL ACCORDINGLY) FROM REFINERY TO MAH BLOCK. LOCATION AND ROUTE OF THESE LINES SHALL BE FINALIZED BY LSTK CONTRACTOR DURING DETAIL ENGINEERING.
- NEW CPU SHALL BE ACCOMMODATED IN THE AREA MARKED AND SHALL BE INTERFACE WITH EXISTING CPU
- PLOT AREA FOR CPU, ETP, ZLD AS SHOWN ARE TENTATIVE AND TO BE VERIFIED BY EPCC CONTRACTOR AT SITE IN CONSULTATION WITH ENGINEER-IN-CHARGE.
- DM WATER STORAGE TANK AND PUMPS SHALL BE INSTALLED IN THE NEW DMU
- BATTERY LIMIT INTERFACE BETWEEN EPCC-01, EPCC-02 & EPCC-03 SHALL BE AS SHOWN AND SAME TO BE FINALIZED AT SITE IN CONSULTATION WITH ENGINEER-IN-CHARGE.
- ALL INTERCONNECTED PIPING / CABLEING ETC. SHALL BE CONSIDERED BY EPCC.
- EXISTING FACILITIES SUCH AS CHEMICAL STORAGE / HANDLING FOR ETP SHALL BE INTERFACE WITH EXISTING ETP TO THE EXTENT FEASIBLE.
- IT IS PREFERRED TO UTILIZE THE EXISTING SUBSTATION / CONTROL ROOM AND SAME SHALL BE EXTENDED IN CASE REQUIRED TO ACCOMMODATE ADDITIONAL EQUIPMENT
- EPCC-02 CONTRACTOR SHALL CO-ORDINATE WITH ENGINEERING IN-CHARGE FOR ADDITIONAL AREA IN CASE REQUIRED.
- LOCATION AND BLOCK SIZE OF C4H UNIT IS TENTATIVE, EPCC TO STUDY AND DEVELOP LAYOUT FOR C4H UNIT BASED ON LICENSOR PKG DURING DETAIL ENGINEERING. EXISTING LAYOUT SHALL BE REVISED BY EPC CONTRACTOR TO INCORPORATE THE REQUIREMENT OF LICENSOR PKG
- IT IS RESPONSIBILITY OF EPC CONTRACTOR TO STUDY ALL THE INTERFACES WITH EXISTING FACILITIES AND CONSIDER THE SCOPE OF SUPPLY & WORK DURING DETAIL ENGINEERING. PARTICULARLY FOR THE IN POINTS, CABLE TRENCHES / TRAYS / DUCTS, EXTENSION OF EXISTING PIPERACK AS REQUIRED, ROAD CONNECTIVITY, DRAINAGE CONNECTIVITY TO THE EXISTING DRAINS / STORM POND, PIPERACK FOUNDATION INTERFACES WITH OTHER CONTRACTORS, ETC
- EXISTING UG PIPELINE LOCATION SHALL BE VERIFIED BY EPCC AND SUFFICIENT CLEARANCE AS PER OISD SHALL BE MAINTAINED. ANY CHANGE IN LAYOUT DUE TO LOCATION OF EXISTING PIPELINE AND COMPLIANCE TO OISD SHALL BE EXECUTED BY EPCC WITHOUT ANY IMPACT ON COST AND TIME.
- LOCATION OF AQMS IS INDICATIVE AND SAME SHALL BE FINALIZED AT SITE AS PER INSTRUCTIONS OF ENGG-IN-CHARGE

LEGEND

	EPCC-01 SCOPE		INTERFACE POINTS WITH EXISTING OR OTHERS
	EPCC-02 SCOPE		
	EPCC-03 SCOPE		

2	10-MAY-24	RE-ISSUED FOR FEED	MSB	ADJ	ADJ
1	27-MAR-24	RE-ISSUED FOR FEED	MSB	ADJ	ADJ
0	21-MAR-24	ISSUED FOR FEED	GAB	ADJ	ADJ
REV NO	DATE	PURPOSE	PREP BY	CHKD BY	APPD BY

PROJECT

MALEIC ANHYDRIDE PROJECT AT PANIPAT REFINERY & PETROCHEMICAL COMPLEX

OWNER

INDIAN OIL CORPORATION LIMITED

PMC

CB&I INDIA PRIVATE LIMITED

MCDEMOTT

This Document or drawing is the sole property and copyright of MCDEMOTT COMPANY* and contains confidential and proprietary information. This Document or drawing can not be reproduced, copied, related or used in whole or in part, without written consent of MCDEMOTT COMPANY.

PMC JOB NO.

359755

SRD Code

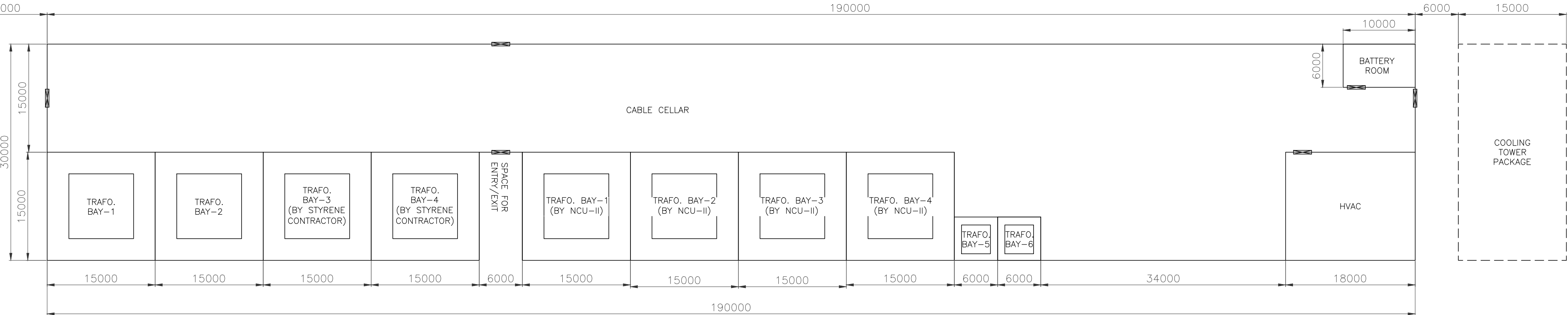
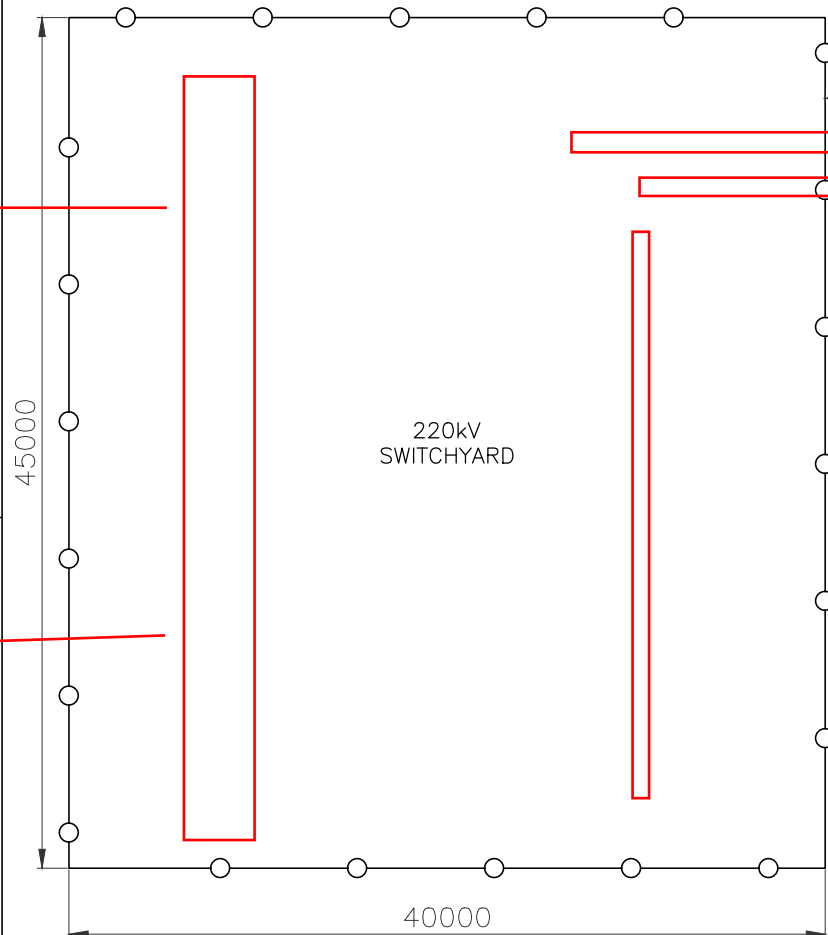
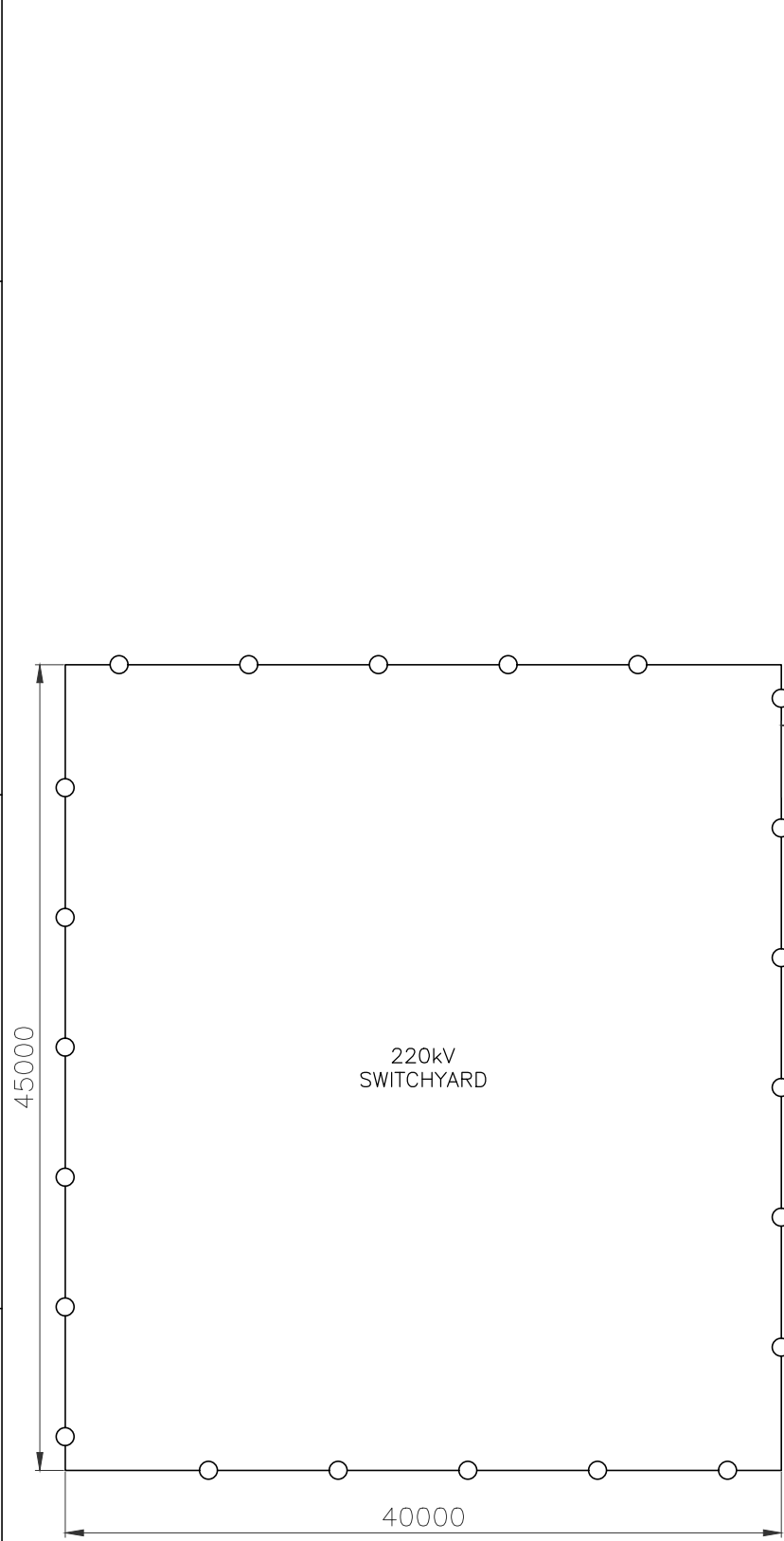
TITLE

INTEGRATED OVERALL PLOT PLAN - PNCP AND MAH

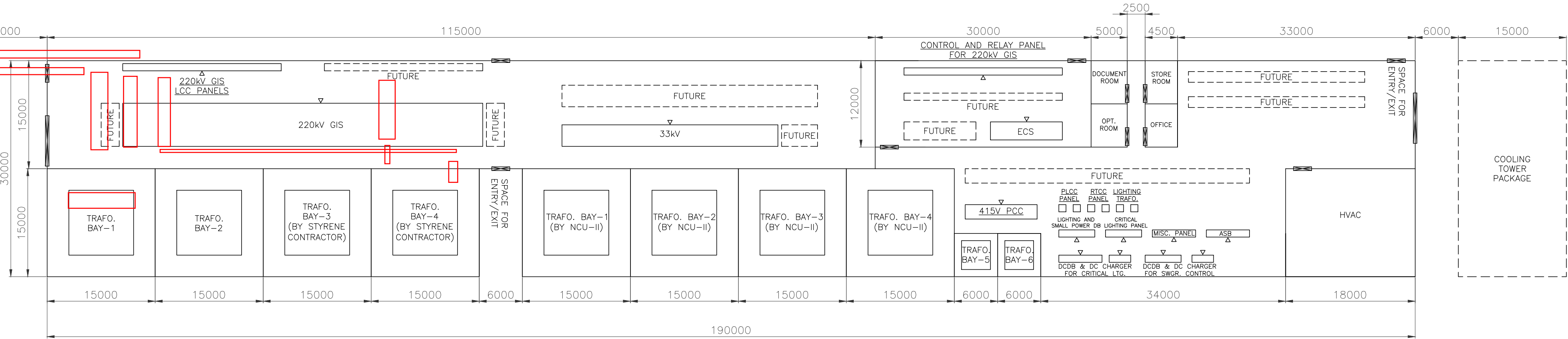
SCALE : 1:3000

DWG. NO. 359755-MDR-000-PIP-01-0002

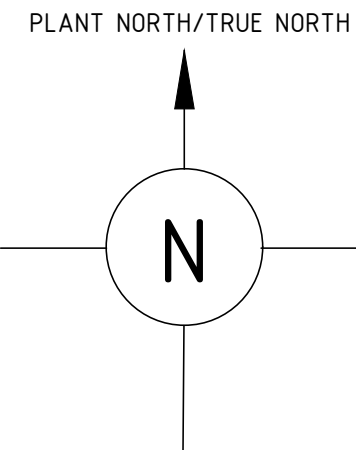
1	1
REV	2



GROUND FLOOR PLAN VIEW



FIRST FLOOR PLAN VIEW



- NOTES:**
1. ALL DIMENSION ARE IN MILLIMETERS AND LEVELS ARE IN METERS UNLESS OTHERWISE NOTED.
 2. BUILDING AND EQUIPMENT DIMENSIONS ARE PRELIMINARY AND SAME SHALL BE VERIFIED BY CONTRACTOR DURING DETAIL ENGINEERING.
 3. SUBSTATION WALL ADJACENT TO THE TRANSFORMER BAY AND WALL SEPARATING TRANSFORMER'S SHALL BE 355MM THICK (INCLUSIVE OF PLASTERING) IN CASE OF BRICK CONSTRUCTION OR 230 MM THICK IN CASE OF RCC CONSTRUCTION.
 4. ENTRY & EXIT LOCATION OF CABLES SHALL BE PLANNED DURING DETAIL ENGINEERING.
 5. DESIGN, ENGINEERING AND CONSTRUCTION OF COMPLETE SUBSTATION BUILDING INCLUDING CABLE CELLAR, CABLE TRENCHES, SWITCHGEAR ROOM, TRANSFORMER FENCE, TRANSFORMER YARD, TRANSFORMER & CAPACITOR FOUNDATION AND COMPLETE BUILDING PERIPHERY FACILITIES IS IN DETAIL ENGINEERING CONTRACTOR SCOPE OF WORK.
 6. THE COMPLETE SUBSTATION BUILDING ARRANGEMENT AND DIMENSION INDICATED IS MINIMUM AND TENTATIVE ONLY. CONTRACTOR SHALL VALIDATE THE SAME DURING DETAIL ENGINEERING STAGE.
 7. VERTICAL CLEARANCE ABOVE THE TOP OF THE HIGHEST EQUIPMENT SHALL BE MINIMUM 1500MM MEASURED FROM BOTTOM OF ROOF SLAB (EXCEPT TRANSFORMER BAY WHERE SAME SHALL BE 1000MM) AND MINIMUM 500MM MEASURED FROM THE BOTTOM OF THE LOWEST ROOF BEAM. HOWEVER FOR THE AREAS WITH FALSE CEILING, MINIMUM CLEARANCE OF 750MM SHALL BE PROVIDED BETWEEN FALSE CEILING AND TOP OF ANY EQUIPMENT.
 8. SUB-STATION BUILDING SHALL BE WITHOUT ANY COLUMNS WITHIN THE SWITCHGEAR ROOM TO THE EXTENT POSSIBLE TO ENSURE OPTIMUM SPACE UTILIZATION, UNLESS OTHERWISE SPECIFIED.
 9. 220KV GIS BUILDING SHALL BE SIZED CONSIDERING FOLLOWING ADDITIONAL REQUIREMENT FOR NCU-II AND OTHER PROJECT SCOPE OF WORK:
 - a. SPACE TO PLACE 33kv GIS.
 - b. BAY SPACE FOR 2 NOS. 220kv/33kv TRANSFORMER (OTHER PROJECT) INCLUDING FIREWALLS BETWEEN THE TRANSFORMERS. FURTHER INSTALLATION, TESTING, COMMISSIONING AND CIVIL WORKS (FOUNDATION, FIREFIGHTING SYSTEM, TRENCHES, OIL PITS, E-STOP PUSH BUTTONS ETC) FOR TRANSFORMERS SHALL BE BY STYRENE CONTRACTOR.
 - c. BAY SPACE FOR 4 NOS. 220kv/33kv TRANSFORMER (NCU-II PROJECT) INCLUDING FIREWALLS BETWEEN THE TRANSFORMERS. FURTHER INSTALLATION, TESTING, COMMISSIONING AND CIVIL WORKS (FOUNDATION, FIREFIGHTING SYSTEM, TRENCHES, OIL PITS, E-STOP PUSH BUTTONS ETC) FOR TRANSFORMERS SHALL BE BY NCU-II CONTRACTOR.
 - d. COMMON BUILDING FACILITIES FOR BOTH MAH, STYRENE/OTHERS AND NCU-II SUCH AS 6.6/0.433kv,1250kVA TRANSFORMER, 415V PCC, 415V DB, LIGHTING TRANSFORMER, DC BATTERY CHARGER AND BATTERIES, HVAC SYSTEM, ECS SYSTEM AS REQUIRED SHALL BE IN MAH DETAIL ENGINEERING CONTRACTOR SCOPE OF WORK. INPUT REQUIRED FROM NCU-II AND STYRENE CONTRACTOR SHALL BE COORDINATED DURING DETAIL ENGINEERING STAGE.
 10. BATTERY ROOM SHALL BE PROVIDED WITH THE NECESSARY EXHAUST SYSTEM AND WATER CONNECTION WITH SINK. FLOOR OF THE BATTERY ROOM AND WALLS UP TO 1.5M HEIGHT SHALL HAVE ACID/ALKALINE RESISTANT PROTECTIVE EPOXY COATING. THE BATTERY ROOMS SHALL BE PROVIDED WITH MINIMUM TWO FLP EXHAUST FANS AND LOUVERED OPENING IN OPPOSITE WALL.
 11. IN ALL SUBSTATIONS/ MCC ROOMS, SPACE FOR FUTURE EXTENSION OF SWITCHBOARDS SHALL BE PROVIDED. ONE PANEL EXTENSION SPACE ON EACH SIDE (FOR EACH BUS SECTION) SHALL BE PROVIDED FOR ALL HV SWITCHBOARDS, PCC'S AND ASB'S.
 12. SUBSTATION BUILDING SHALL BE PROVIDED WITH AIR-CONDITIONING SYSTEM AND SHALL BE MAINTAINED AT A POSITIVE PRESSURE THROUGH PRESSURIZATION SYSTEM IN THE SWITCHGEAR ROOMS.
 13. TRANSFORMER BAYS SHALL BE PROVIDED WITH OVERHEAD REMOVABLE TYPE SHED OF SHEET METAL. SHED HEIGHT SHALL BE AT SUBSTATION FLOOR LEVEL AND MUST HAVE MAN HEIGHT CLEARANCE (I.E. AT LEAST 7FT FROM CONSERVATORS/TANK WHICHEVER IS HIGHER) FOR ANY MAINTENANCE ACTIVITIES. FOR 220KV SWITCHYARD LOCATION, REFER INTEGRATED OVERALL PLOT PLAN - PNCP AND MAH DRAWING NO. 359755-MDR-000-PIP-01-0002.
 - 14.

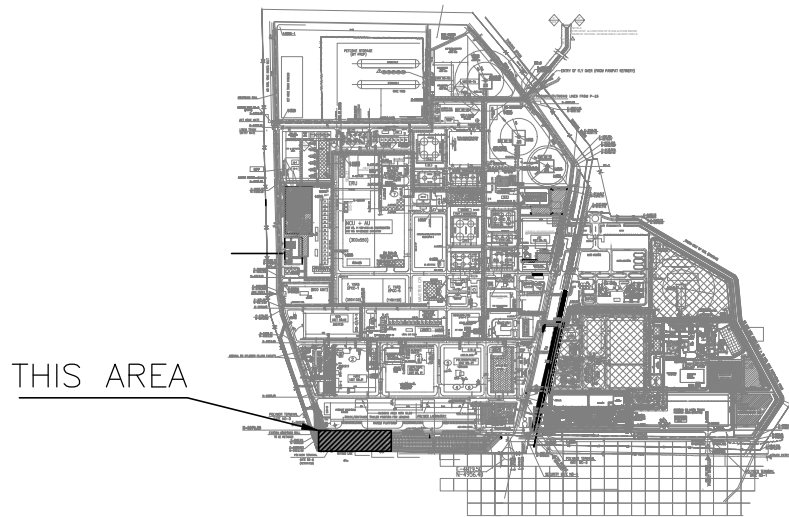
REFERENCE

DOC. NO.	TITLE
359755-MDR-000-PIP-01-0002	INTEGRATED OVERALL PLOT PLAN - PNCP AND MAH
359755-MDR-000-ELE-BOD-0001	ELECTRICAL ENGINEERING DESIGN BASIS
359755-MDR-000-ARC-02-0006	LAYOUT FOR SUBSTATION - 220KV

LEGENDS

△ : EQUIPMENT FRONT

KEY PLAN



0	15-MAY-2024	ISSUED FOR USE	PUN	SAT	SAT
REV NO	DATE		PREP BY	CHKD BY	APPD BY
PROJECT					
MALEIC ANHYDRIDE PROJECT AT PANIPAT REFINERY & PETROCHEMICAL COMPLEX					
OWNER					
 IndianOil					
INDIAN OIL CORPORATION LIMITED					
PMC		CB&I INDIA PRIVATE LIMITED			
		This Document or drawing is the sole property and copyright of MCDERMOTT COMPANY* and contains confidential and proprietary information. This Document or drawing cannot be reproduced, copied, retained or used, in whole or in part, without written consent of MCDERMOTT COMPANY. *Any company in which McDermott International, Ltd holds a controlling interest, either directly or indirectly, CBI India Pvt. Ltd. is a MCDERMOTT COMPANY			
LOA. No. & TITLE		359755	SDR Code	-	
TITLE					
SUBSTATION LAYOUT - 220KV GIS					
SCALE : 1:400		DWG.NO. 359755-MDR-000-ELE-51A1-0002			REV 0

SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR
PROJECT NAME: MALEIC ANHYDRIDE PROJECT
AT
PANIPAT REFINERY PETROCHEMICAL COMPLEX

DOC. NO.: 359755-MDR-000-ELE-SPC-0002



OWNER: INDIAN OIL CORPORATION LIMITED

MCDERMOTT

PMC: CB&I INDIA PRIVATE LIMITED

PMC JOB NO.: 359755

1	15-JAN-24	Issued for Use	SAT	SUL	VB
0	30-OCT-23	Issued for Use	SAT	SUL	ANK
REV	DATE	DESCRIPTION	PREPARED BY	CHECKED BY	APPROVED BY

“CONFIDENTIAL & PROPRIETARY INFORMATION” contained in this document (including drawings) is sole property & copyright of McDermott company¹ which cannot be reproduced, copied, retained, used, in whole or in part, without written consent of that McDermott company which is the proprietor or licensee of such information and/or document.

¹any Co. in which McDermott international, ltd. holds controlling interest. McDermott Co. includes “CB&I INDIA PVT. LTD”.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 2 of 32

REVISION HISTORY

REV.	REVISION DESCRIPTION
0	Issued for Use
1	Issued for Use



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 3 of 32

TABLE OF CONTENT

1.0	General	4
2.0	Codes And Standards	4
3.0	General Requirement	5
4.0	Site Conditions	5
5.0	Design And Fabrication Requirements	5
6.0	Switchgear Components	14
7.0	Inspection, Testing And Acceptance	29
8.0	Packing And Despatch	31
9.0	Deviations	31



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 4 of 32

1.0 GENERAL

1.1 Scope

This specification covers the basic requirements for the design, engineering, manufacture, inspection, testing at manufacturer's works, packing, supply, transportation, supervision to installation, commissioning, and testing at site of Extra High Voltage Gas Insulated Switchgear (GIS) & Gas Insulated Bus Duct (GIBD) for working voltages from 66 kV up to and including 400 kV complete with Local Control Cabinet (LCC), Control Relay Panel (CRP) and interconnecting cabling amongst GIS, LCC & CRP to be installed for M/s Indian Oil Corporation Ltd. (IOCL) for MAH Project at Panipat Refinery & Petrochemical Complex, Panipat, India.

2.0 CODES AND STANDARDS

2.1 The GIS equipment/ components used shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed and shall comply with the latest edition of Indian standard / International Standard including amendments and addenda but not limited to the following.

IEC 60099 - 4	Metal-oxide surge arresters without gaps for ac systems
IEC 60137	Bushings for alternating voltages above 1000 V
IEC 60255	Electrical Relays
IEC 60270	High-voltage test techniques - Partial discharge measurements
IEC 60376	Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment
IEC 60480	Guidelines for the checking and treatment of sulphur hexafluoride (SF6) taken from electrical equipment and specification for its re-use
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60694	Common specifications for high-voltage switchgear and control gear standards
IEC 61243-1	Live working Voltage detectors : Capacitive type to be used for voltages exceeding 1 kV a.c.
IEC 61639	Direct connection between Power Transformers and gas insulated metal enclosed switchgear for rated voltage 72.5 kV and above
IEC 61869-1	Instrument transformers — General requirements
IEC 61869-2	Additional requirements for current transformers
IEC 61869-3	Additional requirements for inductive voltage transformers
IEC 62271-4	Handling procedures for sulphur hexafluoride (SF6) and its mixtures
IEC 62271-100	Alternating current circuit-breakers
IEC 62271-102	Alternating current disconnectors (isolators) and earthing switches
IEC 62271-104	Alternating current switches for rated voltages of 52 kV and above
IEC 62271-110	High-voltage switchgear and controlgear - Inductive load switching
IEC 62271-203	Gas Insulated metal-enclosed switchgear for rated Voltages above 52 kV
IEC 62271-209	Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52kV-Fluid filled and extruded insulation cables-Fluid filled and dry type cable terminations



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 5 of 32

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

2.3 Any contradiction between various referred standards/ specifications/ data sheet and statutory regulations shall be brought to the attention of PMC/OWNER. Until the resolution is officially made by the Company Representative in writing, the most stringent requirement shall govern.

3.0 GENERAL REQUIREMENT

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.

4.0 SITE CONDITIONS

4.1 The EHV GIS & GIBD shall be suitable for installation and satisfactory operation in a pressurized substation or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

4.2 The switchgear shall be designed to operate under site conditions as specified in the data sheets and Electrical engineering design basis.

4.3 All equipment are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Enclosure and Protection

5.1.1 The switchgear shall be an indoor SF6 gas-insulated, metal enclosed design, assembled to form freestanding, self-supporting dead front structure. The degree of protection shall be at least IP65 for gas compartments and IP43 for low voltage and other compartments as specified in IEC-60529.

5.1.2 The switchgear assembly shall consist of completely separate, SF6 gas filled pressurized sections housing various switchgear components. The switchgear gas enclosures shall be sectionalized, with gastight barriers between sections/ compartments.

5.1.3 Each gas-filled compartment shall be equipped with static filters (e.g. molecular sieve or activated alumina or other absorbent), pressure switches, filling & draining valve with automatic shut off and safety diaphragm. The filters shall be capable of absorbing any water vapour which may penetrate into the enclosures as well as the by-products of SF6 created during interruption. Each gas compartment shall be fitted with separate non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.

5.1.4 The enclosures may be three phase enclosure or single-phase enclosure as per the standard design of the vendor.

5.1.5 The enclosure for the SF6 gas and associated circuit elements of enclosure shall be made from non-magnetic material e.g. AL/AL alloy. Enclosures of the same phase shall be electrically interconnected and shall be earthed at appropriate places. At appropriate points single phase enclosures should be connected to other phases, thus ensuring a return current path.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 6 of 32

- 5.1.6 The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions.
- 5.1.7 It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force.
- 5.1.8 All interlocks that prevent potentially dangerous mat-operations shall be constructed such that they cannot be operated easily, i.e. the operator shall use tools or brute force to over-ride them.
- 5.1.9 The switchgear shall have provision earth bus for connection to the plant earth grid running in the vicinity of the equipment.
- 5.1.10 The ladders and walkways shall be provided wherever necessary for access to the equipment. A portable ladder with adjustable height shall also be supplied for access to the equipment.
- 5.1.11 Any paints or other coatings that may be used shall be such that they will not deteriorate when exposed to the SF₆ gas and other vapours, arc products, etc. that may be present in the enclosures. They shall also not contain any substances which could contaminate the enclosed SF₆ gas or affect its insulating properties over a period of time.
- 5.1.12 GIS shall be provided with Online temperature monitoring system and Partial Discharge system.
- 5.1.13 All enclosure shall be suitable for withstanding full internal arcing fault without damage.

5.2 Accessibility & Maintenance

- 5.2.1 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 switchgear. All mounted equipment shall have identification tags of self-sticking tapes at the rear also. In addition, identification numbers shall be painted on the panel wall to give a permanent identification mark.
- 5.2.2 All terminals shall be shrouded with plastic covers to prevent accidental contact.
- 5.2.3 GIS components shall be installed and arranged to facilitate realistic access for maintenance and removal of equipment, with a minimum amount of disturbance to other equipment.
- 5.2.4 Each section shall have plug-in or easily removable connection pieces to allow for easy replacement of any component without removing another element or with the minimum of disturbance to another equipment. Inspection windows shall be provided for disconnect and earth switches.
- 5.2.5 For routine inspection and possible repairs, all elements shall be accessible without removing support structures. The removal of individual enclosure parts shall be possible without disturbing adjacent enclosures or entire breaker bays.
- 5.2.6 All special tools & tackles required for erection & maintenance of GIS & GIBD shall be provided by the vendor.

5.3 Bus Bar



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 7 of 32

- 5.3.1 EHV GIS Bus configuration (Single Bus or Double Bus or One and half breaker scheme) shall be provided as specified in the data sheets/ Job specification.
- 5.3.2 Bus bars shall be of high conductivity electrolytic aluminium.
- 5.3.3 The 3-phase bus bars shall be either housed in single phase enclosures or 3-phase enclosure as per vendor's design. All phase bus bars shall be of uniform cross-section and shall be sized to carry continuously the rated current specified in data sheet.
- 5.3.4 Bus bars and the supports shall be adequately sized and braced to withstand the specified short-circuit current without any permanent deformation. All bus supports shall be of non-hygroscopic, non-inflammable, non-carbonising material, resistant to acids and alkalies.
- 5.3.5 Bus bar earthing facilities for each section of the bus bars, completely interlocked with associated disconnectors & CBs of that section of bus bars including bus coupler / bus sectionaliser shall be provided.

5.4 Expansion and Flexible Connection for Enclosure / Conductors

- 5.4.1 Expansion joints / flexible connections shall be provided in the metal enclosure and conductors to absorb the actual or relative thermal expansion and contraction of the
- 5.4.2 Bus bar & equipment as well as structures resulting from variations of temperature of the switchgear equipment.
- 5.4.3 The number and position of the expansion joints / flexible connections shall be decided by the vendor to ensure that complete installation is not subjected to any expansion stresses which could lead to failure of any piece of the GIS equipment, supporting structures.
- 5.4.4 The electrical connections for the conductor expansion joints / flexible connections shall be made by means of multiple contact connectors preferably same as that provided at the joints between the separate gas compartments.
- 5.4.5 Metallic bellows (preferably of stainless steel) shall be provided over expansion joints.

5.5 Cable Termination

- 5.5.1 All power cables and control cables will be connected from below through cut-outs in the floor or through cable trench. Plug in terminations (including plugs, sockets) and all accessories shall be provided for power cables for all feeders including spare feeders by vendor.
- 5.5.2 Suitable arrangements of test plug / socket shall be provided which will permit full dielectric testing for outgoing cable of all cable feeders including primary current injection test for current transformers.
- 5.5.3 Unless otherwise specified, all control cables shall enter from the bottom. Supporting facilities shall be provided for clamping of control cables.
- 5.5.4 Single compression nickel plated brass cable glands & tinned copper lugs shall be provided by vendor for all cables to GIS assembly, LCC & CRP.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 8 of 32

5.6 Pressure Relief Device

- 5.6.1 Pressure relief devices shall be provided in each gas sections/ compartment to protect the main gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs. Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction. If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided to prevent pieces of the diaphragm or plug from flying out or any dangerous SF₆ arc product gases escaping, in a manner that could endanger personnel who may be present over there.
- 5.6.2 Pressure relief shall be provided for all EHV compartments including SF₆ gas & air insulated enclosures. Relief into cable cellar/ trench shall not be provided.
- 5.6.3 The set points for the pressure relief device shall be lower than pressure withstanding capability of the enclosure with sufficient margin.

5.7 Indication & Verification of Circuit Breaker, Disconnecter & Earth Switch Position

- 5.7.1 Mechanical indicators mounted external to the equipment shall be provided on all circuit breakers, disconnectors and earth-switches, which shall clearly show whether the earth switches/ CBs / disconnectors etc. are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.
- 5.7.2 Viewing windows shall be provided for all disconnectors and earth switches so that the switch contact positions can be verified by direct visual inspection. Viewing windows shall be of type, whereby the open / close position can be checked without any danger to the eyes even when a flashover occurs at that time. Wherever the inspection windows are not accessible, sight glass endoscope shall be provided.

5.8 Foundation Channels & Supporting Frame Works

- 5.8.1 The panels shall be suitable for installation on base frame supplied by vendor along with foundation bolts. Ample dimensioned oblong holes shall be provided at the bottom of the panels for their installation on the base frame. The panels shall be suitable for tack welding and bolting directly to the base frame. The panels with base frame shall be suitable for installation on panel supporting frame through tack welding.
- 5.8.2 All supporting steel structures above grade level for switchgear bays and all panels including SF₆ / Air Bushing support, GIDB support, inspection platform etc. shall be provided by vendor.
- 5.8.3 Details of suitable embedment in the foundation floor as required for supporting the switchgear assembly and panels, necessary supporting framework, levelling screws, inspection platforms etc. to fasten the switchgear base frames to the embedments in foundation floor shall be provided by vendor. Vendor shall provide drawing showing all details of the embedded parts and installation details required on the floor.

5.9 Nameplates



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 9 of 32

- 5.9.1 Engraved nameplates shall preferably be of 3-ply (Black-White-Black) lamicoide sheets or anodised aluminium. However back engraved perspex sheet nameplates are also acceptable. Nameplates shall be fastened by screws and not by adhesives. A weatherproof and corrosion proof name plate shall be provided and shall conform to applicable standards.
- 5.9.2 A nameplate with the switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving details of each feeder compartment of all panels shall be provided. Danger plate (Red) shall be provided at the front and rear for each panel.
- 5.9.3 Blank nameplates shall be provided for all spare feeders.
- 5.9.4 Each of the equipment devices including CB, Disconnect switch, Earthing switch, CT, VT and busbars etc. mounted inside the switchgear shall be provided with proper nameplate and rating plate. All information as per the latest edition of relevant IEC standards shall be included. Special warning plates shall be provided on removable covers or doors giving access to cable terminals and busbars.
- 5.9.5 Special warning labels shall be provided inside the switchgear also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.

5.10 Painting, Protective Finish / Corrosion Protection of Surfaces

- 5.10.1 The switchgear shall be treated and protected to withstand continuous operation under site conditions without sustaining corrosion or attacks from fungus or rodents. The protective finish shall prevent deterioration due to corrosion, humidity, temperature, ageing and weather etc. under site conditions.
- 5.10.2 All metal surfaces shall be thoroughly cleaned & degreased to remove mill scale, rust, grease and dirt. All exterior surfaces shall be cleaned and epoxy painted before leaving the factory with one coat of approved primer and two coats of approved equipment finish paint. 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 underside of all surfaces bearing upon the concrete foundation shall be given two coats of approved primer. The under surface shall be made free from all imperfections before undertaking the finishing coat. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint etc.
- 5.10.3 The exterior surface finish of switchgear paint shade shall be RAL-7032 unless specified otherwise.
- 5.10.4 Supporting framework shall be hot dip galvanized after fabrication.
- 5.10.5 Gas monitoring and service piping including all fittings and accessories shall be made of copper, brass or stainless steel.
- 5.10.6 Electrolytic corrosion shall be avoided in joints of different metals. Before the metal enclosed sections are joined together and charged with the SF₆ gas, they shall be thoroughly cleaned.

5.11 Auxiliary Cabling, Wiring and Terminals



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 10 of 32

- 5.11.1 Owner interface for remote control, metering, indication, alarm etc. of complete GIS equipment shall be at CRP only. Further external AC & DC control & auxiliary power supplies interface for complete GIS equipment shall be at designated LCC only.
- 5.11.2 All cables required amongst various components of GIS i.e. circuit breaker, disconnectors, earth switches, CT, PT, LCC, CRP etc. along with the cable glands & lugs shall be provided by the vendor. The cables shall be Cu conductor, FRLS, armoured type. These shall be suitable for directly laying in cable trays/ lined RCC trenches. Maximum distance between GIS/LCC and corresponding CRP shall be considered as 150 meters unless otherwise specified. Exact distances shall be informed during vendor drawing review based on the final locations of GIS/LCC and CRP.
- 5.11.3 Inside the cubicles, the wiring for control, signaling, protection and instrument circuits shall be done with FRLS type, copper conductor wire. The insulation grade shall be 660V. The wiring shall preferably be enclosed in plastic channels or neatly bunched together. Flexible conduits shall be provided for routing wiring between various compartments.
- 5.11.4 A minimum of 20% 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 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 CB, switches, auxiliary relays etc shall be wired up to the terminals.
- 5.11.5 5 Each wire shall be identified at both ends by correctly sized ferrules. The CT terminal blocks shall have shorting, isolation and injection test facilities whereas VT terminals shall have isolation and injection test facilities.
- 5.11.6 Copper conductor of cross section 1.5 mm² may normally be used for control fuse amps or less. For 16 amps control fuse circuit, 2.5 mm² copper conductors shall be used. CT Circuit wiring shall be done with 2.5 mm 2 copper conductors.
- 5.11.7 All inter-panel control wiring within each shipping section shall be done at vendor works. The inter-panel wiring shall be taken through 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 by vendor for connection at site.

5.12 Earthing

- 5.12.1 Vendor shall provide copper earth bus of GJS and copper earth conductors & associated hardware material for connecting all GIS equipment, earthing switches, surge arrestors, enclosures, cabinets, marshalling boxes, supporting structure, platforms & hand rails, operating handles of disconnector & earth switches etc. to the earth bus of GIS.
- 5.12.2 The GIS shall be earthed at several points so that there shall be earthed cage around all the live parts. A minimum of two nos. of earthing connections should be provided for each enclosure. The earthing continuity between each enclosure shall be effectively interconnected with Cu bonds of suitable size to bridge the flanges.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 11 of 32

5.12.3 LCC, CRP, power and control cable sheaths and other noncurrent carrying metallic structures shall be connected to the earthing grid. At least two earthing paths shall be provided to connect each point to the GIS earth bus.

5.12.4 Minimum earth bus size of 300 mm² copper for earthing of GIS equipment shall be provided.

5.12.5 All flexible earthing leads shall be of copper.

5.13 Interlocks

5.13.1 The interlock system shall positively prevent an Operator from reaching or creating unintentionally a dangerous or potentially dangerous condition.

5.13.2 All interlocks required between circuit breakers, disconnectors and earth switches shall be provided.

5.13.3 Specifically, the following conditions shall be impossible to reach:

- a) Electrically and manually closing or opening of the disconnector / earthing switch while the breaker is closed.
- b) Electrical closing of disconnector switch, while the earthing switch at the remote end is closed.
- c) Electrical closing of earthing switch while the remote end disconnector/circuit breaker is in closed position.
- d) Electrical & manually closing of busbar disconnectors of any circuit while the busbar earthing switch is closed.

5.13.4 When the manual emergency cranks are used, it shall be impossible to control the devices electrically.

5.13.5 Bus VT Miniature Circuit Breaker (MCB) ON auxiliary contacts and under voltage relay contacts shall be monitored in the interlocking scheme to confirm the dead bus condition.

5.13.6 Bus-bar disconnectors of any circuit shall not close electrically or manually while a Bus-bar Earthing Switch is closed.

5.14 Interface with ECS System

5.14.1 The Switchgear shall be hooked up with ECS system in accordance with project specification for ECS system.

5.14.2 All numerical relays shall be provided with IEC61850 communication protocol for interface with ECS system. The numerical relays shall be individually connected to Ethernet switches installed within the switchgear. The quantity of Ethernet switches shall be finalized by switchgear vendor. Minimum 20% spare ports shall be provided in each Ethernet switch.

5.14.3 Supply, installation, testing and commissioning of Ethernet switch, cables along with its accessories (eg. cable glands, lugs etc. as required) from HV switchboard relays to Ethernet Switch located inside the switchboard shall be by switchboard vendor.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 12 of 32

5.14.4 All digital multifunction meters shall be provided with Modbus communication protocol. All digital multifunction meters shall be provided with Modbus communication protocol.

5.14.5 Separate Marshalling cabinets shall be provided for ECS signal interface.

5.14.6 All multifunction meters inside the switchboard shall be looped to form a daisy chain by switchboard vendor for communication with ECS system.

5.15 Space Heaters

5.15.1 CRP & LCC shall be provided with space heaters to prevent moisture condensation and maintain cubicle temperature 5°C above the ambient. The space heaters shall be controlled through a double pole MCB and thermostat. Space heaters shall be supplied from 240V AC auxiliary supply.

5.16 Following equipment shall be supplied along with GIS as mandatory spares:

5.16.1 SF6 Gas Leakage Detector

The detector shall be portable, battery operated with built in battery charger, hand held type and having a minimum SF6 gas leakage sensitivity of 5gm/year. The test kit shall be compatible for EMI/EMC environment as per IEC 1000. The equipment shall have on/off switch & suitable indicating lamps/LEDs, variable pitch audible signal for leakage indication, and a head phone jack. The equipment shall have automatic zeroing of background signals suitable for detecting SF6 gas leakage in charged substation.

5.16.2 Gas filling and evacuating plant

- a) This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas. The capacity of the temporary storage facilities shall be at least be sufficient for storing the maximum quantity of gas that could be removed from at least one phase of one complete Bay (switchgear and associated equipment) or continuous bus section (whichever is higher).
- b) The minimum capacity of evacuation plant will be as under:
 - Vacuum Pump: 60 M3/Hour (Nominal suction pressure)
 - Compressor: 15 M3/Hour (Delivery).

5.16.3 SF6 gas analyser

The SF6 gas analyser should be of portable type and instruments shall have following features:

- a) In-built calibration facility.
- b) Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.
- c) Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.
- d) Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.
- e) Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 13 of 32

- SF6 purity – Range: 0-100% & Accuracy: +/- 0.5 %
 - Dew point - Range : -60 to +20 °C & Accuracy: +/- 0.5 °C
 - SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %
 - CF4 – Range : 0-60% volume & Accuracy : +/- 1 %
 - HF - Range : 0-200 ppm & Accuracy : +/- 5 %
- f) Instrument should work on AC source as well as on rechargeable battery
- g) Input pressure: upto 10 bar
- h) It should be housed in a robust IP67 case with wheels

5.16.4 Portable Partial Discharge(PD) monitoring system

- a) The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.
- b) It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect partial discharges in cable joints and terminations.
- c) Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc. Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed by the contractor.
- d) The equipment shall meet the following requirements:
- Measurement shall be possible in noisy environment.
 - Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.
 - Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.
 - The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/ 50 Hz input.
 - Measurement shall be possible in the charged substation/ switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be furnished for evaluation during detail engineering.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 14 of 32

- Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Laptop PC, diagnostic and expert interpretation software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.
- e) The function of software shall be covering the following:
- Data recording, storage and retrieval in computer
 - Data base analysis
 - Template analysis for easy location of fault inside the GIS
 - Evaluation of PD measurement i.e. Amplitude, Phase Synchronization etc.
 - Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
 - Expert software system for accurate interpretation of cause of PD.
 - Report generation.
- f) To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.
- g) Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS.
- h) Calibration: The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site sensitivity checks during commissioning of PDM system. The data sheet/ frequency response characteristics shall be submitted for reference.
- i) Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory

5.16.5 SF6 topping system

SF6 topping system shall be provided for 220 kV GIS for filling/ topping up SF6 gas to panel under energized condition manually.

6.0 SWITCHGEAR COMPONENTS

6.1 Circuit Breakers

6.1.1 General

- a) The circuit breakers shall be in 3 phase enclosure or single phase enclosure as per vendor standard design. They shall be electrically, mechanically, hydraulically trip free as applicable and anti-pumping with both of the trip circuits connected.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 15 of 32

- b) Pole discrepancy tripping shall be provided which shall detect discrepancy in opening of contacts. Local electrical operation shall be provided from the local control cabinet. An emergency manual trip device & mechanical operation counter shall be provided in the breaker kiosk. The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies.

6.1.2 Duty Cycle (Operating Mechanism)

- a) Circuit breaker shall be C2 - M2 class as per IEC 62271-100.
- b) Circuit breaker shall meet the duty requirements for any type of fault or fault location & also for line charging and dropping as applicable and perform make and break operations as per the stipulated duty cycles satisfactorily.
- c) The CB shall be suitable for carrying out the duty cycle of 0-3.0 minutes-CO-3.0 minutes - CO.

6.1.3 Pre-Insertion Resistor (if specified in job specification/ datasheet)

The circuit breakers for transmission line bay shall be provided with single step pre insertion closing resistors/Controlled switching devices to limit the switching surges to a value of less than 2.3 p.u. The value of the pre-insertion resistor and the duration of pre-insertion time shall be as designed by vendor.

6.1.4 Construction Features

- a) The circuit breakers shall be SF6 type. The circuit breakers shall be of single pressure type / self-blast type and shall utilize puffer cylinder for arc interruption. Each SF6 CB pole shall preferably be with single interrupting chamber. Each SF6 circuit breaker pole shall be provided with its own self-contained gas system.
- b) The service connections for gas handling shall be located on each pole tank to facilitate servicing. The breaker shall be designed to ensure that condensation of moisture is controlled by proper selection of organic insulating materials having low moisture absorbing characteristics, complete drying of container and breaker, selection of 'O' ring, etc.
- c) Materials such as activated alumina or molecular sieve shall be provided at appropriate locations as moisture absorbents. Also suitable absorbents for removing SF6 arc products shall be employed.
- d) Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

6.1.5 Breaker Contacts

- a) Main contacts shall be of copper with silver plating and have ample area & contact pressure for carrying the rated current and the short time rated current of the breaker without excessive temperature rise which may cause pitting or welding. Contacts shall have a minimum of movable parts and adjustments to accomplish these results. Main contacts shall be the first to open and the last to close so that there will be little contact burning and wear.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 16 of 32

- b) Arcing contacts, if provided, shall be the first to close and the last to open and shall be easily accessible for inspection and replacement. Tips of arcing and main contacts shall be silver faced or have tungsten alloy tipping. Provision shall be made for rapid dissipation of heat generated by the arc on opening.
- c) If multi-break interrupters are used, they shall be so designed and augmented that a fairly uniform voltage distribution is developed across them.

6.1.6 Operating Mechanism

- a) General Requirements
 - i Circuit breaker shall be operated by spring charged mechanism or electro- hydraulic mechanism or a combination of these.
 - ii Main poles shall operate simultaneously. The design of the circuit breaker shall be such that contacts will not close automatically upon loss of gas/ hydraulic pressure.
 - iii The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.
- b) Operating Mechanism Control
 - i The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons.
 - ii Two (2) independent tripping circuits, valves, pressure switches, and coils shall be provided for each operating mechanism.
 - iii For all HV Variable frequency drive feeders, breaker shall be additionally provided with under voltage release. However, in case it is not possible to provide under voltage release in the standard design, as an alternative, one shunt trip coil shall be suitable for 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 datasheet.
 - iv A local manual closing device shall also be provided for maintenance purpose.
 - v Direction of motion of handle shall be clearly and indelibly marked.
 - vi Electrical tripping shall be performed by shunt trip coils. Provisions shall be made for electrical control from LCC & CRP.
 - vii The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker.
 - viii Breaker tripping, closing and spring charging devices shall be fed with DC control power supply. Closing coil and associated circuits shall operate correctly at all values of control voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker at all values of supply voltage between 70% and 110% of rated voltage.
 - ix Pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts shall be used for each of tripping and closing circuits.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 17 of 32

- x The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.
 - xi The breakers shall have at least 4 normally open (NO) and 4 normally closed (NC) spare auxiliary contacts for Owner's use. If these are not available, auxiliary relays shall be used to multiply the auxiliary contacts of the breakers.
- c) Hydraulic Operated Mechanism
- i Hydraulic operated mechanism shall comprise self-contained operating unit with power cylinder, control valves, high and low pressure reservoir, pressure gauge, necessary piping, compressor and motor, etc. A hand pump set shall also be provided for emergency operation.
 - ii The piping shall be seamless type and of non-corrodible material such as SS or Brass. The joints shall be welded except at the equipment terminal ends.
 - iii Oil required for initial filling including make-up of usual losses during commissioning and leakages shall be supplied by vendor.
- d) Hydraulic Monitoring Device:
- i Hydraulic pressure system shall be monitored as follows:
 - "Hydraulic first level": this gives an alarm if, after a predetermined time interval, the hydraulic pressure is not returned to its nominal setting. Pressure switch contact to open for alarm.
 - "Hydraulic second level": this will give an alarm indication if the pressure drops below the minimum operable pressure, i.e. mechanism locks out.
 - Hydraulic motor Excessive start: alarm to be provided.
 - Hydraulic motor: excessive running of motor alarm to be provided.
 - ii ' Motor on overload' condition shall be tripped and 'trip' and 'supply failure' conditions shall be annunciated. In the event that non bio-degradable fluids are used, containment trays shall be provided to prevent a spillage.
- e) Spring operated Mechanism
- i Spring operated mechanism shall be complete with motor. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.
 - ii Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided.
 - iii Closing action of circuit breaker shall compress the opening spring ready for tripping.
 - iv When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the LCC.
 - v Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 18 of 32

- vi A mechanical indicator shall be provided to indicate the status of the spring.
- vii Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in closed position.
- viii The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

6.2 Disconnectors & Earthing Switches

6.2.1 General

- a) Disconnectors and Earthing switches shall be of single-pole, group operated type, installed in the switchgear to provide electrical isolation with one motor operated mechanism per three poles. The disconnectors and earth switches shall conform to IEC- 62271-102.
- b) The disconnector shall be MI class operated.
- c) High speed make proof earthing switches shall be EI class operated. Safety earthing switches shall be EO class operated.
- d) Electric motor shall be suitable for DC control supply and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit. The associated circuits shall operate correctly under all values of supply voltage between 85% and 110% of rated voltage.
- e) Disconnectors shall be suitable to make and break the charging currents during their opening and closing. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.
- f) All line side earth switches like Maintenance ES or HSES point shall be insulated type through bushings with withstand capacity of bushing as per IEC requirements.

6.2.2 Constructional Features

- a) The disconnector shall be provided with high current carrying contact surfaces of silver faced copper/silver faced aluminium.
- b) Arrangement shall be provided to permit manual operation of the disconnectors & earthing switches. Whenever the manual handle is inserted into the drive mechanism, it shall not be possible to control the device electrically. Manual operating handle shall be provided with pad lock. The contacts shall be mechanically disconnected during the manual operation.
- c) The disconnectors shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.
- d) The disconnectors and safety earthing switches shall have a mechanical key (pad locking key) and electrical inter-locks to prevent closing of the earthing switches when disconnectors are in the closed position and to prevent closing of the disconnector when the earthing switches are in the closed position.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 19 of 32

- e) The disconnectors & earth switches shall be capable of being padlocked in both fully open and fully closed positions with the operating motor automatically disengaged. The padlock shall be visible and directly lock the final output shaft of the operating mechanism. Integrally mounted lock instead of pad lock can also be provided.
- f) One man shall be able to operate the disconnector/ earthing switch (when manually operated) without undue effort.

6.2.3 Operating Mechanism Control

- a) Disconnectors and earthing switches shall be motor operated, with limit switches and controlled from the LCC and CRP. Connections, interlocking requirements and auxiliary switches shall be provided as per the requirements.
- b) The operating mechanism design shall be such that during the operation of the earth switch (especially manual operation), the moving blades once they reach the sparking distance, springs shall take over to give a quick, snap action closing so that the earth switch closing is independent of manual efforts. Similarly, the springs shall assist during the opening operation to give quick breaking feature.
- c) Disconnectors and earthing switch shall be provided with a mechanism with stored energy to always ensure completed operations.
- d) The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.
- e) Each disconnector, earth switch shall have at least 4 normally open (NO) and 4 normally closed (NC) spare auxiliary contacts for Owner's use.

6.2.4 Additional Requirements for Safety Earthing Switches

- a) Earthing switch, whenever possible can form an integral part of each pole of the disconnector. Two independent earthing pads each with flexible copper braids and suitable connectors for the specified size of earth conductor lead shall be provided at the hinge end of the earthing switch.
- b) Interlocks shall be provided so that manual operation of the earthing switches or insertion of the manual operating device will disable the electrical control circuits.

6.2.5 Additional Requirements for High Speed Make Proof Earthing Switches

- a) High speed make proof earthing switch shall have make proof contacts and high-speed stored energy operating mechanism to enable them suitable to close on to a fault.
- b) High speed earth switches shall be motor driven stored energy operated. After removal of the earth initiated by a fault making earth switch, it shall be possible to re-energize the system without first carrying out the maintenance.
- c) The short circuit making current rating of each earthing switch shall be at least equal to its peak withstand current rating as applicable. The switches shall have inductive / capacitive current switching capacity as per IEC 62271-102.
- d) All portions of the earthing switches and operating mechanism required for connection to earth shall be connected together utilizing copper conductor.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 20 of 32

- e) The main earthing connection on earthing switch shall be rated to carry the peak withstand current rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate design for connection to the earthing grid.

6.3 Surge Arrestors

- 6.3.1 The surge arrestors shall conform in general to IEC 60099-4.
- 6.3.2 The surge arrester shall be of heavy-duty station class and gapless (Metal oxide) type without any series or shunt gaps.
- 6.3.3 The surge arresters shall be capable of discharging over-voltages occurring during switching, lightning impulse etc.
- 6.3.4 The surge arresters shall be provided with a discharge counter located at an accessible position.
- 6.3.5 The nonlinear blocks shall be of inferred metal oxide material. These shall be provided in such a way so as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.
- 6.3.6 The main earthing connection from the surge arrester to the GIS earth bus shall be provided. The size of the connecting conductor shall be such that all the energy is dissipated to the earth without getting overheated.

6.4 Local Control Cabinet

- 6.4.1 Local Control Cabinet (LCC) for each bay shall be supplied. LCCs shall be either separate free-standing floor mounted type panel or mounted on GIS assembly as per vendor's standard design. If separate LCCs are provided, these will be located near GIS.
- 6.4.2 LCC shall be in dust and vermin proof hot dipped galvanized sheet steel construction. Hinged doors giving access to the components shall be provided.
- 6.4.3 Local control of all CBs, disconnectors & earthing switches shall be possible from LCC through control switches & selector switches with all associated interlocks. LCC panels shall house alarms and facia annunciation etc. of GIS including GIS gas pressure system. The LCC shall also be used for termination of CT and PT cables from GIS bay.
- 6.4.4 Two (2) numbers of 415V, TPN, 50 Hz, power supply feeders will be provided by Owner at one location in the LCC for complete switchgear. Further power supply distribution for each LCC and to CRP shall be done by vendor.
- 6.4.5 Two (2) numbers of 220V DC supply feeders will be provided by Owner at one location in the LCC for complete switchgear. Further DC power supply to each LCC and to each CRP shall be done by vendor.
- 6.4.6 The incoming external control supplies (AC & DC) shall be monitored continuously and alarm shall be given on failure. Vendor shall supply all necessary equipment and control for automatic change over from one source of control supply to the other in the event of failure of one source I contactor drop out.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 21 of 32

6.4.7 An isolating switch for disconnection of power supply, open/close push buttons, magnetic contactor with thermal overload relays and HRC link type fuses for sh011 circuit protection shall be provided in LCC for each individual motor of CB, disconnecter and earth switch.

6.4.8 Local Alarm & Annunciation

- a) Alarm contacts shall be provided for monitoring of all vital systems of each circuit breaker and SF6 gas system.
- b) Window type alarm annunciation shall be provided on LCC of each bay for the various abnormal conditions.
- c) Potential free electrical contacts shall be provided for remote alarm / indication of all alarm condition. These contacts shall be in addition to those required for local indication. These shall be wired to the terminal blocks in the LCC.
- d) The following minimum number of abnormal conditions shall be annunciated.
 - i Gas refill level for each gas compartment of the bay. (low gas pressure)
 - ii Breaker Block level for each gas compartment of the bay. (low low gas pressure)
 - iii Zone isolation level for each gas compartment of the bay.
 - iv Over pressure for each gas compartment of the bay.
- e) In addition to the minimum abnormal conditions listed above, any other abnormal condition as per the vendor shall also be annunciated.
- f) Mimic diagram preferably shall be provided.

6.4.9 All current transformer leads shall be terminated on shorting type terminal blocks in the LCC and shall be accessible at all times. All potential transformer leads shall be terminated and protected by MCB.

6.4.10 All other devices shall be wired to terminal blocks provided in the LCC. The terminal blocks shall have minimum 20% spare terminals per cabinet.

6.5 Control Relay Panels

6.5.1 Separate Control Relay Panel (CRP) for each bay shall be supplied to facilitate control of circuit breakers, disconnectors, earth switches and metering, protection etc.

6.5.2 CRPs shall be free-standing floor mounted type panel to be located in separate room adjacent to GIS hall. CRP shall be in dust and vermin proof hot dipped galvanized sheet steel construction.

6.5.3 A mimic diagram shall be provided on the front of the panel with control switches and position indicators for CB, disconnecter and earth switches. The panel shall be dead front type with front door having clear glass cut-out of adequate size so that mimic diagram, annunciator windows, indicating lamps are clearly visible from outside.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 22 of 32

6.5.4 CRP shall house bay control units (BCUs) and protection relays. These panels shall also house the various selector switches, auxiliary relays, timers, local indications, alarms and facia annunciation window etc. to realize various interlocks as per requirement among circuit breakers, disconnectors and earth switches and for breaker pole discrepancy, anti-pumping etc. It shall include the following as minimum:

- a) Local / off/ remote selection switch
- b) TNC control switch for breaker
- c) Breaker ON, OFF, Trip-1, Trip-2, Trip circuit healthy indications
- d) Disconnector & earth switches ON, OFF control switches & indications
- e) DC supply healthy indication
- f) Spring charging devices status
- g) Aux. relays/ other devices as required by the design.

6.5.5 Completely separate and isolated circuits shall be used for each operating mechanism control, trip-1, trip-2, close, alarms and auxiliary devices. Close and trip circuits shall be kept isolated to their final mechanical or electrical actuators from the CRP terminals.

6.5.6 Trip circuit-1 & trip circuit-2 shall be individually monitored for continuity under open and closed condition of breaker. Close circuit shall be monitored under open condition of breaker.

6.5.7 The contacts and signals originating from/going to the GIS, associated auxiliary and monitoring equipment shall be wired up to the CRP, for external use.

6.5.8 Measuring Instruments

All analogue instruments shall be of square pattern, 96 x 96 mm, flush-mounted type. Measuring instruments, shunts, transducers, CTs, VTs, etc, shall be provided, as specified in data sheet. The accuracy class for all instruments shall be 1.0 unless otherwise specified.

Digital meters shall also be acceptable, provided specific approval of PMC/ Owner for make and model is obtained. All digital meters shall be highly reliable, accurate, and compact and self-powered. Digital meter data shall be saved in case of power failure. Field programming from front of the meter shall be possible and shall have RS232/485 port in case specified in the job specification/data sheet.

- a) Ammeters and Voltmeters

Analogue meters shall be of moving-iron type. The range shall be indicated on the drawings.

- b) 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 VT secondary voltage of 110 V.

- c) Frequency Meters

These shall be of direct-reading or digital type and shall operate on a VT secondary voltage of 110V. The standard range shall be 45-50-55 Hz.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 23 of 32

d) Power Factor Meters

Power factor meters shall operate on a VT secondary voltage of 110 V. The standard range shall be 0.5 lead-1.0-0.5 lag.

6.5.9 Relays

- a) Type of relay i.e. electromechanical, static or numerical / bay control unit shall be as defined in datasheet / job specification.
- b) All electromechanical protective relays shall be back-connected, of draw-out 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.
- c) 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.
- d) 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.
- e) All tripping relays 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. Tripping relays will be acceptable in non-drawout cases.
- f) The tripping relay shall be suitable for satisfactory operation from 50% to 110% of the specified control supply voltage.
- g) Numerical relays /bay control unit shall be equipped with communication port to work as an integrated part of the substation automation system. Multifunctional device (bay control and protection unit) shall be with control, indication, metering, protection, mimic, communication/ interface functions.

6.5.10 Alarm & Annunciation

- a) Potential free electrical contacts shall be provided for remote alarm / indication of all alarm/trip condition. These contacts shall be in addition to those required for local indication at LCC. These shall be wired to the terminal blocks in the CRP.
- b) The following minimum no of abnormal conditions shall be annunciated.
 - i Hydraulic motor overload/ circuit trouble
 - ii Hydraulic first level (low hydraulic pressure)
 - iii Hydraulic second level (Low-Low Hydraulic pressure)
 - iv Disconnecter / earth switch motor overload (one per each bay)
 - v Circuit breaker motor overload (one per each bay)
 - vi DC control supply failure
 - vii Common gas alarm for the bay



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 24 of 32

- c) In addition to the minimum abnormal conditions listed above, any other abnormal condition as per the vendor shall also be annunciated.

6.5.11 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.

6.5.12 All other devices shall be wired to terminal blocks provided in the CRP. The terminal blocks shall have no less than 20% spare terminals per panel.

6.6 Current Transformers

6.6.1 The current transformers and accessories shall conform to IEC: 61869-1&2 and other relevant standards.

6.6.2 The short time rating shall be equal to that of the switchgear. 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 0.5 or 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. Separate CTs shall be provided for Differential and Restricted Earth Fault protection. One leg of CTs shall be earthed.

6.6.3 The current transformers shall be of metal- enclosed and epoxy cast resin type and shall be given tropicalized treatment for satisfactory operation in hot and humid climate. The current transformers shall have effective electromagnetic shields to protect against high frequency transients.

6.6.4 The CT secondary terminals shall be brought outside the EHV enclosures through a bushing of 1.1 kV class and mounted in accessible terminal box. All secondary leads shall be wired to shorting type terminals on the terminal strip in the local control cabinet of each breaker bay. All terminals shall be shrouded with plastic covers to prevent accidental contact.

6.6.5 All CTs shall be star connected. Interposing CT (JCT) shall be provided (if required) for differential protection of transformers having star-delta connection.

6.7 Voltage Transformers

6.7.1 The voltage transformers shall conform to IEC 61869-1&3.

6.7.2 The voltage transformers shall be of inductive type with manual integrated isolating device, non-resistant and shall be contained in their own compartment. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients.

6.7.3 Voltage transformer secondary shall be protected by 4 pole MCB for all the windings. The secondary terminals of the VT's shall be terminated to the stud type non-disconnecting terminal blocks in the secondary boxes.

6.7.4 The terminals of the secondary winding shall be brought out of the enclosure through 1.1 kV class bushing. Secondary terminals of each phase shall be located in accessible earthed terminal box on the VT enclosure itself. Neutral side of HV winding shall be brought out through a bushing rated for at least 1.1 kV class and located in a terminal box.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 25 of 32

6.8 Auxiliary equipment

6.8.1 Auxiliary Relays and Contactors

- a) 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.

6.8.2 Control Switches

- a) All control switches shall be rotary type, having a cam-operated contact mechanism. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles.
- b) The Local/off/remote switch shall be three positions type, lockable, key free in remote positions only with the following functions:
 - i Local position (the breaker, disconnector and earthing switches can only be operated locally by its control switches).
 - ii Off position (the breaker, disconnector and earthing switches cannot be operated electrically).
 - iii Remote position (the breaker and disconnector can only be operated from Remote).
- c) 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.

6.9 SF6 Gas Supply

6.9.1 SF6 gas shall comply with the requirements of IEC 60376, 60376A & 60376B, at the time of the first charging & shall be suitable in all respects for use in the switchgear under all operating conditions.

6.9.2 SF6 gas necessary for initial filling (including entire losses, if any, during HV testing, Pre-commissioning / commissioning) and make-up gas for leakages of the complete switchgear shall be supplied by vendor.

6.9.3 The initial gas pressure or density at the time of charging the equipment shall provide a 10% margin above the allowable operating pressure for the plant to be safely operated for a reasonably long period before recharging is necessary.

6.9.4 In addition, 10% of total gas requirement shall be supplied in separate cylinders as spare requirement by vendor.

6.10 SF6 Gas Monitoring Devices and Alarm Circuits

6.10.1 All gas compartments shall have their own independent gas supervision and alarm systems. There shall not be any interconnection between different gas compartments for the purpose of gas monitoring.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 26 of 32

6.10.2 Individual temperature compensated gas pressure gauge(s)/ density device(s) shall be provided in each of the gas compartments which will continuously & automatically monitor and indicate the state of gas density as follows:

a) Compartments except circuit breaker

i 'Gas Refill' level

This will be used to annunciate on the LCC and CRP the need for the gas refilling.

ii 'Zone Trip' level

This is the minimum level at which the vendor will guarantee the insulation rating of the assembly (i.e. one minute power frequency voltage, BIL specified). At this pressure level it will be annunciated on the LCC/ CRP so that manual tripping of the circuit should be done.

b) Circuit Breaker

i 'Gas Refill' level

This will be used to annunciate on the LCC and CRP the need for the gas refilling.

ii 'Breaker Block' level

This is the minimum gas density at which the vendor will guarantee the rated fault interrupting capability of the breaker. Beyond this level the device contacts lock out the breaker (trip and close operation) circuits and annunciate the condition on the LCC and CRP.

c) High pressure interlock and monitoring device shall be provided.

d) Necessary contacts for remote annunciation shall be provided.

e) Pressure gauges or density monitors shall have two-stage temperature compensated pressure (gas-density continuous monitoring) switches with 6.5-20mA analog output.

f) Analog signals shall be available on IEC 61850 protocol for reporting to SAS. Vendor shall consider necessary hardware for converting 6.5-20mA signal to IEC61850 protocol for reporting to SAS.

6.10.3 Vendor shall provide an independent pressure switch for isolation of the particular zone. This alarm level shall be provided to indicate abnormal pressure rise in the gas compartment.

6.10.4 Pressure switches and pressure gauges / density devices shall be located at accessible location suitable for viewing.

6.10.5 It shall be possible to test all gas monitoring devices without de-energising the primary equipment and without reducing pressure in the main section.

6.10.6 Gas Leakage Loss

a) Maximum guaranteed gas leakage loss of the switchgear shall be in no case be more than 0.5% per year over the life time of the switchgear. Initial filling of equipment shall guarantee gas service period of not less than 10 years.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 27 of 32

- b) All gas seals shall be designed to ensure that leakage rates are kept to an absolute minimum under all normal pressure, temperature, electrical load and fault conditions. All gas seals located in the flanges of the equipment enclosures shall be of the O -ring type.

6.11 SF6 Gas Handling Plant/ Service Cart

6.11.1 Portable SF6 gas handling & processing unit suitable for evacuating, liquefying, evaporating, filling, drying and purifying SF6 gas during the initial installation, subsequent maintenance and future extension of GIS shall be provided. The cart shall be equipped with rubber wheels and shall be easily maneuverable within the building.

6.11.2 The unit shall be self-contained suitable for 415 V AC, 3-phase, 50 Hz power supply and fully equipped with an electric vacuum pump, gas compressor, gas drier, gas filter, refrigeration unit, evaporator, gas storage tank, full instrumentation for measuring vacuum, compressor inlet temperature, tank pressure and temperature, valving and piping to perform the following operations as a minimum requirement:

- a) Evacuation from a gas filled compartment using the vacuum pump,
- b) Transfer of SF6 gas from a system at some positive or negative pressure to the storage tank via the gas drier and filter,
- c) Recirculation of SF6 gas in the storage tank through the drier,
- d) Recirculation of SF6 gas in any Switchgear or bus duct compartment through the drier and filter,
- e) Evaporating and filling SF6 gas,
- f) Drawing off and liquefying SF6 gas,
- g) A combination operation of filling SF6 gas into a gas system and evacuating a second, gas system using the vacuum pump.

6.11.3 The unit shall be complete with all necessary instrumentation and control which may include instruments such as decomposition tester, hygrometer, test unit for the density monitors, precision pressure / density gauge and vacuum gauge.

6.11.4 The unit shall include necessary gas cylinders for replenishment and for temporary storage of the evacuated SF6 gas. The capacity of the storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed from the largest compartment of GIS + 10% extra SF6 gas when carrying out maintenance or repair work on the switchgear and associated equipment.

6.11.5 Adequate length of hoses shall be provided for filling of SF6 gas in any of the gas compartment with the help of gas cart.

6.12 Insulators & Gas Seals

6.12.1 The support insulators and section barriers/ insulators shall be of solid moulded composite epoxy resin. They shall be free from all voids and with smooth surface and the design shall be such so as to reduce the electrical stresses in the insulators to a minimum.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 28 of 32

6.12.2 Gas section barriers including seals to the conductor and enclosure wall shall be gas-tight and shall be capable of withstanding the maximum differential pressure that could occur across the barrier, i.e. with a vacuum drawn on one side of the barrier and on the other side, at least twice the rated gas service pressure that can exist under normal operating and maintenance conditions or the maximum gas over-pressure, equal to the operating pressure of the relief devices, that could be attained with internal arc fault.

6.12.3 All gas seals shall be designed to ensure that leakage rates are kept to specified minimum under all pressure, temperature, electrical load and fault conditions. Double gas seals with provision to monitor the failure of first seal shall be preferred to single gas seal leakage.

6.13 Voltage Detectors

6.13.1 Each outgoing & incoming bays and main busbars shall include capacitive type voltage detectors for each phase to indicate phases "ALIVE". The unit shall also be suitable for interlocking of earthing switches (voltage free condition).

6.14 Outdoor SF6 - Air Bushings

6.14.1 Outdoor SF6 - Air bushings, for the connection of conventional external conductors to the GIS shall generally be in accordance with the requirements of IEC 60137 as applicable.

6.14.2 Bushing type shall be any of the following:

- a) Condenser type bushings, liquid filled with liquid level gauges clearly visible from ground level, preferably of the direct reading prismatic type or the magnetic type. Other types of liquid level gauges will be accepted if specifically approved.
- b) The bushings with composite insulators (Silicone rubber) or with porcelain insulators with all surfaces free from imperfections. The internal insulation of the bushings shall be resin impregnated paper winding (RIP body) or compressed SF6 gas. The internal and external electrical field of the bushings shall be controlled by a capacitive grading body /grading shields. The RIP body shall consist of resin impregnated paper insulation with concentric aluminium layers. The space between the RIP body and the insulator shall be filled with insulating foam compound or compressed SF6 gas. Air bushings shall comply with the relevant IEC standards.

6.14.3 Bushings shall be designed to have ample mechanical strength and rigidity for the conditions under which they will be used. Outdoor bushings shall be capable of withstanding a cantilever force applied to the terminal.

6.14.4 All current carrying parts shall be of Copper. Hardware used for current carrying parts (such as nuts, bolts etc.) shall be 304 Grade or brass. All current carrying contact surfaces shall be silver faced.

6.14.5 The flange shall be made of weather resistant, corrosion proof material. Suitable arrangement for connection of flange to earth shall be provided. If required, corona ring shall be provided which will be of Copper I Brass.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 29 of 32

6.14.6 6 Porcelain shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Glazing of the porcelain shall be of uniform brown colour free from blisters, bums and similar other defects.

6.14.7 The parameters characterising the SF₆- Air bushing profile shall be such that it is suitable for "Very heavy" pollution level (salt contamination) prevailing at the site and also suitable for fixed type hot line washing. The creepage distance over the external surface of outdoor bushings shall not be less than 31 mm/kV.

6.14.8 Puncture strength of bushings shall be greater than the dry flash-over value. When operating at normal rated voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion / erosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action.

6.14.9 All joints shall be air-tight. Surface of the joints shall be trued-up; porcelain parts by grinding and metal parts by machining. Bushing design shall be so as to ensure uniform compressive pressure on the joints.

6.15 Gas Insulated Bus Duct

6.15.1 The Gas insulated bus duct shall be 3 phase enclosure or single phase enclosure as per vendor standard design comprising of straight lengths, bends, elbows, gas seals and accessories such as flanges, gaskets, fixing hardware etc.

6.15.2 Bus bars shall be of high conductivity electrolytic aluminum.

6.15.3 The enclosure for the bus duct shall be made from non-magnetic material e.g., AL/AL Alloy.

6.15.4 6.15.4 The busduct shall be capable to withstand the mechanical and thermal stresses due to short circuit currents, as well as thermal expansion and contraction created by temperature cycling.

6.15.5 The busduct shall be suitable for outdoor installation.

6.15.6 The bus duct shall not be supported from the wall when crossing from indoor to outdoor. Necessary accessories supports etc. including wall frame assemblies shall form part of supply. Necessary bellows with sealing arrangements shall be provided.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 General

7.1.1 During fabrication, the equipment shall be subjected to inspection by PMC / 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 vendor shall furnish all necessary information concerning the supply to PMC / Owner's inspectors.

7.1.2 All the equipment should have been successfully type tested as per the relevant standards. Type tests shall not have been conducted earlier than five years. In case the type tests were conducted earlier than 5 years, such type tests shall be carried out by the vendor free of cost before commencement of supply.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 30 of 32

- 7.1.3 Test certificates of bought out components shall be shown to the inspection agency on demand during inspection.

7.2 Type Tests

Type test should have been carried out as per relevant IEC standards at a recognized and well-reputed test laboratory. The following type test certificates shall be available for verification as evidence of successful completion of type tests.

- a) Test to verify the insulation level of the equipment including partial discharge test and dielectric tests viz (i) Lightning impulse test (ii) Switching impulse test (iii) One min, p.f. test (iv) Partial discharge test.
- b) Test to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit.
- c) Test to prove the ability of the main and the earthing circuits to carry the rated peak and the rated short time withstand current.
- d) Test to verify the making and breaking capacity of circuit breaker.
- e) Test to prove the satisfactory operation of switching devices i.e., circuit breaker, disconnector, earth switch.
- f) Tests to prove the strength of enclosures.
- g) Test for degree of protection of the enclosure.
- h) Tests to assess the effects of arcing due to an internal fault (internal arc test).
- i) Gas tightness tests.
- j) Type tests on Circuit breakers, disconnectors, earth switches, surge arrestors, CT, PT etc as per the relevant standards.

7.3 Routine Tests

Switchgears and their components including LCC & CRP shall be subjected to routine tests as per the relevant IEC standards/ project inspection and test plan, not limited to the following in the presence of PMC/ Owner's representatives. Testing of GIS with LCC shall be done at vendor's works.

- a) Power frequency voltage test
- b) Partial discharge measurement tests.
- c) Voltage test on auxiliary and control circuits
- d) Test to verify the resistance of the Main Circuit
- e) Enclosure pressure test on each gas compartment.
- f) Insulation resistance test with 2 kV on all auxiliary circuits.
- g) Complete mechanical operation tests.
- h) Complete test of interlocking devices.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page 31 of 32

- i) Check of wiring
- j) Functional tests of all auxiliary devices including all protective relays, alarm, control and trip circuits.
- k) Visual and dimensional checks.
- l) Gas tightness test
- m) Pressure test on partitions
- n) Acceptance test on SF6 gas
- o) Any other tests as per vendor's recommendation.

8.0 PACKING AND DESPATCH

- 8.1** The equipment shall be carefully packed for transport by sea, rail and road in wooden crates / cases in such a manner that it is protected against the climatic conditions and for any damage during transportation, transit and storage.
- 8.2** The SF6 equipment shall be shipped in the largest factory assembled units within transport and loading limitations and considering handling facilities on site to reduce the erection and installation work on site to a minimum. Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner.
- 8.3** Each individual piece to be shipped, whether crate, container or large unit, shall be marked special notations such as 'Fragile', 'This side up ', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., and other details as per purchase order.
- 8.4** 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.
- 8.5** Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment.
- 8.6** All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided. Any seals, gaskets, 'O' ring s, etc. that will be used as part of the arrangement for sealing off gas sections for shipment of site, shall not be used in the final installation of the equipment at site. Vendor to provide quantity of components accordingly considering permanent installation.

9.0 DEVIATIONS

Deviations from this specification are only acceptable where the SELLER has listed in his quotation the requirements he cannot or does not wish to comply with and the BUYER has accepted, in writing, the deviations before the order is placed. If the SELLER is also to offer alternatives resulting in technical or price advantages, he should submit a supplement to the main quotation.



SPECIFICATION FOR EHV GAS INSULATED SWITCHGEAR

MCDERMOTT

359755-MDR-000-ELE-SPC-0002 Rev. 1

Page **32** of **32**

In the absence of deviation list at quotation, it will be assumed that all the requirements of the specification are met.

**MANDATORY SPARES****MCDERMOTT**

359755-MDR-000-PRM-LST-0001 Rev. 0

Page 27 of 33

6.0 ELECTRICAL

SL. No.	DESCRIPTION	QUANTITY
A.	EHV GIS with LCP and CRP	One set of spare for each GIS, LCP and CRP (Separate, wherever applicable)
	SF6 Gas Leakage Detector	1 set
	SF6 Gas Analyzer	1 set
	Portable Partial Discharge Monitoring System	1 set
B	EHV Power Transformer	
	Dissolved Gas Analysis kit	2 Nos.
	Online Moisture Removal System - Filters	10% or minimum 2 Nos. of each type & rating
	Online Moisture Removal System - Cartridges	10% or minimum 2 Nos. of each type & rating
C	EHV Power and HV Power Transformer (one set of spares for each rating)	
1	Bushing of each type with metal parts	1 set
i	H V	1 set
ii	M V	1 set
iii	Neutral	1 set
2	Complete set of gaskets	1 set
3	Magnetic oil level gauge with 1 set of contacts	3 nos.
4	Oil temp. indicator with A/T contacts	2 nos.
5	Double float Buchholz relay	1 nos.
6	Pressure Relieving device	1 no.
7	Silica gel breather	1 nos.
8	Valves	One of each type
9	Winding temp. indicator with A/T contacts	1 nos.
10	Set of fuses of each rating for MB cubicles.	10 nos. for each rating
D	HV SWITCHGEAR (One set of spares per switchboard)	
1	Digital multifunction meters	1 no. for each bus
2	Spring charging motor	3 nos.

**MANDATORY SPARES****MCDERMOTT**

359755-MDR-000-PRM-LST-0001 Rev. 0

Page 28 of 33

3	Closing coils	1 no. of each rating / type
4	Shunt Trip coil	1 no. of each rating / type
5	Bus support insulator	5 nos.
6	Control fuses (all types & ratings)	10 nos. for each rating
7	Indicating lamps	10 no for each colour
8	Limit switch for spring charging motor	2 nos.
9	Breaker control switch	2 nos.
10	Auxiliary switch	2 nos.
11	Push buttons	2 nos.
12	Anti Pumping contactor	2 nos.
13	Meter of each type	1 No of each type.
14	Vacuum bottles	5 nos. each rating
15	CT and PT (all types and ratings)	3 nos. for each type & rating
16	All protection. relays	Two relay of each type
17	Ammeter	1no ach type and rating
18	Voltmeter	1no each type and rating
19	Panel limit switches and interlocking switches	5 nos.
20	Panel operating switches (all types)	One no of each type
21	Male pads	One set each for all types
22	Breaker limit switches & interlocking switches	5 nos.
23	Panel gasket	1 set
24	Panel door keys	2 nos
25	Control terminal blocks	15 nos. of each type
E	MV SWITCHGEAR (One set of spares per switchboard)	
1	Panel limit switches & interlocking switches	5 of each type
2	Power / control fuse links (all types & ratings)	10 of each type & rating
3	Contactors	1 no for each rating
4	Intelligent Motor Control unit	1 no for each rating
5	Push button unit	5 nos
6	Indicating lamps	10 nos. of each colour
7	Control terminal block	10 of each type
8	Ammeter & Voltmeter of each type	2 No. of each type and rating
9	Digital multifunction meters	One for each bus
10	Bus Insulators	10 nos.
11	CT/ PT/Control Transformer (all types and	3 nos. for each type & rating



MANDATORY SPARES

MCDERMOTT

359755-MDR-000-PRM-LST-0001 Rev. 0

Page 29 of 33

	ratings)	
12	Closing coils	1 no. of each rating / type
13	Shunt trip coil	1 no. of each rating / type
14	All protection -relays	Two no. of each type
15	Male pads	One set each for all types
16	Breaker limit switches & interlocking switches	2
17	Gasket	One set
18	Door keys	2 nos.
19	Control connectors	2 set each for all types
F	LIGHTING FIXTURE (One set of spares for each type of lighting fixture)	
1	LED lighting fixture	2 nos. of each type and rating
2	Bulbs	5 nos. of each type and rating
3	Driver	5 nos. of each type and rating
G	UPS SYSTEM (One set of spares for each rating of UPS)	
1	SCR of all types & ratings	2 set of each rating
2	IGBT of all types & ratings	2 set of each rating
3	PCBs of all types	1 set
4	Control fuses	10 for each rating
5	Power fuses	10 for each rating
6	Switching module with static switch	1 set
7	Power supply card	1 set
8	Operating console card / control logic card	1 set
9	Cooling fans	2 nos. each
H	VARIABLE VOLTAGE AND VARIABLE FREQUENCY DRIVES (One set of spares for each rating of VSD)	
1	Rectifier Control Module	1 set
2	Thyristor module	1 set
3	Inverter control unit	1 set
4	IGBT driver card	1 set
5	IGBT	2 nos. for each rating
6	PCB of each type	1 no.
7	Control fuse	20% or one no (min) of each rating and type, whichever is more.
8	Power fuse	20% or one no (min) of each rating and type, whichever is more.



MANDATORY SPARES

MCDERMOTT

359755-MDR-000-PRM-LST-0001 Rev. 0

Page **30** of **33**

9	Control cards	One set
10	Power supply card	One set
11	Relays	1 no. for each type of rating
12	Contactors	5 nos. for each type of rating
13	CT/PT	One no. for each type & Rating
14	Cooling fans	Two set of each type
15	Limiters & protection devices	One set
16	Indicating lamps	5 of each colour
I	BATTERY (One set of spares for each type & rating of Battery)	
1	Cell Container with cover per set	2 nos.
2	Vent plugs per set	2 nos
3	Acid level indicator(float) per set	2 nos
4	Inter cell connector per set	2 nos
5	Nut, bolts and washer per set	2 nos
J	INDUCTION MOTORS	
1	Bearing set (DE & NDE)	1 set of each type and make
2	Motor Fan	1 set of each Frame Size
3	Terminal studs / bushing assembly	One no. for each motor rating / Stud size
K	SYNCHRONOUS MOTOR	
1	Rotating Diodes	6 Nos each type and make
2	Power Supply unit for Exciter	1 No each type and make
3	Metering and Protection CTs	3 No for each type and rating
4	Terminal studs / bushing assembly	One no. for each motor rating / Stud size
5	Bearing Set (DE & NDE)	1 set of each type and make
L	DC SYSTEM (One set of spares for each type & rating of Charger)	
1	SCR / Thyristor of all types & ratings	1 set of each rating and type.
2	PCBs of all types	1 set
3	Control fuses	10 for each rating
4	Power fuses	10 for each rating
5	All type of cards such as Power supply card, input and output cards, processor cards etc.	1 no. of each type and rating.
6	Blocker diode	Two nos.
7	Bridge diode for float charger	1 no. for each rating of SCR
8	Bridge diode for float cum boost charger	1 no. for each rating of SCR



MANDATORY SPARES

MCDERMOTT

359755-MDR-000-PRM-LST-0001 Rev. 0

Page **31** of **33**

9	Potentiometer	2 no's
10	Filter condenser	2 no's
11	Semiconductor HRC fuses for float charger	10 nos. for each rating of fuses
12	Semiconductor HRC fuses for float cum boost charger	10 nos. for each rating of fuses
13	Battery tap circuit blocking diode	2 nos.
M	GIS (One set of spares per switchboard)	
1	Numerical Relays	2 no. for each type of rating
2	CT/ PT/Control Transformer (all types and ratings)	3 nos. for each type & rating
3	Power and control fuses	10 nos. for each rating
4	SF6 gas leakage detector	1 set
5	Digital multifunction meters	1 no. for each bus
6	Indicating lamps	5 of each colour
N	SCADA / ECS	
1	All cards such as input & output cards, power supply cards, processor cards etc.	One No of each type
2	All control fuse	10 Nos of each rating & type
3	Interposing relays	5 Nos. of each type
O	SOFTSTARTER (One set of spares for each rating of Soft Starter)	
1	Thyristors/IGBT/IGCT/IEGT/SGCT	1 set
2	PCB of each type	1 no.
3	Control fuse	10 nos. for each rating
4	Power fuse	10 nos.for each rating
5	Control cards	One set
6	Power supply card	One set
7	Relays	2 no. for each type
8	Contactors	5 nos. for each type of rating
9	CT/PT	One no. for each type & Rating
10	Cooling fans	Two set of each type
11	Limitors & protection devices	One set
12	Indicating lamps	5 no. of each color

**MANDATORY SPARES****MCDERMOTT**

359755-MDR-000-PRM-LST-0001 Rev. 0

Page 32 of 33

P	CURRENT LIMITING REACTOR (One set of spares for each rating)	
1	Oil temp. indicator with A/T contacts	1 No.
2	Winding temp. indicator with A/T contacts	1 No.
3	Silica gel breather	1 No.
4	Pressure Relieving device	1 No.
5	Magnetic oil level gauge with 1 set of contacts	1 No.
6	Double float Buchholz relay	1 No.
7	Set of fuses of each rating for MB cubicles.	10 nos. for each rating
8	Complete set of gasket	1 set
Q	Solar Photovoltaic System	
1	Power Thyristor / Transistors / IGBT / IGCT	1 No. of each rating & type
2	Control cards	1 No. of each type
3	Power supply cards	1 No. of each rating and type
4	Cable connectors	10% or minimum 2 Nos. of each type

Notes :

1. The word 'TYPE' means the Make, Model no., Type, Range, Size/ Length, Rating, material as applicable.
2. Wherever % age is identified, Contractor shall supply next rounded figure.
3. The terminology used under 'Part Description' is the commonly used name of the part and may vary from manufacturer to manufacturer.
4. Mandatory spares as indicated above do not cover commissioning spares.
5. Mandatory spares as indicated above do not cover two year O&M spares.
6. Mandatory spares shall be applicable for electrical items of motors / sub- packages as per mandatory spares philosophy specified elsewhere in the bid document.

Spare mentioned separately in Electrical design basis shall also be supplied if differ from the above list. In the case of similar items, list with more numbers shall be supplied.

INSPECTION & TEST REQUIREMENT FORM FOR EHV GAS INSULATED SWITCHBOARDS (GIS)

PROJECT NAME: MALEIC ANHYDRIDE PROJECT
AT
PANIPAT REFINERY PETROCHEMICAL COMPLEX

DOC. NO.: 359755-MDR-000-INS-ITP-0037



OWNER: INDIAN OIL CORPORATION LIMITED

MCDERMOTT

PMC: CB&I INDIA PRIVATE LIMITED

PMC JOB NO.: 359755

0	26 th Dec 2023	Issued for Use	SOP	RAD	APD
REV	DATE	DESCRIPTION	PREPARED BY	CHECKED BY	APPROVED BY

This Document or drawing is the sole property and copyright of MCDERMOTT COMPANY* and contains confidential and proprietary information. This Document or drawing cannot be reproduced, copied, retained or used, in whole or in part, without written consent of MCDERMOTT COMPANY.

*Any company in which McDermott International, Ltd. holds a controlling interest, either directly or indirectly. CB&I India Pvt. Ltd. is a MCDERMOTT COMPANY



**INSPECTION & TEST
REQUIREMENT FORM FOR EHV
GAS INSULATED
SWITCHBOARDS (GIS)**

MCDERMOTT

359755-MDR-000-INS-ITP-0037 – Rev 0

Page 2 of 8

Contents

1.0 Purpose	3
--------------------------	----------



INSPECTION & TEST REQUIREMENT FORM FOR EHV GAS INSULATED SWITCHBOARDS (GIS)

MCDERMOTT

359755-MDR-000-INS-ITP-0037 – Rev 0

Page 3 of 8

1.0 Purpose

The purpose of the document is to establish the minimum inspection and test requirement for EHV Gas insulated Switchboards (GIS).

CLIENT : IOCL – PANIPAT	PMC : MCDERMOTT
PMC JOB NO. : 359755	INSPECTION CATEGORY : C
ITEM: EHV GAS INSULATED SWITCHBOARDS (GIS)	APPLICABLE CODE : As per MR / PR, PS
Tag No. :	MR / PR NO. :

SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	TPIA
1.0	Procedure						
2.0	Material Inspection						
2.1	Incoming Material like Basic HT kit with Circuit Breaker/ Disconnecter and Earthing Switches, SF6 Gas Properties, Checks On Tank, Plating of Joints, Bus Bars, Fabricated Items, Static Filters, Safety Diaphragm, Pressure Relief Devices, Valves, Expansion Bellows, Pipe Fittings, Bus Bar Sleeves, Cable Wire (FRLS), Instrument Transformers, Relays, Indicating Instruments, Switches, Breakers, Surge Arrestor, Hooters, Push Button etc. as applicable	Visual, Dimensional, Operational/performance checks, Review of Manufacturer's Certificates etc. as applicable	100%	TC'S/ Inspection Test Records/ Lab test records	H	H/R	R
3.0	In Process Inspection						
3.1	Breaker Truck Assembly	Mechanical Operation including spring charging mechanism (current and time) / electro hydraulic mechanism (As applicable), Breaker opening closing at normal and worst voltage conditions, Stroke, Opening / closing time and speed, bouncing time,	100% By supplier and random by TPJA	Test Records/ Inspection Witness Records	-	H	RW



INSPECTION & TEST REQUIREMENT FORM FOR EHV GAS INSULATED SWITCHBOARDS (GIS)

MCDERMOTT

359755-MDR-000-INS-ITP-0037 – Rev 0

Page 4 of 8

SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	TPIA
		simultaneous closing of all poles, Contact resistance measurement, Gas leakage check (for SF6 breakers), Insulation resistance test, High voltage/ Power Frequency, partial discharge test					
3.2	Disconnecter and earthing switches	Breaker Duty Cycle Test Visual checks. Mechanical and electrical interlocks •Insulation resistance test. •High voltage/Power frequency test.	100% By supplier and random by TPIA	Test Records/ Inspection Witness Records	-	H	H
3.3	Wiring checks	Size, type, make termination, ferruling, continuity, color coding	100%	Supplier Test record	-	H	R
4.0	FINAL INSPECTION						
4.1	Switchgear Assembly	ACCEPTANCE TESTS: Visual check including layout, Tag plates, Paint shade, Bus marking and sleeving, Joint shrouding, Earthing arrangement, safety features, accessibility of arcing contact, Identification and location of components etc • Dimension check including operational height, Bus bar size, Clearances, Head room from gland plate to terminal link, mounting arrangement for CTs, VTs	100%	Test Records/ Inspection Witness Records	-	H	H



INSPECTION & TEST REQUIREMENT FORM FOR EHV GAS INSULATED SWITCHBOARDS (GIS)

MCDERMOTT

359755-MDR-000-INS-ITP-0037 – Rev 0

Page 5 of 8

SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	TPIA
		Compartmentalization, cable gland size, Paint thickness etc. • Verification of Bus bar support arrangement with respect to type tested panel drawings and provision for external cable termination. • Bill of material check . Density/pressure switches indication /operation checks. Operation check of circuit breaker operation counters. • Mechanical/Electrical interlock checks of Circuit breaker/Isolator /earthing switches* • Operation check for auxiliary equipment circuits and auxiliary contacts • Operation checks for all control functions and interlocks as per schematic diagrams in Service position including mechanical interlock check. • Functional/operation checks on LCC panel including alarm, indication, annunciation, mimic diagram display etc. • Functional/ operation checks on CRP panel including alarm, indication, annunciation, mimic diagram display,					



INSPECTION & TEST REQUIREMENT FORM FOR EHV GAS INSULATED SWITCHBOARDS (GIS)

MCDERMOTT

359755-MDR-000-INS-ITP-0037 – Rev 0

Page 6 of 8

SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	TPIA
		relays, auxiliary contact etc. • HV and IR checks on LCC & CRP panel. • Relay operation check through secondary injection.* • Primary current injection test for all current and voltage transformers.* • Measurement of resistance of main circuit. • Communication check between relays and Data concentrator / HMI (if applicable)* • HMI operation and functional checks as per separate agreed ITP/FAT (if applicable) Insulation resistance of main, auxiliary and control circuits before and after High Voltage Test. • Power Frequency voltage withstand test on main, auxiliary and control circuits. • Partial discharge test • Enclosure pressure test and Leak Tightness checks. • Acceptance test on SF6 Gas *					
4.2	Switchgear Assembly	TYPE TESTS • Short time current withstand test on main and earthing circuit. • Temperature Rise test.	On Each Type / Model	Test Report	-	R/W**	R/W**



INSPECTION & TEST REQUIREMENT FORM FOR EHV GAS INSULATED SWITCHBOARDS (GIS)

MCDERMOTT

359755-MDR-000-INS-ITP-0037 – Rev 0

Page 7 of 8

SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	TPIA
		• Internal Arc test. • Lighting Impulse, Switching impulse, Power Frequency withstand Test and partial discharge test(Dielectric test) • Making and breaking capacity test of circuit breaker • Short circuit test duties for Circuit breaker. • Tightness test and pressure withstand test for gas filled compartment. • Operation and mechanical endurance test • Degree of protection for panels. • Electromagnetic compatibility (EMC) test on circuit breaker					
4.3	Disconnecter and Earthing Switches	TYPE TEST • Operation and mechanical endurance test • Short time and peak withstand capacity test. • Measurement of contact resistance • Temperature rise test • Impulse and power frequency withstand test • Electromagnetic compatibility test • Degree of protection test.	On Each type/Model	Test Report	-	R/W**	R/W**
4.4	Surge arrestor, CT,PT	Type test as per relevant IEC	On Each type/Model	Test report	-	R/W**	R/W**
5.0	Painting						



INSPECTION & TEST REQUIREMENT FORM FOR EHV GAS INSULATED SWITCHBOARDS (GIS)

MCDERMOTT

359755-MDR-000-INS-ITP-0037 – Rev 0

Page 8 of 8

SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	TPIA
5.1	Painting of panels (prior to assembly)	•Pre treatment, primer and final paint, shade, thickness	On Each type/Model	Test Report	-	R/W**	R/W**
6	Documentation & IC						
6.1	Documentation & Inspection certificate (IC)	•Review of Internal Test Reports •Certification from supplier for complete relay parameterization of 100% numerical relays at works IC issuance.	100%	Supplier's Test Records/ Inspection Certificate	-	H	H
6.2	Final Document submission	Compilation of Inspection reports, drawings, etc. as per VDR / PR	100%	Final data folder/ Completeness certificate	-	H	H

LEGEND : 1) TPIA – THIRD PARTY INSPECTION AGENCY APPOINTED BY SUPPLIER, 2) PMC - MCDERMOTT 3) OWNER – INDIAN OIL CORPORATION LIMITED (IOCL), 4) H – HOLD (OFFER FOR WITNESS & OBTAIN CLEARANCE), 5) W - WITNESS, 6) RN - RANDOM WITNESS, 7) A – REVIEW & APPROVE, 8) R – REVIEW ONLY, 9) P – PERFORM, 10) X – REQUIREMENT OF RECORD.

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. For orders placed on stockiest, items shall be accepted based on manufacturer's TC with EN10204 type 3.2 certification from approved suppliers.

SPECIFICATION FOR 3D MODEL REVIEW

**PROJECT NAME: MALEIC ANHYDRIDE PROJECT
AT
PANIPAT REFINERY PETROCHEMICAL COMPLEX**

DOC. NO.: 359755-MDR-000-PIP-SPC-0034



OWNER: INDIAN OIL CORPORATION LIMITED



PMC: CB&I INDIA PRIVATE LIMITED

PMC JOB NO.: 359755

0	11-Oct-23	Issued for Use	YT	RM	RM
REV	DATE	DESCRIPTION	PREPARED BY	CHECKED BY	APPROVED BY

“CONFIDENTIAL & PROPRIETARY INFORMATION” contained in this document (including drawings) is sole property & copyright of McDermott company¹ which cannot be reproduced, copied, retained, used, in whole or in part, without written consent of that McDermott company which is the proprietor or licensee of such information and/or document.

¹any Co. in which McDermott international, ltd. holds controlling interest. McDermott Co. includes “CB&I INDIA PVT. LTD”.



SPECIFICATION FOR 3D MODEL
REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 2 of 15

SPECIFICATION FOR 3D MODEL REVIEW

REVISION HISTORY	
REV.	REVISION DESCRIPTION
0	Issued for Use



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 3 of 15

TABLE OF CONTENT

1.0	INTRODUCTION	4
2.0	ABBREVIATIONS, CODES & STANDARDS	4
2.1	ABBREVIATIONS	4
2.2	CODES & STANDARDS	4
3.0	3D-CAD MODEL.....	5
3.1	GENERAL	5
3.2	DESIGN CRITERIA ASPECTS	5
3.3	INSTRUCTION.....	5
3.4	MODEL REVIEW FEATURES.....	5
4.0	3D MODEL REVIEW	6
4.1	GENERAL	6
4.2	RECORDING OF COMMENTS	6
4.3	3D MODEL REVIEWS.....	6
4.4	SCOPE OF 3D MODEL REVIEW.....	6
4.4.1	30% MODEL REVIEW	6
4.4.2	60% MODEL REVIEW	7
4.4.3	90% MODEL REVIEW	7
4.4.4	SUPPLIER PACKAGE 3D MODEL REVIEW	8
5.0	ORGANIZATION OF A MODEL REVIEW	8
5.1	GENERAL	8
5.2	3D-CAD MODEL REVIEW	8
5.2.1	TOOLS	8
5.2.2	TEAM COMPOSITION	9
5.2.3	METHOD OF CHECKING MODELLING.....	9
5.2.4	Following Reference Documents Shall be Included for The Model Review	10
5.2.5	MODEL REVIEW REPORT	10
5.2.6	HANDLING OF COMMENTS.....	10
	APPENDIX-1.....	12
	APPENDIX-2.....	14



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 4 of 15

1.0 INTRODUCTION

IOCL is planning for installation of facilities for setting up grass root Maleic Anhydride (MAH), Butane Diol and Tetra Hydrofuran (BDO/THF) Unit along with Utility Boiler, Effluent Treatment Plant, Demineralization and Condensate polishing unit, Cooling Tower and all required Offsite facilities including Storage Tanks, Loading Gantries, Dispatch facility, Substation, Control room and other plant / non-plant buildings.

The project shall be implemented at Panipat Refinery and Petrochemical Complex (PRPC) located at Panipat, Haryana. PRPC includes two major complexes namely Panipat Refinery (PR) and Panipat Naphtha Cracker Complex. Currently Panipat Refinery expansion for augmentation of crude processing capacity from 15 to 25 MMTPA is under implementation (P-25 project). As a part of further Petrochemical expansion, following major Units are proposed to be installed under Naphtha Cracker Complex of PRPC along with associated and offsite facilities.

The purpose of this document is to outline the minimum requirements for the 3D Model Reviews for the project.

2.0 ABBREVIATIONS, CODES & STANDARDS

2.1 ABBREVIATIONS

Code	Description
AG	Above Ground
CAD	Computer Aided Design
UG	Under Ground
CCTV	Closed Circuit TeleVision
P&ID	Piping & Instrument Diagram
PFD	Process Flow Diagram
HVAC	Heating, Ventilation, and Air Conditioning
MVAC	Mechanical, Ventilation, and Air Conditioning
IFC	Issued for Construction
GA	General Arrangement
CSA	Civil, Structural and Architecture
HSE	Health, Safety & Environment

2.2 CODES & STANDARDS

None



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 5 of 15

3.0 3D-CAD MODEL

3.1 GENERAL

The 3D-CAD model is a collection of graphical data which describes the facilities of a plant for visualization purposes. The project 3D-CAD modelling tool to be used shall be E3D. The graphical data is often an integral part of an engineering database supporting the design process. An important advantage of a 3D-CAD engineering database is the possibility to maintain consistency between the produced documents and to assist the co-ordination of work among different disciplines. It enables the EPC Contractor to integrate the different design stages and the different subjects, such as piping, foundations, structures, equipment, electrical and instrumentation into one 3D-CAD model. It also facilitates the easiness of review by OWNER/PMC and assists during plant operation and maintainability.

3.2 DESIGN CRITERIA ASPECTS

The 3D-CAD system shall be structured in such a way that all disciplines involved can check whether engineering criteria have been met with respect to safety, constructability, operability and maintenance. This shall include accessibility for maintenance and fire fighting, location of valves, convenience of construction, process instrumentation, routing of the piping adequate for the process, location of emergency shut-down stations, proper and safe location of vents and drains, location of fire protection, fire-fighting equipment, escape routes, cable laying, underground facilities like piping, pits, UG vessels etc.

3.3 INSTRUCTION

The 3D-CAD model shall be used for training and instruction of plant operators, construction personnel, maintenance personnel and emergency response teams.

3.4 MODEL REVIEW FEATURES

The required features shall be agreed between the Owner/PMC and the EPC Contractor before the set-up of the 3D-CAD system and the engineering database starts.

The application of 3D-CAD model allows the following.

1. Definition of classified 3D-shapes to indicate envelopes for
 - Safety
 - Access / escape corridors
 - Head room clearances
 - Valve hand wheels
 - Reach / clearances for activities
2. Access envelopes for
 - Maintenance equipment
 - Operability
 - Escape routes
3. Modeling of foundations and underground system



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 6 of 15

4. Consistency between the 3D-CAD model and the P&ID

4.0 3D MODEL REVIEW

4.1 GENERAL

The 3D-CAD model used during the design reviews shall be a frozen copy of the live engineering database being used for development of the project. Any necessary changes shall be agreed upon and immediately recorded and shall be marked with tag numbers to avoid misunderstanding.

4.2 RECORDING OF COMMENTS

Model review comments shall be made directly into the design review system. The comments shall be numbered automatically by the system. All comments and “actions by” shall be agreed in the meeting to avoid any misunderstanding.

Comments recorded during the review will be transferred to the Model Review Report. The report will attach model snapshots showing comment locations. As a general principal the words “consider”, “investigate” and “review” should be avoided whilst recording comments unless the action required is by Owner/PMC or process engineering.

4.3 3D MODEL REVIEWS

The Owner/PMC and EPC Contractor shall review the models for all areas jointly. The model review agenda shall indicate the extent of each model review area and illustrate the geographical coverage of each review.

4.4 SCOPE OF 3D MODEL REVIEW

3D model reviews shall be performed in the following three stages. The items listed below shall be completed for these model reviews and shall not be limited to:

4.4.1 30% MODEL REVIEW

The 30% model review shall be performed to confirm the plot plan dimensions, and conceptual layout, for further development considering the items listed below.

The minimum contents of modeling for the 30% model review shall be

- Location of all mechanical equipment
- Platform access to spacers / spades in large bore lines (Lines 8” & Above)
- Construction and maintenance aspects verified
- Dropout, bundle pulling and laydown areas
- Check escapes routes
- Pipe racks, Technological structures and main Sleepers shown
- Building in outline (Compressor house, Analyzer shelters)
- Location of access roads shown and maintenance access ways



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 7 of 15

- Stationary foundations shown.
- Packaged unit located (Only outline)
- Major critical piping that determines equipment locations which has undergone initial stress analysis considerations.
- Outline of underground electrical, instrumentation trenches and piping headers.
- Main Electrical and instrument Cable racking
- Major safety distance requirements

4.4.2 60% MODEL REVIEW

The 60% model review shall be made to review and confirm the detailed plant design such as piping systems, underground facilities, cable trays, platforms and ladders, etc.

The minimum contents of modeling for the 60% model review shall be

- Operation and maintenance aspects verified
- Dropout, bundle pulling, laydown areas and davit drop zones
- Final dimensions of structures and steel constructions
- Permanent cranes and hoisting beams
- All foundations and footings shown
- Orientation of equipment nozzles
- Packaged unit orientation (Only outline)
- Orientation of ladders, stairs, platforms on vessels and columns
- Safety shower and eye washer locations
- 2" and larger piping for process, 6" and larger for utility
- Major and special pipe supports.
- Stress comments incorporate for 10" and larger piping
- Fire fighting equipment (hydrants, monitors, water spray systems, etc) located
- All underground piping
- Underground sewer systems and collecting and separation systems
- Concrete slabs and paving
- Electrical and instrument Main & Sub Cable racking (& supports)
- Instruments on equipment and in-line instruments
- Local control panels
- Clash checks complete
- Location & content of utility stations

4.4.3 90% MODEL REVIEW

The 90% model review shall be substantially completed, including instrumentation.

The minimum contents of modeling for the 90% model review shall be

- Remaining lines (1.1/2" and smaller piping)
- Operation and maintenance aspects verified.



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 8 of 15

- Dropout, bundle pulling and laydown areas
- Secondary steelworks and bracing
- Platform for valves and operation
- Outline of steam tracing manifolds
- Stress comments incorporate for 8" and smaller piping
- Packaged unit (Supplier model graphics attached)
- Instrument junction boxes, CCTV
- Fire & Gas detection locations
- Remote mounted Instruments / Telecom equipment
- Local Control Stations for Electrical Motors
- Plant and Area Lighting Fixtures.
- All Electrical Field Junction Boxes
- Clash checks complete

4.4.4 Supplier Package 3D Model Review

The items inside Supplier Packages shall be reviewed separately in Supplier Package 3D Model Review post 60% 3D Model Review. Respective supplier shall present their 3D model and comments from those will be tagged and closed according to clause 5.2.5 and 5.2.6 of this specification.

Supplier Model graphics shall be imported into main model by the EPC Contractor and shall be part of 90% 3D Model Review.

5.0 ORGANIZATION OF A MODEL REVIEW

5.1 General

The EPC Contractor shall give invitation (at least 14 days) before the review date, and inform the type of review and number of drawings, which are the basic documents for the constructed model at the time of the notice to Owner/PMC. 3D model Review file shall be made available to the OWNER/PMC at least 7 days before the start of the Model review.

5.2 3D-CAD Model Review

5.2.1 Tools

- A 3D-CAD model presentation shall be performed using Navisworks. The system will have sufficient capacity to allow the display of a complete model of at least one area or unit of a plant. The computer system will be of sufficient capacity to move easily through the model, rotate the view angle around the model items and search a particular model item. Point-to-point distance measurements will be possible on request.
- Reference items, mobile cranes, bundle pulling equipment, etc. and an operator shall be available.



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 9 of 15

- Plot plan drawings, PFD and P&ID, which have been used for developing the model, shall be made available during the Model Review meeting.
- Model review shall not be used for the Review of the PFD/P&IDs/Supplier documents etc.

5.2.2 Team Composition

- An EPC Contractor's engineer familiar with the project, the model and the 3D-CAD system capabilities shall present the 3D Model Review. EPC Contractor shall guide the audience through the model with the assistance of a 3D Model Review operator. EPC Contractor will be responsible for the efficiency of the review process, for adequate reporting of comments and for the subsequent follow-up.
- To prevent specialist's sub-meetings during a model review, model review team shall comprise of members with sufficient knowledge in the subject(s) under review. Specialists shall be invited on call, if required.
- Model review shall be attended by the following disciplines.

Disciplines	Attendance
Project Engineer(s)	Full time
Piping Engineer(s)	Full time
Process Engineer(s)	Full time
Mechanical Engineer(s)	On call
Instrument or Electrical Engineer(s)	On call
Civil/Structure Engineer(s)	Full time
HSE (Health, Safety & Environment)	On call
Construction Manager	On call
Commissioning Manager	On call
OWNER's Team comprising of Process, Commissioning, Operation, Maintenance & Construction members	Full time

5.2.3 Method of Checking Modelling

- Model shall be checked with focus on maintenance, access and operation.
- Critical line circuits shall be checked in detail (item by item).
- Check the model against the latest issue of the P&ID.
- Line by Line (item by item check against P&ID) checking is responsibility of EPC Contractor and shall be performed prior to IFC Piping Isometrics issue. Hence, this shall not be performed during Model Reviews.
- Comments on P&IDs during Model review shall be avoided.

- Any model presented to Owner/PMC for Model review shall be clash free

5.2.4 Following reference documents shall be included for the model review

Sl. No.	Document
1	Plot Plan (Overall, Key Plan, Unit Plan)
2	PFD (Process Flow Diagram)
3	Line List
4	Equipment List
5	Escape Route
6	Civil & Architectural Drawings
7	Instrument Index
8	Main Electrical and Instrumentation Cable Tray Sectional Drawings.
9	Equipment and Package GA Drawings
10	P&IDs
11	Model Review Matrix
12	Maintenance Matrix

5.2.5 Model Review Report

Upon completion of a particular phase of a model review, EPC Contractor shall issue a Model Review report to Owner/PMC for information. The report shall contain the list of attendees, Model review Tags (Snapshot and tag text) and Model review tag index listing all the model review tags' text with responsibilities. Model Review Report shall be issued for each model review separately.

5.2.6 Handling of Comments

- It shall be ensured that the level of completion of the model is in line with the requirements defined in clause 4.4
- All Model review tags from previous model review shall be concluded at least 3 days before the next model review starts. Pending tags, if any, shall



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page **11** of **15**

be reviewed during the next model review for closure or be added part of the model review tags.

- The 3D-CAD tools shall have sequence tagging facilities to describe the comments given by Owner/PMC. The text of each tag shall be as complete and unambiguous as possible to avoid confusion in a later stage of the review process.
- EPC Contractor shall attempt to close out tags expediently. EPC Contractor shall issue completed model review tags on a regular basis to Owner/PMC for approval. Owner/PMC shall review each issued tags and return to EPC Contractor with approval. Once all (or maximum possible) tags are completed, EPC Contractor shall issue 3D Model Review Close-out report to Owner/PMC before start of next 3D Model Review.



SPECIFICATION FOR 3D MODEL REVIEW

MCDERMOTT

359755-MDR-000-PIP-SPC-0034 Rev. 0

Page 14 of 15

APPENDIX-2

Model Review Matrix

No	Activity	30% Model Review								60% Model Review								90% Model Review							
		Piping	Process	HSE	CSA	Structure	Mechanical	Electrical	Instrumentation	Piping	Process	HSE	CSA	Structure	Mechanical	Electrical	Instrumentation	Piping	Process	CSA	HSE	Structure	Mechanical	Electrical	Instrumentation
1	Location of all Mechanical Equipment	x	x																						
2	Platform access to spacers / spades in large bore lines (Lines 8" & Above)	x																							
3	Construction and maintenance aspects verified	x					x																		
4	Dropout, bundle pulling and laydown areas	x					x																		
5	Check escape routes	x		x																					
6	Pipe racks, Technological structures and main Sleepers shown					x																			
7	Building in outline (Compressor House, Analyzer shelter)					x		x	x																
8	Location of access roads shown and maintenance accessways				x		x																		
9	Stationary Foundations shown				x																				
10	Packaged unit located (Outline)	x					x																		
11	Major critical piping that determines equipment locations which has undergone initial stress analysis considerations	x																							
12	Outline of underground electrical, instrumentation trenches and piping headers.				x			x	x																
13	Electrical and instrument Main Cable racking							x	x																
14	Major safety distance requirements	x	x		x	x	x	x	x																
15	Operation and maintenance aspects verified									x	x				x										
16	Dropout, bundle pulling, laydown areas and davit drop zones									x					x										
17	Final dimensions of structures and steel constructions													x											
18	Permanent cranes and hoisting beams													x	x										
19	All foundations and footings shown												x												
20	Orientation of equipment nozzles									x															
21	Packaged unit orientation (Only outline)									x					x										
22	Orientation of ladders, stairs, platforms on vessels and columns									x				x											
23	Safety shower and eye washer locations									x		x													
24	2" and larger piping for process, 6" and larger for utility									x															
25	Major and special pipe supports									x				x											
26	Stress comments incorporate for 10" and larger piping									x															
27	Fire fighting equipment (hydrants, monitors, water spray systems, etc) located									x		x	x												
28	All underground piping									x			x												
29	Underground sewer systems and collecting and separation systems												x												
30	Concrete slabs and paving												x												
31	Electrical and instrument Main & Sub Cable racking (& supports)															x	x								
32	Instruments on equipment and in-line instruments									x							x								
33	Local control panels																x								
34	Clash checks complete									x	x		x	x	x	x	x								
35	Location & content of utility stations									x	x														

Electrical Engineering Design Basis

**PROJECT NAME: MALEIC ANHYDRIDE PROJECT
AT
PANIPAT REFINERY PETROCHEMICAL COMPLEX**

DOC. NO.: 359755-MDR-000-ELE-BOD-0001



OWNER: INDIAN OIL CORPORATION LIMITED

MCDERMOTT

PMC: CB&I INDIA PRIVATE LIMITED

PMC JOB NO.: 359755

1	29-JAN-24	Issued for Use	SAT	SUL	VB
0	12-OCT-23	Issued for Use	SAT	SUL	ANK
REV	DATE	DESCRIPTION	PREPARED BY	CHECKED BY	APPROVED BY

“CONFIDENTIAL & PROPRIETARY INFORMATION” contained in this document (including drawings) is sole property & copyright of McDermott company¹ which cannot be reproduced, copied, retained, used, in whole or in part, without written consent of that McDermott company which is the proprietor or licensee of such information and/or document.

¹any Co. in which McDermott international, ltd. holds controlling interest. McDermott Co. includes “CB&I INDIA PVT. LTD”.



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 2 of 10

REVISION HISTORY

REV.	REVISION DESCRIPTION
0	Issued for Use
1	Issued for Use



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 3 of 10

Addendum to IOCL Design Philosophy for Electrical System doc.no. RHQ-EC-EL-0001, Rev-01

Sr. No.	Sheet no.	Reference clause no.	Clause related to	Amended clause
1	5.2 (3)	8 of 138	Equipment installed in hazardous area	The reference to IS code number for IS 5571 shall be updated to IS 16724.
2	5.2 (6)	9 of 138	Combined testing of HV and VSD	Shall be added at the end of clause: In case of HV motors, combined testing of HV motor and Variable frequency drive shall be conducted at Vendor's factory.
3	5.4.2, Notes	13 of 138	Ex designation / marking	Note 13 shall be added at the end: The designation / marking indicated in design basis for Ex e and Ex n is as per previous edition of IEC 60079-7(2006) & 60079-15(2010). The same will be followed. However, marking of "Ex-eb" in place of Ex-e and "Ex-ec" in place Ex-n for Electrical equipment is acceptable as per new designation of IEC-60079.
4	5.5.2, Note	15 of 138	Neutral connection for TPN or SPN circuit	Note 3 shall be added at the end: For TPN or SPN system the neutral connection for ACB / MCCB / MCB / SFU shall be the fourth pole of the breaker. Solid link for neutral connection shall not be provided.
5	5.6, Note	16 of 138	Voltage Drop across EDG terminal, Voltage drop between EDG and Emergency Switchboard	Note 4 shall be added at the end: The voltage drop across EDG terminal during motor starting shall be restricted to 10%. The voltage drop for cables between EDG and Emergency Switchboard will be restricted to 1% and from emergency switchboard to EMCC / EPMCC will be restricted to 1%. The cables from EPMCC / EMCC to motor will be sized for voltage drop of 5.5%. For marginal cases of voltage drops for sizing cables of emergency loads shall be discussed with Owner/ PMC before finalization.
6	6.1 (25)	21 of 138	Each vertical section shall consist of 1 no. circuit breaker only.	This clause shall be deleted as it limits the options in case there is any requirement for optimization of space inside substation. However this shall only be done after due approval from PMC/Owner.
7	6.1 (28)	22 of 138	One panel of highest breaker rating shall be subjected to type test.	This requirement shall be established in ITP of HV switchgear. This requirement may not be applicable if valid type test certificates are available with vendor as per CEA guidelines.
8	6.1 (47),	23 of 138, 27 of 138	Sea worthy packing with external lifting	Point shall be read as Wherever required sea worthy packing with external lifting arrangement to be provided.



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 4 of 10

	6.2 (45)		arrangement to be provided.	
9	6.1, 50	23 of 138	Continuous parallel operation	Clause shall be read as: All Switchgear/ PCC/ MCC in distribution substation shall be designed for momentary paralleling not continuous parallel operation. Short circuit capacity shall be based on the contribution from motors and contribution from one transformer only. (Typical comment wherever applicable for entire EDB)
10	6.1	23 of 138	HV Generation and Distribution System- Additional points	Following points shall be additionally considered for HV System: Point no.52 - Double bus bar system shall be considered for EHV generation system. Point no.53 - Double trip coil shall be considered for 33kV and above GIS. Point no.54 - Microprocessor based Fast bus transfer (FBT) scheme shall be provided between two incomers and bus coupler in 6.6kV HV switchboards. Point no.55 - All Switchgears shall be provided with Online wireless temperature monitoring system. The passive sensor should be wireless, battery less, dielectrically safe, robust to high voltage, high electromagnetic field, and harsh environment. It should take direct measurement on critical point. This facility shall be interfaced with ECS. Point no.56 - Double bus coupler shall be provided for all HV distribution buses. Point no.57 - Closing coil supervision shall be provided for double bus-coupler breakers and standby motor feeders with auto-start facility. Point no.58 - Separate Marshalling cabinet on each bus shall be provided for DCS & ECS interfacing.
11	6.2	26 of 138	All loads above 15 KW rating shall be provided with ELCBs	Shall be read as: All motor feeders shall be provided with CBCT for earth fault protection including transformer feeders and other outgoing feeders.
12	6.2	27 of 138	MV & LV Distribution System - Additional points	Following points shall be additional considered for MV and LV Distribution System: Point no.47 - In MCC/ EMCC, control power supply for outgoing feeders shall be derived from Line-Neutral buses of respective feeders, no control transformer shall be considered. Point no.48 - Low Voltage panel design shall be closed door type only. Point no.49- Copper busbars shall be considered for all PCC & MCC, EMCC, MLDB, ELDB, ASB irrespective of the rating. Point no.50 - Separate Marshalling cabinet on each bus shall be provided for DCS & ECS interfacing. Point no.51 - All Switchgears/ PCC shall be provided with Online temperature monitoring system.



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 5 of 10

				Point no.52 - MCCB shall be provided with short circuit and earth fault protection.
13	6.6 (6)	33 of 138	MV Motors	Clause shall be read as: Energy efficient motors IE3 shall be used for MV motors.
14	6.6	36 of 138	HV, MV & LV- Motors & Feeder- Additional points	Point no.39 - Logic for re-acceleration (restart) of breaker fed motors shall be built in switchgear relays. However, for contactor fed motors from LV MCC, Re-acceleration (restart) logic shall be built inside DCS. Point no.40 - Tripping command to motors shall be direct and hardwired without routing through motor relays/ auxiliary relays.
15	6.7 (4)	37 of 138	Transformers -Additional points	Point d - In case of Lighting Transformer, rating shall be equal to or greater than maximum demand plus 20% margin for future load growth. Point e - Maximum demand shall be calculated as 100% continuous load +30% Intermediate load or largest of intermediate load whichever is higher+10% and Standby load or largest of standby load whichever is higher.
16	6.7 (14)	38 of 138	String insulators in Transformer terminal boxes	String insulators are not feasible for transformers terminal boxes. Hence, point shall be considered as deleted.
17	6.9 (2)	41 of 138	DC Charger is indicated as 110V	220V DC system for switchgear control supply shall be implemented.
18	6.9 (2) and entire EDB	41 of 138	DC Charger is 220V DC	DC Charger system for Switchgear control power supply shall be read as 220V DC instead of 110V DC. (Typical comment for entire EDB wherever applicable)
19	6.9 (29)	43 of 138	Spare Capacity shall be 25%	Clause shall be read as: Each battery bank, charger & DCDB shall have at least 25% spare capacity to meet future requirements.
20	6.9	44 of 138	DC Power supply system - Additional points	Point no.38 - DC Battery Charger shall be Thyristor based only. Point no.39 - NI-CD batteries shall be used for DC Charger system. Battery backup time shall be 60 minutes.
21	6.10 (17)	46 of 138	UPS input power supply from ACB/ MCCB	Clause shall be read as: All the input supplies to the UPS shall be provided from ACB/ MCCB with earth fault protection & not from the SFU or contactor-controlled modules.
22	6.10	47 of 138	UPS System -Additional points	Point no.31 - For Non essential/Non Process application, 240V AC UPS may be considered as 2 X 100% with one common bypass to optimize the cost & space of control building. The other associated items requirement such as ACDB, batteries etc remains as per above. Prior approval from Owner/ PMC shall be taken for these cases. Point no. 32 - NI-CD batteries shall be used for 110V AC UPS for Instrumentation system.



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 6 of 10

23	6.11 (9)	48 of 138	Control supply	Clause shall be read as: The auxiliary / Control supply of the drive panel shall be provided from reliable source e.g. UPS / DC source depending upon the requirement. For control supply of VFD, PLC and relay, redundant UPS supply with diode O- ring for 24V/ internal control supply.
24	6.11 (17)	49 of 138	Redundant cooling fans	Clause shall be read as: All VFD's shall be provided with redundant cooling fans and along with provision of fan fail alarm shall may be provided. VFD internal cooling Fans shall be fed from its internal supply only.
25	6.11	49 of 138	Additional points	Point no.30 - Each VFD shall be equipped with data logger scan time of 30mSec.
26	6.13 (2)	51 of 138	Multicore cables for 33kV system	Clause shall be read as: In general, all HV cables shall be with stranded aluminum conductor, dry cured XLPE insulated, insulation screened, PVC inner sheathed, armoured & FRLS PVC outer sheathed.
27	6.13	51 of 138	Power and Control Cables (Additional note)	Additional note 15: Copper cables shall be considered for 220kV system and 66kV EHV system.
28	6.13	52 of 138	Power & Control cables- Additional points	Point no.15 - Communication system cables shall be 0.9 Dia copper as minimum. Fire Alarm system cables shall be 1.5 sq.mm copper as minimum. Telephone system cables shall be 0.63 Dia copper as minimum. Point no.16 - All Electrical Power cables from Substation or MOV DB to Fire proof MOVs shall be Fire survival / Fire resistant type. The cables shall retain the circuit integrity for 3 hours at 750 deg.C in accordance with IEC 60331.
29	6.14	53 of 138	Cabling work	Added "All control and power cables shall be routed in above ground cable trays within the plant as far as possible".
30	6.14 (3)	53 of 138	Cabling work	Clause shall be read as: If cable trays routes are not practical, the cables may be laid in concrete trench. The cable trenches shall be sized depending upon the number and voltage grade of cables. The trenches in hazardous areas shall be filled up with sand. Where underground cables cross road ways, pipe sleepers at grade etc. they shall be protected by being drawn through sleeves/ducts to provide a permanent crossing.
31	6.14 (11)	54 of 138	Cabling work	Clause shall be read as: Cable trays shall be run on overhead cable rack or along the pipe rack to suit the site conditions. Cable trays, racks and trenches shall be sized to allow for 10 % space for future cables. Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer. Separate trays shall be provided for HV Cables, MV power cables, MV control cables and plant communication cables to the possible extent. However, where specifically agreed upon in



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 7 of 10

				exceptional cases, HV and MV power, control cables may be laid together, with a barrier plate separating HV and MV cables.																					
32	6.14	57 of 138	Cabling work -Additional points	Point no.44 - All control and power cables shall be routed in above ground cable trays within the plant as far as possible.																					
33	6.14 (41)	57 of 138	Cable Laying philosophy	Clause shall be read as:<table><tr><th>Sr.No</th><th>Description</th><th>Philosophy</th></tr><tr><td>1</td><td>Process area</td><td>Above ground cable trays/ RCC Trench with sand filled</td></tr><tr><td>2</td><td>Offsite paved area</td><td>Above ground cable trays/ RCC Trench without sand filled and with racks.</td></tr><tr><td>3</td><td>Offsite unpaved area</td><td>Above Ground cable tray / RCC trench without sand filled and with racks.</td></tr><tr><td>4</td><td>Type of cable trays</td><td>Galvanized prefabricated</td></tr><tr><td>5</td><td>Road Crossings for Underground cables</td><td>RCC Duct Bank with RCC Pull Pits on both sides of Duct Bank for smooth Cable Pulling</td></tr><tr><td>6</td><td>Road Crossings for Above ground cables</td><td>Overhead cable bridge</td></tr></table>	Sr.No	Description	Philosophy	1	Process area	Above ground cable trays/ RCC Trench with sand filled	2	Offsite paved area	Above ground cable trays/ RCC Trench without sand filled and with racks.	3	Offsite unpaved area	Above Ground cable tray / RCC trench without sand filled and with racks.	4	Type of cable trays	Galvanized prefabricated	5	Road Crossings for Underground cables	RCC Duct Bank with RCC Pull Pits on both sides of Duct Bank for smooth Cable Pulling	6	Road Crossings for Above ground cables	Overhead cable bridge
Sr.No	Description	Philosophy																							
1	Process area	Above ground cable trays/ RCC Trench with sand filled																							
2	Offsite paved area	Above ground cable trays/ RCC Trench without sand filled and with racks.																							
3	Offsite unpaved area	Above Ground cable tray / RCC trench without sand filled and with racks.																							
4	Type of cable trays	Galvanized prefabricated																							
5	Road Crossings for Underground cables	RCC Duct Bank with RCC Pull Pits on both sides of Duct Bank for smooth Cable Pulling																							
6	Road Crossings for Above ground cables	Overhead cable bridge																							
34	6.15	58 of 138	Emergency Power supply System (Additional Point)	Additional Point no.4: The KVA rating of emergency Diesel generator shall calculated on following basis: a) The KVA rating shall be equal or greater than the maximum demand of the load, in running condition plus 10% margin for future load growth. EDG shall be suitable for DOL starting of highest rated induction motor with other emergency load in operation. b) Maximum demand shall be calculated as 100% continuous load + 30% intermediate load or largest of intermediate load whichever is higher.																					
35	6.16 (11)	60 of 138	DC critical lighting	Clause shall be read as: DC critical lighting shall be provided in the pipe rack, exit/entry point only in case considered for process units. 220V DC Critical lighting shall be normally kept “ON” and during Normal/Emergency power failure, battery of DC Charger will provide power.																					
36	6.16	64 of 138	Lighting system- Additional points	Point no.45 - LDB Incomer/ Lighting Transformer Incomer shall be provided with ACB / MCCB with earth fault protection. Point no.46 - MCCB with earth fault protection shall be provided in LDB outgoing feeders.																					



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 8 of 10

37	6.19	68 of 138	Additional points – SCADA system	Point no. 8 - For connection to SCADA/ ECS, ring topology shall be considered for Protection relays in Switchgear, PCC & MCCs. Point no. 9 - For all switchgears/PCCs/MCCs SOE signals like Breaker ON/ OFF/ Trip shall be hardwired only. All MFM data shall be taken to ECS along with Numerical relays.
38			Additional clause	Additional clause to be considered in the EDB: Electrical Heat Tracing (1) The electrical heat tracing wherever required shall be provided, with the exception of electrical tracing on packaged equipment. The electrical heat tracing on packaged equipment will be supplied by the supplier. (2) Electrical heat tracing installation including tracer cables, junction boxes, thermostats, end seals and cabling shall be suitable for the hazardous area classification where they are installed. Where possible, self-regulating tracing cable shall be applied.
39	6.22 (1)	71 of 138	Paging System	Clause shall be read as: PA system shall meet the requirements of plant operations. It shall consist of: • IP/Microprocessor based exchange, • Master station with external loudspeaker, microphone etc. • Desk type call stations along with external loudspeaker for installation in buildings. • Wall mounted call stations suitable for area classification with horn type loudspeaker. Note: Requirement of Stand-Alone Loudspeakers (Flameproof and Weatherproof type) shall be verified by Detail Engineering Contractor on the basis of Paging Coverage Study.
40	6.23 (1)	72 of 138	Telephone System	Clause shall be read as: The process plant substations, control rooms, & other non-process/plant buildings etc. shall be provided with sophisticated microprocessor based intercom telephone system to facilitate intercommunication. This consists of an Electronic Private Automatic Branch Exchange (EPABX), where existing EPABX is not available else Node/MDF for process plant and building area that shall be hooked further with Central EPABX.
41	6.23 (2)	72 of 138	Telephone System	The EPABX system if envisaged in case of non-availability of hook up scenario with Central Exchange, shall have battery backup for 8 hours in case of power supply failure. Ni-Cd Battery shall be provided.
42	6.23	73 of 138	Telephone System- Additional point	Requirement of LAN System components shall be evaluated during Detail Engineering.
43	6.24 (4)	73 of 138	Fire Detection & Alarm System	Clause shall be read as: The fire detection and alarm System shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke/heat detectors, main panel, zonal



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page 9 of 10

				panel, hooter, battery, battery charger and other hardware. Fire Alarm Equipment shall be provided based on approved F&G Layouts during Detail Engineering. The system shall be designed to provide audio visual indication at the main panel to be located in fire station and zonal panels. Repeater panel shall be provided as specified in project.
44	7.3 (10)	81 of 138	HT cable from TPS	Point shall be deleted as there is no HT cable directly from TPS in MAH project.
45	7.3 (61)	85 of 138	Protection & control in HV, LV SWB & Transformer	Clause shall be read as: Transformer feeders shall be provided with at least the following protections: High set O/C protection, IDMT O/C, instantaneous earth fault, REF, SEF, transformer differential protection (in case of transformers with HV primary and secondary windings), Buchholz alarm & trip, OTI alarm & trip, WTI alarm and trip, MOG alarm & PRV trip (if provided). Separate VAA auxiliary relays for Transformer fault (Buchholz, Oil temp, Winding temp) alarm functions and separate for above Transformer trip functions shall be provided in switchboard. The auxiliary relays for alarm function shall be self-reset type and for trip functions shall be hand reset type. Additionally separate LED indications for each trip and alarm signals of transformer fault (Buchholz alarm & trip, OTI alarm & trip, WTI alarm and trip, MOG alarm & PRV trip) as above, shall also be considered in the numerical relay.
46	7.3	87 of 138	Protection & control in HV, LV SWB & Transformer – Additional points	Additional clause to be considered in the EDB: Point no.79 - All motor protection relays shall have provision for connection of CBCT to earth fault element along with residual connection. Point no.80 - ELCB shall be provided for all welding receptacle feeders.
47	7.7 (Note 7)	96 of 138	For critical/long feeders and plant feeders connected to main power generation and distribution bus. A plant feeder implies outgoing feeders from one switchboard to another switchboard of same voltage level	Note 7 shall be read as: For critical/long feeders and plant feeders connected to main power generation and distribution bus. A plant feeder implies outgoing feeders from one switchboard to another switchboard of same voltage level. Feeder differential relay shall be provided with OFC for communication between the two relays.



Electrical Engineering Design Basis

MCDERMOTT

359755-MDR-000-ELE-BOD-0001 Rev. 1

Page **10** of **10**

48	7.8	97 of 138	Protection device selection chart for Generators	Clause heading shall be read as: Protection device selection chart for Generators and External Power Supply
49	7.7	97 of 138	Additional note	Additional note 32: EHV switchboards shall be provided with low impedance type bus bar differential protection system with provision of manual bypass. Check zone relay (87CH) shall be provided as a separate relay.
50	9.0	105 of 138	Substation Building design - Additional points	Point no. 30 - Transformer bays shall be provided with overhead removable type shed of sheet metal. Shed height shall be at substation floor level and must have man height clearance (i.e. at least 7 Ft from conservators/Tank whichever is higher) for any maintenance activities. Point no. 31 - Overhead monorail of required capacity shall be provided in substation building/ area housing EHV GIS panels. Point no. 32 - Humidity, Temp monitoring for substation building shall be recorded at DCS via HVAC system. Point no. 33 - Roof top solar plant shall be installed on Substation, as specified in scope of work. Solar system shall be designed in line with Government of India Green initiatives.
51	12 to 15	110 of 138	Spare parts, Commissioning spares, recommended spares & special tools	There will be a separate documents on project for covering all types of spares.

ATTACHMENTS

1. IOCL Design Philosophy for Electrical System doc.no. RHQ-EC-EL-0001, Rev-01

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

1.0 SCOPE

- (1) The specification covered in this document along with applicable project design data sheet shall form the basis for developing detailed design & engineering for the Electrical system to be developed in the various projects of M/s. Indian Oil Corporation Ltd., India.
- (2) This design philosophy along with Reliability concepts shall form the minimum requirement & it is the responsibility of the CONTRACTOR to incorporate this philosophy & reliability concepts in the detailed design & engineering including during execution as a final deliverable.
- (3) Review of any of the contractor document shall in no case relieve the contractor of his contractual obligations & Compliance to this specification/Design Philosophy.

2.0 ABBREVIATIONS

AC	Alternating Current	LAN	Local Area Network
ACB	Air Circuit Breaker	MOV	Motor Operated Valve
ACDB	AC Distribution Board	LDB	Lighting Distribution Board
ASB	Auxiliary Service Board	LV	Low Voltage
BIS	Bureau of Indian Standards	MCB	Miniature Circuit Breaker
CCOE	Chief Controller of Explosive	MCC	Motor Control Centre
CEA	Central Electricity Authority	MV	Medium Voltage
CIMFR	Central Institute of Mining and Fuel Research	MCCB	Moulded Case Circuit Breaker
IEC	International Electro- Technical Commission	LCIE	Laboratoire Central Industries Electriques
CT	Current Transformer	NEC	National Electric Code
DC	Direct Current	NFPA	National Fire Protection
DCDB	DC Distribution Board	OISD	Oil Industries Safety
DG	Diesel Generator	ONAF	Oil Natural Air Forced
DGM	Director General Mines	ONAN	Oil Natural Air Natural
DOL	Direct On Line	PCC	Power Control Centre
ELCB	Earth leakage Circuit	PEM	Project Engineering
ELR	Earth Leakage Relay	PMC	Power Cum Motor Control
ERTL	Electronic Regional Test Laboratories	PT	Potential Transformer
FM	Factory Mutual	PTB	Physikalisch-Technische
GI	Galvanised Iron	PVC	Polyvinyl Chloride
HV	High Voltage	UL	Underwriters Laboratory
IE	Indian Electricity Rules	VFD	Variable Frequency Drive
CPRI	Central Power Research	UPS	Uninterrupted Power Supply

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

3.0 CODES AND STANDARDS

The design and the installation shall be in accordance with established codes, good engineering practices and shall conform to the statutory regulations applicable in the country. The main codes and standards, considered as minimum requirements, as applicable, are as follows. **Latest version of these shall be followed:**

Sl. No.	Standards/ Codes	Description
1.	IS-1646	Code of practice for the fire safety of buildings - Electrical Installations.
2.	IS-2189	Code of practice for selection: installation and maintenance of automatic fire detection and alarm system.
3.	IS/IEC-62305	Code of practice for the protection of buildings and allied structures against lightning.
4.	IS-3034	Code of practice for fire safety of industrial buildings- Electrical generating and distributing stations
5.	IS-3043	Code of practice for Earthing
6.	IS-3646	Code of practice for Interior Illumination
7.	IS-3716	Application guide for Insulation Coordination
8.	IS-4051	Code of practice for installation and maintenance of electrical equipment in mines
9.	IS-5216	Guide for safety procedures and practices in electrical work
10.	IS-5571	Guide for selection of electrical equipment for hazardous areas.
11.	IS-5572	Classification of hazardous areas(other than mines) having flammable gases and vapours for electrical installations.
12.	IS-6665	Code of practice for Industrial Lighting.
13.	IS-7689	Guide for Control of undesirable static electricity
14.	IS-7752	Guide for improvement of power factor - consumer's installations.
15.	IS-8478	Application guide for on load tap changers
16.	IS-9676	Reference ambient temperature for electrical equipment
17.	IS-10028	Code of practice for selection, installation and maintenance of transformer
18.	IS-10118	Code of practice for selection, installation and maintenance for switchgear and control gear
19.	IS-10561	Application guide for Power Transformer
20.	IS-12360	Voltage bands for electrical installations including preferred voltages and frequencies

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

21.	IS-13234	Guide for short circuit calculations in three phase AC systems.
22.	IS-13408(Part-1)	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
23.	IS- 15142	Guide to the use of electrical apparatus for potentially explosive atmospheres in the presence of combustible dusts
24.	SP-30	National Electrical Code (NEC) - BIS Publication.
25.	OISD-STD-110	Recommended practices on static electricity
26.	OISD STD-113	Classification of Area for electrical installation at Hydrocarbon Processing and handling facilities
27.	OISD-STD-147	Inspection and safe practices during electrical installation
28.	OISD STD-149	Design aspects for safety in electrical systems
29.	OISD STD 173	Fire Protection System for Electrical Installations
30.	OISD STD-180	Lightning Protection
31.	IS/IEC 60079-0	Electrical apparatus for explosive gas atmospheres - General requirements
32.	IS/IEC 60079-1	Equipment protection flameproof enclosures "d"
33.	IS/IEC 60079-2	Equipment protection Pressurized enclosures "p"
34.	IS 7724/IEC60079-5	Electrical Apparatus for explosive gas atmospheres Powder filling 'q'
35.	IS 7693/IEC60079-6	Electrical apparatus for explosive gas atmospheres Oil immersion "o"
36.	IS-6381/IEC60079-7	Electrical apparatus for explosive gas atmospheres Increased safety type "e"
37.	IS 5780/IEC60079-11	Electrical apparatus for explosive gas atmospheres Intrinsic safety "i"
38.	IS 9570/IEC60079-12	Classification of flammable gases or vapours with air with air according to their maximum experimental safe gaps and minimum igniting currents
39.	IS/IEC 6007915	Electrical apparatus for explosive gas atmosphere - Part-15 Construction, test and marking of type of protection "n" electrical apparatus

Any other standard may be followed provided it is equivalent or more stringent than the standards specified above.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

4.0 STATUTORY REQUIREMENTS

The latest version of the following statutory regulations shall be followed for design of electrical system

- a) Indian Electricity Act
- b) Indian Electricity rules
- c) The Factories Act
- d) The Petroleum rules
- e) The Mines Act
- f) Requirements of the other statutory bodies as applicable, e.g. CEA/State Electrical Inspectorate, CCOE, DGMS

5.0 BASIS OF ELECTRICAL DESIGN PHILOSOPHY

The design of electrical installation shall ensure provision of a safe and reliable supply of electricity at all times. Safe conditions shall be ensured under all operating conditions including those associated with start up and shut down of plant as well as those arising out of failure of electrical equipment. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety.

(1) System shall be designed considering following aspects in general

- a) To facilitate inspection, cleaning and maintenance with the care to safety in operation and personnel protection.
- b) To minimize turnaround times.
- c) To provide safety, reliability and flexibility of service.
- d) Adequate provision for future extension and modification.
- e) Maximum interchangeability of equipment.
- f) Desired level of operator interface to achieve co-ordinated efficient and fail-safe operation, data logging and maintenance of the equipment.
- g) To decide redundancy, stand by, spares and overload capacities to achieve desired.
- h) Minimum fire risk.
- i) Automatic protection of all electrical equipments through selective relaying System.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- j) Electrical supply to equipment and machinery within the design operating limits.
 - k) Adequate provision for future extension and modification.
 - l) Suitability for applicable environmental factors.
 - m) Equipment with adequate:
 - Insulation levels.
 - Interrupting capacity.
 - Make Duty capability.
 - Through Fault capability.
 - Continuous current carrying capacity.
 - n) Control and indication.
 - o) Maximum interchangeability of equipments/spares.
 - p) Energy efficient equipment (motors, lighting fixtures).
 - q) Fail safe feature.
 - r) Aesthetics.
- (2) All the electrical consumers within the battery limit shall be correctly identified and listed to have complete details of rating, efficiency, power factor, operating duty cycle (continuous, intermittent, standby), category of supply required (emergency, normal, critical) etc
 - (3) Required redundancy (based on specific process / operating needs) shall be built in substation which feeds power supply to process units / important facilities so that in case of tripping of one feeder, the unit may not be adversely affected and continuity in operation at full capacity is achieved.
 - (4) While sizing the system necessary consideration shall be given to restrict the system voltage drop within permissible limits during starting of large rated motor or group of motors. At the same time, the short circuit current shall be kept within limits keeping in view of the market availability of switchgears. For this purpose current limiting reactors / unit ratio transformers if required may be used. Reduced voltage starting (soft starter feature) for motors may be considered as per system requirements.
 - (5) The design shall be assessed with regards to health and safety during construction, commissioning, operation and maintenance. Where practical, potential risks shall be mitigated at source and incorporated into the design.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (6) Following voltage grade shall be used in defining the voltage range of switchgear

S/no	Classification	Philosophy
1	LV - Low Voltage.	The voltage which does not normally exceeds 250 V.
2	MV - Medium Voltage.	The voltage which normally exceeds 250 V and does not exceeds 650 V.
3	HV - High Voltage.	The voltage which normally exceeds 650 V but does not exceed 33 kV.
4	EHV - Extra High Voltage.	The voltage which exceeds 33 kV under normal condition.

5.1 LOAD GROUPING

- (1) Based upon the following principle/ concepts electrical loads shall be classified as: normal / non-essential, emergency / essential or vital / critical
- (2) Emergency or essential loads shall be identified as loads that, when failing in operation or when failing if called upon, will affect the continuity of operation, the quality or quantity of product. For such loads, reliable source shall be ensured. Such feeders shall be grouped on a separate bus-section in the respective MCCs / PCCs.
- (3) Some of the loads which can be identified as emergency or essential load but not essentially limited to following:
 - a. Electrical loads required for continuous operation of process plants / utility etc.
 - b. Electrical loads required for safe shut down of facilities.
 - c. Emergency lighting -All communication facilities.
 - d. Fire Alarm System / Firefighting equipment.
 - e. Level gauge / vessel lamp illumination.
 - f. AC & DC UPS / Battery charging equipment.
 - g. Control room AC equipment -Essential ventilation system for offices / manned areas of other buildings.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (4) Critical or vital loads shall be identified as loads that, when failing in operation or when failing if called upon, can cause an unsafe condition of the installation, jeopardize life, or cause a major damage to the installation. For critical loads other than critical drives, UPS (parallel redundant with battery backup of 60 min) shall be provided. Critical drives shall be provided with DC motors.
- (5) Some of the load which can be identified as critical / vital load but not essentially limited to following:
 - a. Loads providing control and protection to plant equipment.
 - b. Loads serving critical equipment for safety of plant, equipment and / or personnel.
- (6) Non-essential service is a service, which is neither 'essential' nor 'vital'. Hence the non-essential load does not require any special measure such as standby feeder or standby source to safeguard the continuity of service.
- (7) Care shall be taken to distribute the electrical load in the two sections of the electrical distribution panel in such a manner that shutdown of one section does not adversely affect the normal plant operation.
- (8) Power feeding of critical HT auxiliary motors of the Power Plant should be done in such a manner that outage of any primary generation or distribution bus shall not affect the power plant operation due to the tripping of any of the auxiliary drives e.g. CW pumps / BFP / GBC / Fans /Compressor etc.

5.2 AREA CLASSIFICATION AND EQUIPMENT REQUIREMENTS

- (1) All the areas within the battery limits shall be classified for the degree and the extent of hazard from flammable materials. Classification of hazardous area shall be done in accordance with petroleum rules, DGMS regulations (where applicable), IS 5572, IS-15142, OISD standards and process licensors' recommendations.
- (2) Following factors shall be considered for proper selection of electrical equipments for use in hazardous area;
 - a. Area classification i.e. Zone 0/ Zone 1/ Zone 2
 - b. Gas Classification i.e Group – the characteristics of the gas or vapour involved in relation to the ignition current or minimum ignition energy and safe gap data- Group IIA/ IIB/ IIC
 - c. Dust classification i.e. Group – the characteristic of the dust involved.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- d. Temperature classifications – the ignition temperature of the gas, vapour or dust involve or the lowest value of the ignition temperature is more than one combustible materials is present. i.e T1- T6
 - e. Environmental conditions in which apparatus is to be installed – the selected electrical apparatus shall be adequately protected against quality and solvent agencies, water ingress, thermal and mechanical stresses as determined by the environmental conditions.
 - f. In case of hydrogen or hydrocarbon mixture having more than 30% hydrogen, the gas group to be considered as IIC
- (3) All electrical equipments installed in hazardous area shall be selected as per IS-5571 and IS-15142 and shall meet the requirements of relevant IS and statutory regulations. Ordinary industrial electrical equipment's (even though permitted for use in Div.2 area as per NFPA – 70), shall not be used in zone 2 areas. Type of explosion protection to be used for individual equipment shall be as specified in the project design data sheet.
- (4) Electrical equipment's for hazardous area shall be certified by testing authorities like CMRI/CIMFR/ CPRI/ ERTL or equivalent recognized independent test house such as BASEEFA/ LCIE/ PTV/UL/ FM/ ATEX/ CENELEC/ PTB, UL / FM. All equipment's (indigenous and imported) shall also have valid statutory approval i.e. CCOE/DGMS/CCE as applicable for use in the specified hazardous area. All indigenous flame proof equipment's shall have valid BIS licence and making as required by statutory authorities. All imported flameproof, increased safety equipment shall have EEX certification and stamping.
- (5) All electrical equipment installed in hazardous areas shall be selected as per latest standard IEC 60079-14 Ed 4.06:2007 to be adopted for "Explosive Atmosphere – Part 14 Electrical Installations design, Selection & Erection", IS – 5571, Guide for Selection of Electrical Equipment for Hazardous Area and IS-14154, Electrical Enclosures for Combustible Installations and shall meet the requirements of relevant IS and Statutory regulations.

However, electrical equipment's for Zone 2 areas as a minimum shall be Ex e/Ex n type as per IS/IEC codes. Increased safety, Ex e equipment shall not be used in Zone 1 areas. Industrial electrical equipment (even though permitted for use in Div.2 area as per NFPA-70) shall not be used in Zone 2 areas. Type of explosion protection to be used for individual equipment shall be as specified in the data sheets.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

For pressurised electrical equipment Ex p on failure of pressurisation system, the following minimum actions shall be provided:

Area classification	Minimum Action to be Taken
Zone 1	Alarm and Switch off
Zone 2	Alarm

- (6) The hazardous area motors (Ex e or Ex d) fed by variable frequency drives shall be certified as a combination for the specified location by Independent test house and shall have valid statutory approvals. Non-sparking (Ex n) motors shall not be used with frequency converters/Variable frequency drives. In case of Ex d flameproof motors, the motor and variable frequency drive combination may not need to be certified together if direct temperature control by embedded temperature sensors are provided, which will disconnect the motor.
- (7) All portable equipments to be used in zone-1 & zone-2 shall be 'Ex-d' type.

5.3 ZONES

Unit's areas that have potentially explosive gas atmospheres shall be classified as follows:-

Zone 0	In which an explosive gas-air mixture is continuously present, or present for long periods.
Zone 1	In which an explosive gas-air mixture is likely to occur in normal operation.
Zone 2	In which an explosive gas-air mixture is not likely to occur, and if it occurs it will only exist for a short time

Units areas that have a combustible dust hazard shall be classified as follows:-

Zone 20	Area in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.
Zone 21	Area in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.
Zone 21	Area in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but if it does occur, will persist for a short period only.

Areas of unit not classified as one of the above shall be designated as being non-hazardous.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

5.4 ELECTRICAL EQUIPMENT ENCLOSURES

5.4.1 ENCLOSURE

IP ratings to IEC 60529 or equivalent Indian standards shall be applied.

5.4.2 ELECTRICAL EQUIPMENT FOR HAZARDOUS AREAS

- For gas and vapour risk areas, electrical equipment and the types of protection for enclosures shall comply with IEC 60079 / IS13346 and shall meet requirements of statutory regulations.
- The requirements for construction of electrical apparatus for use in potentially explosive atmospheres shall comply with relevant part of IEC 60079 or equivalent Indian Standards.
- Electrical Equipment for dust risk areas shall comply with IEC 61241-10 and IS 14154-1, IS 14154-2 and IS 15142.
- The type of protection to be applied to the electrical apparatus relative to the area classification zone shall be as follows:

ZONE	TYPE OF PROTECTION								DEGREE OF PROTECTION OF ENCLOSURE
	ia	ib	d	e	p	n	o	q	
0	X								Min. IP55
1	X	X	X	*	X				Min. IP55
2	X	X	X	X	X	X	X	X	Min. IP55

* Increased safety enclosure is not permitted in Zone 1 area. Industrial equipment (even though permitted for use in Div. 2 area as per NFPA-70) shall not be used in Zone 2 areas.

- Types of protections 's' and 'm' may be considered depending on the application and on appropriate certification being available.
- The maximum surface temperature shall not exceed the ignition temperature of the gases, dusts or vapours involved. This shall be indicated by the T Class (T1-T6) of the apparatus as defined in IEC 60079 / IS 8239. The minimum temperature class to be considered as T3 & degree of protection $\geq$ IP 55

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- g. The electrical equipment for hazardous areas shall be selected as per IS 5571. The guide providing minimum requirement is summarized below:

Equipment		Zone 1		Zone 2	
		Gas Group	Gas Group	Gas Group	Gas Group
		IIA, IIB	IIC	IIA, II B	IIC
LV Motors (≤ 160 kW) See Note 7 & 9		Ex d	Ex d	Ex de/ Ex n Note 3&7	Ex de /Ex e Note 3,7&10
HV Motors (> 160 kW) See Note 7, 9 & 12		Ex d/Ex p	Ex d See Note 1	Ex e/ Ex p Note (1,10, 11, 12)	Ex e/Ex p Note 1,10,11, 12
Push Button station		Ex d	Ex d	Ex d	Ex d
Plug & Socket		Ex d	Ex d	Ex d	Ex d
Welding Receptacle		Ex d	Ex d	Ex d	Ex d
Lighting Fixtures					
i	Lighting fitting	Ex d	Ex d	Ex e/Ex n Note 3	Ex e/Ex n See Note 8
ii	Control gear Box	Ex d	Ex d	Ex d	Ex d
Junction Boxes		Ex d	Ex d	Ex e	Ex e
Hand lamps					
i	Light fitting	Ex d	Ex d	Ex d	Ex d
ii	Transfer unit	Ex d	Ex d	Ex d	Ex d
iii	Plug & Socket	Ex d	Ex d	Ex d	Ex d
Break glass Unit (Fire Alarm System)		Ex d	Ex d	Ex d	Ex d
Lighting Panel/power Panel		Ex d	Ex d	Ex d	Ex d
Transformer		Hermetically Sealed with Surface temperature Not exceeding 200°C			

Notes:

- ~~Pressurised type of motors Ex(p) may be considered in case flameproof motors in required kW rating and gas gr. are not available. All pressurised motors shall be~~

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

~~complete with flameproof pressurisation panel, control valves, flow meter, pressure switch etc. DC power supply shall be considered for the pressurisation panel of the pressurised motors. Pressurisation system shall have parallel filter and draining arrangement prior to purging. Necessary interlock shall be provided such that on failure of pressurisation system, electrical equipment will be switched off with audiovisual alarm.~~

1. Pressurised type of motors Ex(p) may be considered in case flameproof motors in required kW rating and gas gr. are not available. All pressurised motors shall be complete with flameproof pressurisation panel, control valves, flow meter, pressure switch etc. DC power supply shall be considered for the pressurisation panel of the pressurised motors. Pressurisation system shall have parallel filter and draining arrangement prior to purging. Necessary interlock shall be provided such that on failure of pressurisation system, electrical equipment will be switched off with audiovisual alarm. Alternatively, pneumatic control system can also be considered for pressurization of Exp motors in place of electrical control system with DC power supply
2. The electrical equipments for hazardous areas shall generally be suitable for gas group IIA/IIB/IIC and temperature classification as applicable to the selection type of explosion protection. In case of hydrogen or hydrocarbon mixture having hydrogen more than 30%, the gas group to be considered shall be IIC.
3. As additional safety features, the following requirement for electrical equipment shall be followed;
 - a. All electric motors for agitators/mixers, LPG Pumps and metering pumps handling flammable material shall be flameproof type (Ex d) irrespective of the area being classified as zone 2 or zone 1.
 - b. All electric motors for vertical oil sump pumps including ETP area shall be flameproof type (Ex d).
 - c. Irrespective of the area classification (whether zone 1 or zone 2), all motors and lighting fixtures within the storage areas, pump house associated with storage areas and within the loading / unloading gantries shall be flameproof type (Ex d).
 - d. All emergency/ critical lighting fixtures and associated junction boxes in hazardous areas (whether zone 1 & zone 2) shall be flameproof type (Ex d).
 - e. All electrical equipment installed for an analyser room shall be flameproof type suitable for gas group-IIA, IIB, IIC irrespective of the area being classified as Zone-1 or Zone-2
4. Even though fired heaters in process units are not considered for area classification, all electrical equipment's associated with fired heaters in process units shall as a minimum be suitable for installation in zone 2 area.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

5. Where air conditioning system is designed considering ammonia as refrigerant, the room housing air conditioning equipment shall be adequately ventilated to classify it as safe area. For additional safety the following shall be considered:
 - (a) 100% stand by system for ventilation.
 - (b) Location of MCC /local panels in adjacent separate room.
 - (c) Instrumentation to be flameproof type or hermetically sealed.
 - (d) AC unit room motors with type 'e' protection.
 - (e) Lighting in AC unit room suitable for zone 2 area.
6. Compressor sheds in hazardous area shall be designed to allow adequate ventilation to allow area classification as Zone 2 Lighting equipment, EOT crane etc. in the shed shall be flameproof type. All other electrical equipment shall be suitable for zone 1 or zone 2 area depending on extent of hazard.
7. Motors fed from variable frequency drive in hazardous area application shall be type tested as unit with the VSD panel in case of Ex e type of motors and provision for tripping the motor in case temperature rise exceeds the permissible limits, shall be considered for flameproof motors as per relevant standards. VSD motors in Zone 2 areas shall be Ex d.
8. Ex e Fluorescents, Ex n other type.
9. For Ex e motors, if the sum of risk factor is greater than 6 as per section 5.2.4.3 & Table 4 of IEC 60079-7, the machine or representative sample shall be tested in accordance with section 6.2.3.2 of IEC 60079-7, or the machine shall be constructed to allow special measures to be employed to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting. The machine instruction provided, in accordance with IEC 60079-0, shall include on the implementation , where required, of the additional measures.
10. For Ex e motors rated >1kV, Section 5.2.7 of IEC 60079-7, type tests in accordance with Section 6.2.3.1 shall be conducted, and the machine shall be fitted with anti condensation heaters, and the machine shall be constructed to allow additional measures to be employed to ensure that its enclosure does not contain an explosive gas atmosphere at the time of starting. The machine instructions provided, in accordance with IEC 60079-0, shall include on the implementation, where required, of additional measures.
11. All electrical equipment installed for an analyser room shall be flameproof type suitable for gas group-IIA, IIB, IIC irrespective of the area being classified as Zone-1 or Zone-2. All equipment inside the process units shall be suitable for Zone-2 Ex (e) temperature class T3 irrespective of area being safe.
12. Selection of HV motors (>160KW), Zone-2, Gas group IIA,IIB,IIC shall be Ex de/Exp.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

5.4.3 ELECTRICAL EQUIPMENT FOR NON-HAZARDOUS AREA

5.4.3.1 INDOOR LOCATIONS

Electrical equipment in a relatively dust free environment (e.g. Substation Building) shall be standard industrial equipment. Switchboards shall have a minimum degree of protection of IP 42. Ancillary apparatus shall have a minimum degree of protection IP 42. Electrical apparatus in dusty areas shall have a minimum protection of IP55 and with appropriate protection class for classified areas.

The substation floor shall not be considered as part of the enclosure.

5.4.3.2 OUTDOOR LOCATIONS:

The minimum enclosure for electrical equipment shall be IP 55. Increased safety / non sparking apparatus located outdoor shall be provided with minimum IPW55 protection as per IS 4691. Electrical equipment shall be suitable for the environmental conditions (e.g. dust, moisture, snow or rain) with additional protection provided (e.g. rain shields, sun shields) where required.

5.5 SYSTEM VOLTAGES

5.5.1 Following factors shall be taken into account while selecting the voltage levels:

- (a) Short circuit level.
- (b) Availability of the switchgear with suitable current rating and short circuit rating.
- (c) Existing available voltage levels in the refinery.
- (d) Utilisation voltages of various equipment.
- (e) Provision of future extension.
- (f) Size and location of loads.
- (g) Choice of voltage may also be affected by local regulations, standards as well as the voltage of existing installations

5.5.2 Overall economy for optimum voltage & frequency selection.

The system voltages shall be considered as per the project design data sheet with variations are as follows

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

(a) AC System:

Voltage $\pm 6\%$

Frequency $\pm 3\%$

(b) DC System:

Electrical protection control voltage $\pm 10\%$

DC lighting voltage $\pm 10\%$

(c) Utilization voltages

For general utilization voltages for critical supplies, refer **following tables**.

General utilization voltages and shall be selected as per site conditions.

S.No.	Description	utilization voltages
1	HV motor voltage for DOL	6.6kV (For motors rating $> 160\text{kW}$)
2	MV motor voltage	415 V AC (except VFD motor) (For motors rating $0.18 \leq \text{kW} \leq 160$)
3	AC Motors	240V AC (except MOVs) (For motors rating $< 0.18\text{kW}$)
4	DC Motor	As per equipment supplier standard
5	Motor operated valves	415V AC, TP
6	Battery chargers incoming power supply	415V AC, TPN
7	UPS System incoming power supply	415V AC, TPN
8	AC Lighting/Power Panels	415V AC, TPN
9	Auxiliary Boards incoming power supply	415V AC, TPN
10	Welding Receptacles	415V AC, TPN
11	Bulk loads like Process Heaters etc	415V AC, TPN
12	Normal Lighting/Emergency Lighting	240V AC, SPN
13	LAN UPS	415V AC, TPN

Note:

1. Separate generation and distribution switchboards
2. Input power supply for VFDs up to 160 kW shall be 415V AC and 6.6kV for VFDs above 160 kW.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

5.6 VOLTAGE DROP

- (1) While designing the system due consideration shall be given to restrict the system voltage drop within permissible limits during starting of large motor or group of motors. At the same time, short circuit current shall be kept within limits. For this current limiting reactors / unit ratio transformers, if required, may be used. Reduced voltage starting (soft start feature) for motors may be considered as per system requirements.
- (2) The maximum voltage drops in various sections of electrical system under steady State conditions at full load shall be within the limits stated in the following table:

Sl.No.	System Element	Maximum Permissible voltage Drop
a)	Cable between transformer secondary and Switchboards	0.5%
b)	Cable between PCC/PMCC & MCC, or auxiliary switchboard (ASB) (i) MCC or ASB near PCC/ PMCC (ii) MCC or ASB situated remote from PCC/ PMCC	0.5 % (Note-3) 2 to 2.5 % (Note-3)
c)	Cable between HV switchboard and HV motor	3%
d)	Cable between PCC/ PMCC and motor	5.5%
e)	Cable between MCC(situated near PCC/PMCC) and motors	5%
f)	Cable between MCC(situated remote from PCC/PMCC) and motors	3%
g)	Cable between auxiliary switchboard /LDB and lighting Panel	1 to 1.5% (Note-2)
h)	Circuit between lighting panels and lighting points	4% (Note-2)
i)	DC supply circuits (Electrical controls)	5%
j)	DCDB to Control Room	2% (Note-1)
k)	UPS outgoing Circuit	5%(Note-1)

Note-1

Minimum voltage available across any instrument in the field shall be as per instrumentation design basis. Distribution system for instrumentation shall be designed accordingly. In case of any conflict between electrical design basis and instrument design basis, the latter shall govern regarding instrumentation power supplies.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

Note-2

In case of difficulty in achieving specified voltage drops in cable up to Lighting panel, 5% drop from Auxiliary Switchboard up to lighting points may be permitted.

Note-3

Higher voltage drop may be permitted between PCC/ PMCC and remote mounted MCC/ASB, if overall voltage drop up to motor (from PCC/ PMCC) is limited within 5.5%.

For large Substation 1% drop may be permitted.

The maximum voltage drop at various buses during start-up of large motor and / or Motor reacceleration conditions shall be within the limit stated below:

Sl.No	System Element	Operating Condition	Max. Permissible Voltage Drop
a)	At the busbars of the worst affected Switchboard	Start up of the large HV motor with other loads on the bus or reacceleration of a group of HV motors(Simultaneous start up or group reacceleration of HV motors is not envisaged)	15%
b)	At the busbars of the worst affected MV Switchboard(PCC/P MCC/MCC)	Start up of large MV motor with other loads on bus, or reacceleration of a group of MV motors.	10%
c)	Cable between MV Switchboard and Motor	Motor start-up or reacceleration	5%(Note-a)
d)	Cable Between MV Switchboard (PCC/PMCC/MCC) and motor	Motor start-up or reacceleration	15% (Note-a)

NOTES:

a) Higher Voltage drop in motor cables may be permitted, in case the conditions given in Note b), c) and d) are complied.

b) The voltage available at the motor terminals during start-up must be sufficient to ensure positive starting or reacceleration of the motor (even

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

with the motor fully loaded, if required), without causing any damage to the motor.

- c) For medium voltage motor, the voltage available at the motor terminals must not be less than 75% of the rated value during start up or reacceleration.
- d) For HV motors, the voltage available at the motor terminals must not be less than 80% of the rated value during start up or reacceleration.

5.7 SHORT CIRCUIT CAPACITIES

Each short circuit interrupting device shall be designed to have rated service short circuit breaking capacity (Ics) equal to or higher than the maximum value of short circuit current calculated, at its location. The related switchgear and busducts shall withstand the above maximum available fault current for a minimum period of one second. The minimum size of high voltage cables shall also be based on the short circuit with stand capacity for a minimum time period of 0.25 Sec with backup protection in line.

5.8 INSULATION SYSTEM

- (1) The insulation of electrical facilities shall be designed considering the system voltage, the system neutral earthing and the over voltages resulting due to system fault, switching or lightning surges. The insulation coordination between the electrical equipment and the protective devices shall be done in line with IS 3716. Lightning arrestors and surge absorbers shall be provided where necessary. The selection of cables, cable terminations and straight through joints for radial feeders shall be based on insulation suitable for unearthed system for the distribution voltage levels.
- (2) For resistance grounded systems, the resistance value shall be chosen so as to limit the earth fault current to a value recommended by generator / motor manufacturer for insulation protection, and sufficient for selective and reliable operation of earth fault protection system. The value of limited earth fault current shall generally not exceed 50% of transformer or generator full load current.

6.0 ELECTRICAL SYSTEM DESIGN PHILOSOPHY

6.1 HV GENERATION AND DISTRIBUTION SYSTEM

- (1) The system shall be designed considering following aspects in general
 - a. To facilitate inspection, cleaning & maintenance without compromising safety.
 - b. To provide reliability & flexibility of service.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- c. Maximum interchange ability of equipments.
 - d. Sufficient level of operator interface to achieve coordinated, efficient & fail safe operation, data logging & maintenance of equipments.
- (2) Rated three phase short circuit fault level (KA / MVA) of the HV switchgear is to be higher than the actual fault level for the maximum operating machines configuration. The same shall be selected after due validation through system study as per IEC guidelines **(Refer Annexure-6A/B/C: Schematic Drawing No. – 2C.1, 2C.2 & 2C.3)**
- ~~(3) In the Primary Sub Station, other than Gas Insulated Switchgears (GIS), Separate generation bus and separate Distribution buses is to be provided. The generation bus shall be with Double Bus configuration without any bus coupler. The primary distribution bus shall comprise of two sections with double bus coupler (2 breakers in series between 2 sections) with zone crossover of bus differential. **(Refer Annexure-1: Schematic Drawing No. – EL-1)** ⚠~~

In the Primary Sub Station, other than Gas Insulated Switchgears (GIS), Separate generation bus and separate Distribution buses is to be provided. The generation bus shall be with Double Bus configuration without any bus coupler. The primary distribution bus shall comprise of two sections with double bus coupler (2 breakers in series between 2 sections) with zone crossover of bus differential. **(Refer Annexure-1: Schematic Drawing No. – EL-1)**. Gas insulated switchgear (GIS) shall be considered for generation bus for 33KV & above. There shall be separate generation & distribution bus configuration in primary substation.
- (4) Sectionalizing breakers in the generation bus between generators is to be provided. **(Refer Annexure-1: Schematic Drawing No. – EL-1)**.
- (5) Double bus couplers in generation bus are to be provided to enable maintenance of Bus Coupler.
- (6) The sectionalizing breaker, wherever provided in the generation bus, shall normally remain in closed condition, unless otherwise situation demands. These breakers shall be provided ONLY with manual closing feature from Control room through synchronization scheme.
- (7) In order to build in reliability in the system, it is desirable that primary as well as secondary distribution buses with bus couplers shall not be fed from the same generation bus or their adjacent sections. **(Refer Annexure-1: Schematic Drawing No. – EL-1)**
- (8) In case of hook-up of new generator with existing generation system, the scheme to be adopted shall be in line with **Annexure-2 Schematic Drawing No. EL-2**

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (9) Locations having more than one primary distribution substation in close vicinity are to be considered for a manual emergency tie connection in distribution buses of the two sub stations (of same fault level) for increased operational flexibility.
(Refer Annexure-7: Schematic Drawing No. – 2C.6).
- (10) Ratings shall be based to suit the maximum process load as per designed throughput under the most severe operating conditions of the unit. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and an additional margin shall be taken into account for intermittent service loads as well as standby equipment loads, if any.
- (11) All process units (or cluster of related process units) shall be fed through respective distribution substations, which shall be radially connected to the primary distribution buses.
- (12) The amount of electrical power consumed by each process unit shall be calculated for its operation at the design capacity. System design shall permit direct online starting of all motors unless specified otherwise. Where turbine drives have electric drives as spares, the rating of the system shall include the load of the largest such electric drive. Ratings shall also consider single ended arrangements and specified future allowances.
- (13) Based on specific process / operating needs, sufficient redundancy shall be built into the sub-station that feeds power to the unit, so that in case of tripping of one feeder, the unit may not be adversely affected and continuity in operation is maintained.
- (14) While designing the system, due consideration shall be given to restrict the system voltage drop within the permissible limits during starting of large motor or group of motors. At the same time, short circuit currents shall be kept within the limits. For this current limiting reactors/ unit ratio transformers, if required may be used. Reduced voltage starting (soft starter feature) for motors may be considered as per system requirement.
- (15) Other Critical loads e.g. Fire Station supply shall have two supplies from different generating sources.
- (16) The design shall comply with Electricity Association G5/4 Engineering / IEEE519 recommendation for Harmonics at the point of common coupling.
- (17) All Switchgear and associated equipment fed from generators and transformers shall have rating at least equal to the rating of respective generators and transformers feeding it, under any circuit configuration. Generator incomer shall be rated w.r.t. maximum power output of the generator set over entire operating

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

temperature range. Transformer incomer shall be rated at least equal to forced cooled rating of transformer or 110% of ONAN rating as applicable.

- (18) Bus-section feeder/circuit breakers shall have rating whichever is higher of the following:
 - a) Largest incoming circuit breaker / feeder.
 - b) Maximum connected running load on either side of bus section.
In no case, shall the bus section breaker rating be less than the bus bar current rating.
 - c) Not less than bus bar current rating.
- (19) Rating of Buscoupler shall be suitable for following conditions
 - a. Maximum running load on either side of bus section
 - b. Bus coupler rating equal to largest incoming circuit breaker rating. Incomer and bus coupler breakers shall be of same rating for interchangeability.
 - c. Should not be less than bus bar current rating
- (20) All other switchgears not directly fed from generator and transformers shall have rating at least equal to the maximum demand under any circuit configuration plus a provision for 20% future load growth. Incomers of these switchgears shall be designed to cater to the complete load including 20% margin for future load growth.
- (21) HV switchgear shall be metal clad only.
- (22) Two adjacent distribution buses shall not be fed from the same generation bus.
- (23) Spare outgoing feeders shall be provided in all switchboards. At least one number of each rating and type or 20% whichever is more shall be provided as spare on each bus section. All the three compartments, i.e. breaker / bus / cable compartments shall also be provided with metal barrier sheets.
- (24) Circuit breakers/ contacts controlling motor feeders shall have a rating of at least 125% of the maximum continuous rating of the connected motors.
- (25) Each vertical section shall consist of 1 no. circuit breaker only.
- (26) All breakers shall be horizontal isolation draw out type VCB. Trolley shall have SERVICE, TEST and ISOLATION positions, each having locking facility. These positions shall have limit switches with auxiliary contacts for interlock. CB shall be operable in SERVICE and TEST positions with the cubicle door closed. The TEST position shall be within the cubicle. A flexible duty interlocked plug and socket arrangement with scrapping earth terminals shall be used for auxiliary supply. Shutters shall be gravity fall type with pad locking arrangement.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (27) Electrical running loads shall be uniformly distributed on each bus and it shall be ensured that running and standby loads are fed from two different bus sections.
- (28) One panel of highest breaker rating shall be subjected to type test. This test can be exempted only in case of extension of existing panels.
- (29) HV switchgears shall be supplied with necessary earthing trollies / earthing rods / breaker lifting trollies.
- (30) For tie feeders, receiving end circuit breaker shall have ON / OFF control and indicating lamps for sending end circuit breaker with selective closing of sending end breaker
- (31) Dummy panel shall be provided in switchboards where a switchboard is located over the expansion joints in substation building.
- (32) All bus bars shall be properly sleeved, and shrouds shall be provided on joints. 4 nos. Non-hygroscopic phase barriers and shrouds shall be provided at uncovered portion of bus-bars. All breakers and cable compartment shall have phase barriers (4 nos. each).
- (33) All protection and metering CTs, PTs shall be easily accessible for testing, maintenance and replacement.
- (34) Line PTs and bus PTs shall be in separate compartments and shall not be part of incomer breaker or outgoing feeder breakers.
- (35) All panels shall have IR (infra red) window at the rear suitably located for monitoring of temperature of joints / terminations, in running condition, using thermographic (IR) imaging device.
- (36) All breaker contacts shall be silver plated.
- (37) Normal and standby loads shall be evenly distributed on both bus sections. Normal and standby loads shall be fed from different bus sections.
- (38) Marshalling cabinet shall be provided for DCS / PLC interfacing.
- (39) An independent process unit to be fed from independent and separate HV switchboard and PCC / MCC.
- (40) Suitable length of Equipotential wire of the window type CT's shall be provided and any control / CT wiring shall not be laid through the main HT bus chamber.
- (41) Anti condensation heaters with thermostat control shall be provided in HV switchgears in cable chamber and breaker chamber.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (42) HV Switchgear shall comply with IEC 62271-200 and equivalent Indian standard. HV Motor Feeder Control Gear shall comply with IEC 60470 and equivalent Indian standard.
- (43) The degree of enclosure for HV switchgear shall be minimum IP42.
- (44) All indicating lamps shall be clustered LED type.
- (45) All panels shall be vermin proof.
- (46) All rear panel doors of HV panels shall have handle for ease of maintenance.
- (47) Sea worthy packing with external lifting arrangement to be provided.
- (48) For resistance grounded HV systems, all PTs shall be provided with additional Open Delta Tertiary winding with damping resistor to mitigate ferro-resonance phenomenon.
- (49) In impedance grounded HV systems, the Earth fault protection shall be provided with CBCT for providing sensitive E/F protection. Single CBCT of suitable size shall be provided to accommodate all power cables in a particular feeder. Split core/Flexible CTs is also acceptable.
- (50) All the bus sections are to designed for continuous parallel operation unless there are limitations of bus fault level.(RTF Clause- 4.1.3)
- (51) Typical control schemes for AIS Switchboards is attached as Annex-C which can be customized as per Project requirements.

6.2 MV & LV DISTRIBUTION SYSTEM

- (1) All components of electrical system shall be designed to take into account the following:
 - a) Maximum demand under most severe operating conditions.
 - b) Intermittent service loads, if any.
 - c) Distribution transformer spare capacity shall be determined as follows:
Transformer rating shall suit 20% spare capacity with 100% load as basis. During normal operation, each transformer shall be loaded to 40% of rated capacity. During outage of one transformer, other healthy Transformer shall be loaded to 80% of rated capacity
- (2) Adequate numbers of distribution transformers along with the associated Power control centers, Motor control centers and auxiliary service boards etc & power

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

supply units shall be provided to meet the electrical load demand of each of the process units.

- (3) Distribution systems shall be of the secondary selective type. In secondary selective systems, the rating of all equipment in the distribution system shall be such that any one transformer, feeder, switchboard, PCC, PMCC or MCC feeder can be taken out of service without affecting the availability of the unit supplied.
- (4) Each PCC should be fed by two identical incomers and a bus coupler. **Only four pole breakers in Incomer and Bus-coupler to be used in PCC.** Supply from transformer to PCC Incomers should be sourced from different HT sections from the upstream. Care to be taken that the HT supply to PCC incomers should not be fed from the same generation bus or their adjacent sections. **(Refer Schematic Drawing No. – 4C.1/7C.1)**
- (5) MV & LV PMCC and MCC switchboards respectively shall have two bus sections each with provision for auto/manual changeover scheme.
- (6) Construction of MV switchgear (MCC only) shall be withdrawable type. Internal separation by barriers or partitions shall be provided.
- (7) Three transformer secondary selective systems may be adopted where increased firm capacity is required. In this case the two bus-sections shall be electrically interlocked, in order that only one may be closed at a time with all three incomers ON only. Switching and interlocking to allow parallel operation of two transformers shall be provided in a similar way to that outlined above. For three-incomers scheme suitable feeding arrangement to be implemented.
- (8) Both transformers should be of identical ratings and PCC bus suitable for continuous parallel operation with both transformers in service, unless there are limitations of bus fault level.
- (9) Short circuit levels for secondary selective systems with two transformers (i.e. normally open bus-section), shall be based on the process requirements as under:
 - Electrical interlocking of incomers and bus tie combined with a fast auto-manual transfer scheme that allows momentary paralleling of incomers. Secondary short circuit level shall be based on the contribution from motors and contribution from only one transformer.
- (10) Air Circuit Breakers shall be used for MCC:
 - Incoming Feeder Units.
 - Bus Section Units.
- (11) Switchgears shall have rating atleast equal to maximum demand under any circuit configuration and provision for 30 % future load requirement.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (12) Minimum 25 % spare feeders or one no. of each rating and type on each side of the bus section whichever is more shall be provided.
- (13) Separate feeders shall be provided in the switchboard for each load/motor. However, as an exception maximum two numbers welding receptacles may be connected to one power feeder.
- (14) In PCC switchgear, for outgoing ACB feeders, 02 nos of breakers per vertical shall be provided so as to optimize the substation space.
- (15) Short circuit calculations shall be based on IEC 60909 /IS 13234. Rated service short circuit breaking capacities (i.e. Ics) for all breakers and MCCBs shall be equal to or higher than the maximum specified value of the short circuit current at the point of installation. MCCBs with backup fuses shall be acceptable.
- (16) Air circuit breakers (ACB) shall be provided in MV switchboards for all feeders rated above 400A and switch fuse /MCCB/ACB shall be considered for feeder rated up to 400A. However in the feeders feeding power to small rated MCCs/ASBs, switch-fuse feeders shall not be used.
- (17) The maximum rating of bus-bars for MCCs/ASBs should preferably be limited to 800 Amps. Incomers and buscoupler of MCC shall be provided with ACB and numerical relays with auto-changeover facility.
- (18) Incomer and bus coupler breakers shall be of same rating for interchangeability
- (19) Circuit breakers/ Switch fuse units for capacitors shall, have a current rating of at least 135% of the capacitor rated current. Circuit breakers capability to interrupt applicable capacitive current shall be specifically verified.
- (20) The switchboard component viz. circuit breakers, main horizontal and vertical bus-bars, bus-bars joints, bus bar supports etc. shall be designed to withstand the maximum specified short circuit current for a minimum time of 1 second, unless otherwise specified.
- (21) Motors rated above 55 kW & upto 160 kW shall be controlled through ACB & motor protection relay and shall be fed from PCC.
- ~~(22) All motors feeders rated above & including 18.5 kW & upto 55 kW shall be controlled through switch fuse unit, contactor, overload relay with CBCT, ELR for earth fault protection & shall be fed from MCC. ⚠~~

All motors feeders rated above & including 15.0 kW & upto 55 kW shall be controlled through switch fuse unit, contactor, overload relay with CBCT, ELR for earth fault protection & shall be fed from MCC. Overload relay & ELR shall be compact microprocessor based communicable motor protection relays with Earth Leakage protection through CBCT. ⚠

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

~~(23) All motor feeders rated upto 15 kW shall be controlled through switch fuse unit, contactor & overload relay. All loads upto 15 KW rating shall be provided with ELCBs. ⚠~~

All motor feeders rated upto 15 kW shall be controlled through switch fuse unit, contactor & overload relay. All loads above 15 KW rating shall be provided with ELCBs. Overload relay shall be compact microprocessor based communicable motor protection relays with Earth Leakage protection through CBCT. ⚠

(24) Motors rated above 5.5 kW, CT shall be provided in the switchgear for ammeter on the local control station/local control panel.

(25) Starters for the motors in general shall be provided in the switchboards PCC/MCC located in substation. However in special cases like MOVs & EOT cranes etc. they shall be located in the field near the motors.

(26) Power supply to auxiliary services board where single phase / lighting loads are connected shall be through lighting / isolation transformer only.

(27) The degree of enclosure for MV switchgear shall be minimum IP42.

(28) All breaker contacts shall be silver plated.

(29) Normal and standby loads shall be connected to different bus sections.

(30) All TPN switch fuse feeders rated 250 A and above shall be provided with ammeter. All emergency / critical drives, irrespective of ratings, shall be provided with ammeter.

(31) PMCC shall be suitable for top entry bus duct.

(32) All devices shall be mounted on the front side of the compartment. Mounting on trolley is not acceptable.

(33) All bus bars shall be sleeved, and shrouds shall be provided on joints.

(34) All PMCC feeders shall be provided with horizontal isolation drawout type ACBs. No SFU shall be used.

(35) All push buttons shall be momentary type.

(36) For contactor operated motor feeders with long control circuit leads, suitable RC circuit /Shielded control cable shall be provided.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (37) CBs shall be provided with minimum 4 NO and 4 NC spare auxiliary breaker contacts wired up to the terminal box.
- (38) Contactors shall be air break type with 3 main contacts and 3 NO + 3 NC auxiliary contacts.
- (39) Marshalling cabinet shall be provided for DCS / PLC interface requirements. It shall have provision for termination of incoming / outgoing multicore copper conductor armoured cables.
- (40) All indicating lamps shall be clustered LED type.
- (41) All panels shall be vermin proof.
- (42) Panel space heaters with thermostat control shall be provided in MV switchgears
- (43) Switchgear and MCCs shall be provided with the manufacturer's standard accessories for:
 - a) Motor Starter Unit components.
 - b) Fuse Switch Units.
 - c) Protective Relays.
 - d) Current and Voltage Transformers.
 - e) Auxiliary devices.
 - f) Air Circuit Breakers.
 - g) Motor Protection Relays.
- (44) All rear panel doors of LV panels shall have handle for ease of maintenance.
- (45) Sea worthy packing with external lifting arrangement to be provided.
- (46) The distribution of MV/LV auxiliary loads shall also fall under the same HT bus w.r.t. feeding primary HT loads.

6.3 BUS-DUCT

- (1) The rating of bus ducts connected to breakers shall have same continuous and short circuit rating as that of breakers. Similarly bus ducts connecting to two bus section shall have same continuous and short circuit rating as that of main bus bars.
- (2) HV bus duct shall be phase segregated type, and MV & LV bus duct shall be non phase segregated type.
- (3) The bus bar material shall be electrolytic aluminum / copper.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (4) Flexible expansion joints to account for thermal expansion to be provided at the equipment end. In case the equipment terminals are other than the aluminum, suitable bi-metallic connection or silver plating of the contacts to be provided.
- (5) The busduct bus bar material shall be same as that used for switchgear busbar.
- (6) Bus insulators shall be non-hygroscopic, non-inflammable and flame retarding type & shall be capable to withstand dynamic forces.
- (7) Outdoor bus duct shall be weather proof IP55 and shall be provided with suitable seal and canopy.
- (8) Space heater with auto cut-off shall be provided at suitable location.
- (9) Continuous earthing strips of proper sizes shall be provided on the two sides of the bus duct, for connection with the earthing grid.
- (10) The entire bus duct support structure would be of galvanized iron.
- (11) Seal-Off bushing to be provided at the entrance point of the bus duct inside the sub-station.

6.4 UNDER VOLTAGE MANAGEMENT

- (1) All Bus incomer breakers up to the PCC level shall be provided with the “Under Voltage Tripping Scheme”.
- (2) Upstream (primary side) feeders for Transformer, bus couplers, PCC outgoing feeders to MCC & HV outgoing feeders (radial feeders) shall not be provided with U/V tripping.
- (3) The complete under voltage tripping scheme provided for the distribution system at various voltage levels should be time graded.
- (4) Under voltage protection co-ordination of power distribution shall preferably be such that the time delay at the highest voltage level is minimum and the time delay at subsequent lower voltage levels is suitably increased in steps.
- (5) Under Voltage tripping of the incomer breakers shall not be given through the master relay.
- (6) The under voltage tripping shall be initiated from the line side PT of the incomer breaker and should not be from bus PT.
- (7) To achieve reliability in the scheme and to prevent its mal-operation, under voltage condition of at least two phases shall be used for tripping to the extent possible.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (8) In case numerical relays either "AND" mode is to be selected (If the feature is available) otherwise contacts derived from two phases shall be used.
- (9) Under voltage scheme is to be so engineered that;
- The incomer breaker should not trip in case the other incomer is also experiencing under voltage simultaneously.
 - The incomer breaker should also not trip in case the other incomer breaker is OFF

~~(10) In case of Incomer PT fuse failure condition, feature of under voltage trip scheme blocking to be provided in order to prevent mal-operation of the scheme~~

In case of Incomer PT fuse failure condition, feature of under voltage trip scheme blocking to be provided in order to prevent mal-operation of the scheme. Blocking of under voltage (U/V) tripping of motors is to be provided in case of PT fuse failure. Fuse Failure relays/ PT supply MCB contact shall be used for Blocking of U/V trip.

- (11) In order to achieve faster restoration of the system after total power failure, under voltage tripping relay contact multiplication (if required) should be provided through self reset relays.
- (12) If incomer trips on under voltage, the bus coupler shall automatically close, if the other bus is healthy and protective relays of tripped incomer, bus, differential of both sections and bus coupler are healthy. Auto changeover shall be deactivated after a certain time delay of incomer trip.
- (13) Interlock of upstream breaker shall be taken in closing and tripping circuits of incomers.
- (14) Under voltage trip shall be blocked to prevent mal-operation of due to incomer PT fuse failure condition. Fuse failure relays to be used to block under voltage trip scheme.
- (15) All HT motors shall be provided with a Time Graded under-voltage trip scheme. The voltage input to relay shall be derived from the Bus PT of the switchgear section from which the motors are connected.
- ~~(16) Blocking of under voltage tripping of motors to be provided in case of fuse failure by using Fuse Failure relays.~~

Blocking of under voltage (U/V) tripping of motors to be provided in case of PT fuse failure. Fuse Failure relays/ PT supply MCB contact shall be used for Blocking of U/V trip

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (17) Contact multiplication of under voltage relay, for the purpose of tripping of various HT motors, shall be provided through self reset type relays / auxiliary relays/ direct to breaker trippings and not through master trip relays.
- (18) The under voltage schemes in HV & LV systems for line under voltage & bus under voltage should work on the same voltage base i.e. both shall sense either Ph-N or Ph-Ph voltage at the same time to prevent mal-operation during earth faults. Relays shall be provided accordingly.

6.5 AUTO CHANGEOVER (BUS TRANSFER) SYSTEM

- (1) All the HT incoming / distribution bus section (Primary and secondary) and PCCs with two incoming sources should be provided with a bus coupler with Auto-Manual changeover scheme in order to maintain the reliability of the plant.
- (2) In case of manual transfer in Bus Coupler, the closing of bus coupler breaker should be though check synchronization relay wherever there are chances of paralleling of two unsynchronized sources.
- (3) Provision shall be made for manual changeover, to enable momentary paralleling of two incomers, under the following conditions:
 - For taking one transformer out of service during planned maintenance.
 - For bringing both the transformers into service after restoration of incoming supply.
- (4) Momentary Paralleling Scheme For Bus Sections:
 - In “Momentary Paralleling Mode” of bus transfer scheme, manual open command to the breaker should be defeated.
 - It is also desirable to incorporate suitable time delay (5 to 10 sec) in the monetary paralleling mode of the scheme such that the tripping command to the intended breaker is initiated only after successful transfer operation
- (5) The automatic transfer system shall be independent for each switchboard and shall include time delay such that transfer takes place at the higher voltage side before transfer at lower voltage side is affected. Return to normal after main power restoration shall be manual. Momentary paralleling of two incomers for the purpose of ‘No Break’ load transfer shall be provided. In momentary paralleling mode of bus transfer scheme, manual open command to the breaker shall be defeated.
- (6) Bus transfer schemes shall be designed mainly in PLC logic form in the numerical relays to eliminate / minimize unreliable contact multipliers / relays. Auto-independent-manual and trip selector switch shall be provided.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (7) The bus coupler change over scheme shall have separate relays for monitoring the bus healthy and Un -healthy condition. It is preferable to have healthy bus relay setting at 80% and unhealthy Bus relay setting at 40% (or less).
- (8) The change over schemes having separate monitoring with above settings can be provided with instantaneous changeovers.
- (9) Protection shall be provided to prevent transfer in the case of fault in downstream of the circuit breaker. It shall also be ensured that the Automatic changeover is not blocked for fault in upstream transformer or cable.
- (10) Once the power supply is resumed / fault is cleared on affected incomer, closing of the incomer and tripping of unwanted breaker (any of the incomer or bus coupler) shall be done manually, with momentary paralleling of two incomers through synchro check relay.
- (11) MCC shall be provided with 2 incomers and one no. bus coupler. Working & standby load shall be distributed on different bus sections. MCC with incomer rating ≤ 630 A shall have only manual bus transfer facility with necessary Castle key interlock. MCC with breaker for Incomers and bus coupler shall have auto transfer scheme / Manual scheme.
- (12) 86 relay contacts of both the incomers shall be provided in the bus coupler closing circuit to block the operation in both the Auto / Manual mode.
- (13) In order to ensure the healthiness of Bus coupler auto changeover scheme, it is desirable to incorporate Bus coupler "Auto Circuit Supervision Scheme" for all bus couplers utilizing the concept of trip circuit supervision scheme. **(Refer Annexure-13: Schematic Drawing No. – 5C.2A)**
- (14) To the extent possible, the control supply for auto-changeover scheme should be taken from reliable source e.g. DC.
- (15) Master relay (86) contacts of both the incomers to be provided in the common path of the bus coupler closing circuit to block the operation in both the "Auto / Manual" scheme.
- (16) It is desirable to block the closing command to bus coupler breaker (i.e. to deactivate the auto change over scheme) after a suitable time gap on tripping of any of the incomer breaker, wherever feasible. Blocking may be provided through a timer activated from the dead bus condition of the unhealthy bus.
- (17) It is recommended to provide inter-tripping from upstream breaker contact between upstream & downstream breaker.
- (18) Upstream & downstream ends of a distribution section should have breakers at both the end to ensure operational reliability and effective bus transfer during

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

upstream faults (faults out side the bus zone). **(Annexure-12: Refer Schematic Drawing No. – 5C.1)**

- (19) Provision of Inter tripping shall be provided mainly in the following breakers:
 - Incomer breakers at Generation & distribution buses
 - HT & LT breakers of transformers
 - Upstream & Downstream breakers of the radial feeder
 - PCC outgoing feeders and respective MCC incomer
- (20) It is to be ensured that downstream Bus coupler changeover scheme should not get blocked on operation of cable differential protection. Cable differential protection should operate master trip relay of upstream breaker. The downstream breaker shall either be directly tripped or through a dedicated master relay for cable differential protection.
- (21) In case of transformer protection, the trip command from REF protection should not actuate the master trip relay of the LT breaker to enable auto changeover of the bus coupler.
- (22) It is desirable to provide alarm in control room / manned location for the manual mode selection of the Bus Transfer Scheme.
- (23) Auto change over scheme shall be provided through logic in Numerical relay of bus coupler.
- (24) Fast bus transfer (FBT) scheme is to be provided in switchboard having high residual voltage during voltage dip.

6.6 HV, MV & LV- MOTORS & FEEDER

- (1) In general, three phase squirrel cage induction motors designed for direct on line starting shall be used. Motors shall be totally enclosed, fan closed type and suitable for continuous use. Synchronous motors and motors with variable frequency operation, soft starter shall be designed for special application.
- (2) All motors shall be continuous maximum rated with possible exception of crane and hoist motors, soot blowers, turbine / engine starting motors etc. which may be rated for the envisaged duty cycle.
- (3) The mechanical parameters such as duty, mounting type, shaft extension, direction of rotation, starting torque requirements etc. shall be adequate for the application. Sleeve or anti friction type bearings shall be used. Vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery. Motors with sleeve bearings may require proximity probes to measure shaft

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

vibration adjacent and relative to the bearings. Generally, all motors, except for application such as crane, hoist, turbine / engine starting, shall be designed for continuous duty with rated load.

- (4) The HT & LT motors shall be suitable for operation at (+/-)6% & (+/-)10% voltage variation respectively, +3% & -5% frequency variation & at 10% combined voltage & frequency variation.
- (5) Motor rating at 50 degree C ambient (i.e after derating for higher ambient) shall be 10% above the power requirement of the driven equipment at design duty point. Also the motor shall not be overloaded at any point of time in the entire operating range of the driven equipment.
- (6) Energy efficient motors IE2 shall be used for MV motors.
- (7) All motors shall have class F insulation with temperature rise limited to class B.
- (8) DOL start high voltage motors shall be suitable for starting under specified load conditions with 80% of the rated voltage at the terminals and DOL start medium voltage motors shall be suitable for starting under specified load conditions with 75 % of the rated voltage at the terminals. Voltage available at the motor terminals of large size motors which are started through dedicated transformer shall be decided considering the speed torque characteristics of the driven equipment and ensuring the voltage dip at the source bus does not exceed the permissible limits as per design basis.
- (9) Critical contacts used for providing process interlocks should be direct hard contacts and these shall not be taken from the multiplying contactors / auxiliary relays,
- (10) Soft starters or V/F controlled soft starter may be considered for starting HV motors if essential/unavoidable as per system design requirement/equipment design limitation. Reliable control supply shall be provided for soft starter control panel. PLC based control schemes shall be provided in soft starters. Breaker hard contacts shall be used for interlocks of soft starter.
- (11) Synchronous motors shall be complete with CT and PT cubicles, excitation panel, control and protection panel etc. Excitation panel shall be located in air conditioned room.
- (12) All synchronous motors shall be provided with brushless excitation system.
- (13) For critical synchronous motors, excitation panels shall have reliable power supply either from dedicated three phases or single phase UPS or any other reliable source as feasible.
- (14) Motors shall be capable for 20 % over speed without danger of mechanical failure

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (15) All HV motors shall be provided with 6 nos. duplex RTDs temperature detectors for winding temperature detection and 2 nos. for bearing temperature detection. Dual dial type temperature indicator without contacts for bearing also shall be provided for all HV motors. All LV motor including & above 75 KW shall be provided with PTC thermistors. Winding and bearing temperature alarm and trip shall be provided for HV motors.
- (16) Terminal box of HV motors shall be phase segregated type and shall withstand specified short circuit current for 0.25 sec. A separate neutral terminal box shall be provided for making star connection, and shall accommodate CTs for differential protection.
- (17) All motor terminal boxes shall be on the left hand side of the motor viewed from non driving end.
- (18) Terminal box of the motor shall be suitable for rotation by 90°.
- (19) The surge arrestors provided in the vacuum circuit breakers of Motor Feeders shall be rated for maximum continuous operating voltage. The maximum continuous operating voltage should be equal to the highest system voltage i.e. equal to the line to line voltage plus 10%.
- (20) Only Metal oxide type Surge suppressors shall be provided in VCB type motor feeders at Switchboard.
- (21) Selection of surge arrestors for ungrounded system is as under :
 - o MCOV rating must be equal to HSV.
 - o nominal discharge current should be minimum 5 KA for motor protection.
 - o Residual voltage at nominal discharge current must be less than the BIL of the motor (typically it will be 4U+5).
 - o The protection margin must be above 1.2 (Protection margin = BIL of motor / residual voltage)
- (22) The installation of surge arrestors to be done after the CTs so that in the event of surge arrestor failure particular motor feeder shall trip only without affecting other feeders.
- (23) All LV motors rated up to & including 2.2KW shall be with STAR connected. Motors rated above 2.2KW shall be DELTA connected winding.
- (24) Re-acceleration for identified critical motors shall be provided to cover brief interruption up to 5 seconds in normal power supply. Insulation for these motors shall be designed for 140 % of rated insulation level to take care of any over voltages that might result during changeover.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (25) To ensure the proper functioning of space heaters in HV & MV motors, it is desirable to have an ammeter in the panel for monitoring the space heater current.
- (26) Motors rated 22 kW and above shall have space heaters. Ammeter of size 48X48 shall be provided for space heater circuit on PMCC/HV panel.
- (27) VFD drive motor shall be provided with suitable harmonic filter to keep the system harmonics within limits (IEEE 519).
- (28) VSD operated motors shall be designed to withstand voltage spikes for at least 1 sec.
- (29) Type of motors that require variable speed drive system shall be suitable for variable speed range with temperature rise within limit and also shall be suitable for area classification. For hazardous area application motors with variable speed drive system shall be Ex 'd' type. The total system i.e. motor including VSD / VVFD shall be type tested as a unit. All motors operating on VSDs / VVFDs shall have embedded temperature detectors / thermistors for winding with thermistor relay which will trip the motor in case the temperature of winding exceeds the permissible limits. Flameproof motors operating on variable speed drive system shall have CMRI or equivalent authority certifying the suitability of drive motor with VSDs / VVFDs. For temperature detectors / thermistors 2/3 logic shall be provided for tripping.
- (30) Sleeve or ant friction type bearings shall be used. Vertical motors shall have thrust bearing.
- (31) HV motors with VSD application shall have insulated bearing.
- (32) Limiting Conditions for Motor start up (e.g. starting current limitation or method of starting): -
 - Starting current of HT motors rated upto 2.0 MW shall be limited to 500 % (inclusive of +ve tolerance). Generally, motors rated between 2.0 MW & 7.5 MW shall be started through Soft starter and motor rated above 7.5 MW unless otherwise required by process, shall be started through variable speed drive system having soft start feature
 - Starting current of MV motors rated from 0.18 KW upto 160 KW shall be limited to 600% (exclusive of +ve tolerance as per IS) of normal current.
- (33) Outdoor motors shall be provided with canopy
- (34) Motors for MOV actuator shall have F class of insulation with temperature rise limited to class-B.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (35) Power feeding of critical HV auxiliary motors of the Power Plant should be done in such a manner that outage of any primary generation or distribution bus shall not affect the power plant operation due to the tripping of any of the auxiliary drives e.g. CW pumps / BFP / GBC / Fans / Compressor etc.
- (36) Emergency Stop Button of HV motors should directly trip the breaker without routing the command thru' DCS/ PLC or a parallel direct command to be provided in addition to the command thru DCS / PLC.
- (37) Emergency push button & LCS STOP PB of all breaker fed HT & LT Motors shall have two NO elements. One shall be wired to trip breaker directly & other shall be wired to BI of numeric motor protection relay.
- (38) Control supply of local panel of air compressor shall be provided with UPS reliable power supply. Multiple compressors shall be provided with separate UPS supply to avoid total failure.

6.7 TRANSFORMER

- (1) Power Transformers shall comply with IEC 60076 and IS 2026 & applicable Govt. regulations. Generally transformers shall be:
 - a. Located outside (unless there is a specific Project requirement for them to be located indoors like lighting transformers).
 - b. Three phase oil-filled, self-cooled type (ONAN).
 - c. Vector Group – Dyn1 or to be decided based on Site requirement
 - d. Insulation Class - Class A
 - e. Double wound type.
 - f. Indoor transformers including Lighting transformers shall be three phase dry type (ANAN).
- (2) All transformers except lighting transformers shall be three phase, oil immersed, double wound type suitable for outdoor use, unless otherwise specified. Lighting transformers shall be dry type, unless otherwise specified. The transformers for variable frequency drive system shall be oil immersed or dry type as per project requirement.
- (3) 100% standby transformers (for power distribution and lighting) shall be provided in all unit, offsite and utility substations, unless otherwise specified.
- (4) In general KVA rating and percentage impedance of each transformer shall be selected to limit the rated current and short circuit current to values which are within the current rating and interrupting capacity of switchgear available.

The KVA rating for power, distribution and lighting transformers shall be decided on the following basis and should be as far as possible a standard value.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- a) In systems having redundancy for transformers, with transformers with cooling i.e. ONAN/AN, each transformer shall be rated equal to or greater than the 8 hour maximum demand of the load, starting of highest rated induction motor with other load in running condition plus 20% margin for future load growth.
 - b) In systems having redundancy for transformers, with transformers having forced cooling i.e. ONAF, each transformer shall be rated equal to or greater than the 8 hour maximum demand of the load plus 20% margin for future load growth (within 120% of it's self cooled (ONAN) rating and shall be fitted with automatic forced air cooling fans.
 - c) Where redundancy in number of transformers is not provided, rating shall be equal to or greater than 8 hour maximum demand plus 20% margin for future load growth. Fan cooled rating, where provided, shall be reserved as spare capacity for further future load growth.
- (5) Power transformers shall be of low losses type. Usually no load & load losses shall be optimised for operation around 40 – 50 % of their ONAN rating. Distribution transformer upto 2.5 MVA shall comply to IS 1180 part-1 read with govt gazette notification 2968 dated 16/12/2016 with respect to star rating.
- (6) The rating and no. of various transformers shall be decided based on the following criteria and in addition to that rating shall be decided based on largest motor start up capability and all possible plant operating conditions with respect to process design and plant operation such as running of normal and standby loads together. The transformer feeding a bus section of PMCC/PCC (HV, MV) shall be capable of feeding the entire load connected in both the sections of its switchgears i.e. during normal operation with bus coupler open, it should be loaded to 40 to 45 %of the capacity at its maximum efficiency point. During failure of the other section transformer say section 2, the section-1 transformer shall take the full load with temperature rise within the limits. Voltage drop with the transformer feeding the entire load and starting the biggest motor or reacceleration of group of motors connected to its switchgear shall be suitably considered for designing the transformer.
- (7) Construction of transformer shall be a
 - a) Less than 1000 kVA: oil- filled hermetically sealed type or dry type(if indoor)
 - b) 1000kVA & above: oil-filled conservator type (for high humidity locations - with a membrane(air bag), in order to prevent “direct oil-to-air” contact).
 - c) Cable connected to secondary switchgear (bus duct to be used if the current exceeds the limit given in I.E rules).
 - d) Transformers shall have externally operated off-load primary tap changer with full capacity taps +/- 2.5, +/- 5.0 %.
 - e) Indoor transformers shall be three phase, dry type (ANAN)

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- f) Synthetic fluid (e.g. silicone or Midel) shall be used instead of mineral oil in applications where it is desired to reduce the risk of fire to a minimum, and dry-type transformers are not specified.
- (8) The maximum rating of distribution transformers shall be 2 MVA. Number of such distribution transformers shall be decided based upon the total load requirement. Due consideration shall be given to the starting current of large motors. Transformer of rating up to 2.5 MVA maximum can be considered as an exceptional case in order to accommodate marginally higher load requirement.
- (9) Transformer rating shall suit 20% spare capacity with 100% load as basis. During normal operation, each transformer shall be loaded to 40% of rated capacity. During outage of one transformer, other healthy transformer shall be loaded to 80% of rated capacity.
- (10) Transformer rating and impedance shall be selected in order to limit short circuit current to value within the current rating & rupturing capacity of switchgear and also to permit the DOL starting of the largest motor without exceeding the permissible voltage drop limit. Transformer impedances shall be as per Indian standards unless otherwise specified.
- (11) Neutral CTs for protection shall be mounted in terminal box only, and shall be easily accessible for maintenance and testing purpose. The neutral CT shall be so mounted that even the fault between neutral and earth is reflected in REF protection.
- (12) All the transformers shall be provided with Buchholz alarm & trip, OTI alarm & trip, WTI alarm and trip, MOG alarm & PRV trip.
- (13) All transformers above 10MVA shall be supplied with online PD monitoring system.
- (14) String insulators with high creepage distances shall be used in terminal boxes, especially in transformers
- (15) Breather connection in transformer terminal box and bus ducts shall be done from the bottom only instead of side and top of the terminal box or bus duct.
- (16) In general kVA rating and percentage impedance of each transformer shall be selected to limit the rated current and short circuit current to values which are within the current rating and interrupting capacity of switchgear available.

S.No.	Transformer	Voltage Ratio	Vector Group	Tap Changer	Cooling
1	Grid power transformer	220/66 KV	YNyn0	OLTC	ONAN/ONAF

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

2	Grid power transformer	132/11kV	YNyn0	OLTC	ONAN/ONAF
3	Generator unit transformer	11/11.7kV	YNd 11	Off-circuit	ONAN
4	Power transformer	11/6.9kV	Dyn 1	OLTC	ONAN/ONAF
5	Dedicated (e.g. for VFD)	As Req'd.	As Req'd.	Off-circuit	ONAN
6	Distribution transformer (<= 2500 KVA)	6.6/0.433kV	Dyn 11	Off-circuit	ONAN

Note:

- Provision of Oil Soak Pit & Oil Collection Pit for transformers shall be as follows:
 - Oil quantity $\leq 2000\text{L}$: Not Required
 - $2000\text{L} < \text{Oil Quantity} \leq 9000\text{L}$: Soak Pit
 - Oil Quantity $> 9000\text{L}$: Soak Pit + Collection Pit
- Fire fighting system for transformers above 10MVA or oil greater than 2000 Liters.

6.8 GENERATOR / GENERATOR AUXILIARIES

A. GENERATOR AND ITS EXCITATION SYSTEM/ PMG

- In case of tripping of Gas turbine, generator is to be tripped directly through Gas Turbine trip command instead of tripping the generator on reverse power protection.
- NO" contact of the Unit Master Trip Relay (86U) is to be used in Mark-V/VI, for turbine tripping
- Provision of mechanical closing of generator breaker from the breaker front plate is properly covered to prevent accidental closing
- For emergency tripping of generator, two Emergency Push buttons (with a protective cover) in series at Generator Control Panel is to be provided.
- Manual opening of the field breaker is to be blocked if either of both the generator breakers is ON
- Check synchronization relay contact is to be provided in series with the "Auto Synchronizer" command for closing generator breaker. The Check synchronization relay should be of "SKE" type and not "SKD" type

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (7) In case of Generator High Temperature trip, 100 deg C tripping contact in series with the 80deg. C alarm contact is to be considered or incorporate the logic 2 out of 3 (2-o-o-3) of the temperature sensors
- (8) In case the Generator High Temperature trip command has been routed through a Fire Alarm Panel, the Fire Alarm panel is to be provided with DC supply / UPS AC supply to.
- (9) Generator space heater supply is to be controlled through generator breaker contacts or an alarm "Space Heater' ON" may be wired up to the control room. "
- (10) Trip commands from the generator master relay and TNC switch to the breaker is to be wired separately
- (11) DAVR performance to remain unaffected during the power system voltage dips.
- (12) DAVR limiter settings are to be done as per generator capability with all the limiters in service.
- (13) Proper sizing of the outgoing cable from AVR to exciter is to be ensured by considering the allowable voltage drop.
- (14) Time delay of 2.5- 3.0 sec is to be provided in the DAVR's auto- manual changeover logic during under voltage condition.
- (15) Alarm for DAVR internal power supply failure is to be provided at manned location.
- (16) Generator should be provided with instantaneous trip in case of DAVR stage-3 faults (AVR Trip condition).
- (17) Proper settings of field forcing limiter in DAVR are to be provided to boost the excitation during voltage dip conditions for maximum duration depending upon machine capability.
- (18) Scheme for "DAVR changeover from Auto to manual mode on PT fuse failure" is to be provided in order to prevent tripping of DAVR on DAVR PT fuse failure.
- (19) DAVR are to be provided with separate emergency channel (Dual Chanel) with dual PLC to take care of excitation requirement in case of operation of stage-3 fault is to be provided (**Refer Annexure-3: Schematic Drawing No. 1C.3**).
- (20) Harmonic suppression filters in the PT input circuits is to be provided to take care the harmonics in the power supply

B. GENERATOR- CTS/ PTS/ LIGHTING ARRESTORS SYSTEM

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (1) Only window type CT's are to be provided in Generator bus duct (phase & neutral side up to switchgear to avoid any possibility of CT insulation failure/ bursting due to heating. It is to be ensured that the PD value of the CT's shall be less than 20 pc during procurement.
- (2) In order to prevent tripping of generator due to flashover in the LA / PT/ NGR panel / HT Chamber because of faults, No non-essential equipments e.g. light fittings etc. is to be installed at these locations.
- (3) Equipotential wire of the window type CT's installed in generator bus duct are to properly dressed and without having any extra length of the wire to avoid possibility of flashover with the adjacent buses of the other phases

6.9 DC POWER SUPPLY SYSTEM

- (1) Independent DC power supply system shall be provided for the following (unless otherwise specified):
 - (a) Plant shutdown system including DC instrumentation.
 - (b) Electrical Switchgear controls
 - (c) DC critical lighting.
 - (d) Instrument system
 - (e) DC critical drives e.g. emergency lube oil pumps for centrifugal compressor fire sirens etc.
- (2) Separate 110 V separate dedicated DC system for each HV substation complex is to be provided.
- (3) Each DC power supply system shall include battery bank, charger-cum rectifier and DC distribution board. System should be provided with a redundant battery charger with paralleling operation scheme or auto changeover feature for switching to standby battery charger in case of fault in main (running) charger or vice – versa. **(Refer Annexure-14: Schematic Drawing No. – 6C.1).**
- (3) The two incoming power supply sources of the battery charger system shall not fall on the same primary Generation / distribution source at HV level. **(Refer Annexure-15: Schematic Drawing No. – 6C.2).**
- (4) The battery charger supply should be taken from the switch fuse units / MCCB's/ACB and not from contactor based modules.
- (5) The battery charger should have a provision to come into service automatically after the system is recovered from voltage dips or restoration of power supply in the event of plant interruptions.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (6) The DC distribution system should have dual DCDB with a coupler switch. **(Refer Annexure-15: Schematic Drawing No. – 6C.2)**
- (7) The loads may be distributed accordingly on two DCDBs by giving redundancy in supply to critical loads.
- (8) For critical DC loads, where failure of DC supply leads to tripping of the critical equipment (Fail safe) should be provided with redundant DC supply fed from different feeder of DCDB.
- (9) Emergency interconnection between the two DC systems having the same voltages either in the same substation or from nearest substation is to be provided. **(Refer Annexure-16: Schematic Drawing No. – 6C.3)**
- (10) A Battery charger fail alarm, DC ground fault alarm, boost charging alarm & other critical battery charger alarms to be provided in the control room / manned locations. If required single summary fault contact alarm may be provided.
- (11) Alarm for filter capacitor bank fuse monitoring to take care of ripple content is to be provided.
- (12) Provision shall be made for current, voltage signals, ON-OFF status, DC fault identification, filter capacitor bank fuse monitoring signals for SCADA/PMS/ECS.
- (13) Battery charger shall be provided with ripple overshoot annunciation.
- (14) Scheme shall be provided with a milliamp meter at DCDB / control room or in ECS to monitor the extent of leakage current in the system
- (15) DC distribution system to ensure proper fuse coordination between the upstream & downstream sections.
- (16) The ratings of each fuse shall be marked on the panel above the fuse base.
- (17) The battery bank provided with the battery charger should be in healthy condition and of adequate capacity to provide sufficient backup in case of power failure.
- (18) Separate DC systems feeding to Instrumentation system (110V DC System) and emergency light (220V DC System) should be provided.
- (19) Each HV bus section shall be provided with redundant DC control supply. Each bus section should be fed from separate DC feeder. The redundant DC control supply shall be designed for changeover to the alternate backup DC supply in case of failure of the main supply.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (20) The DC system for control supply to switchgears shall be 110V DC as failure of insulation between terminals and relay connections in 220V DC systems is high.
- (21) Use of VRLA batteries shall be restricted to FA/PA/Paging system. For other applications NI-CD batteries to be used.
- (22) While sizing the batteries, temperature correction, ageing factor and maintenance factor shall be considered.
- (23) Float type of level indicators shall be provided for each cell in the battery bank
- (24) Batteries shall be adequate to meet the requirements as per duty cycle, type of load and min. 20 % spare capacity for future requirement
- ~~(25) Isolator shall be provided for battery bank isolation near battery.~~ 

Isolator shall be provided for battery bank isolation near battery. If isolators are provided in battery room, the isolators shall be flame proof.

- (26) The charger shall have dual parallel redundant modules of float cum boost charging unit. Necessary mode selector switch shall be provided for the two chargers & battery connection. The output of FCBC shall be connected to two DC bus sections with coupler switch and finally connected to each section of a dual DCDB
- (27) The battery charger/rectifier shall feed the load and keep the batteries under fully charged condition. Provision shall also be made for necessary boost charging/initial charging of battery.
- (28) Battery chargers shall be provided with tap cell connection to take care of interruption of float charger when other charger is being used to boost charge the battery bank.
- (29) Each battery bank, charger & DCDB shall have atleast 20% spare capacity to meet future requirements.
- (30) Rating of charger shall be suitable for trickle / boost charging of batteries and to feed the DC loads, with 25% spare capacity.
- (31) DCDB incoming and outgoing cables shall be copper cables.
- (32) DCDBs shall be provided with semiconductor fuses for fast isolation.
- (33) A milliamp meter shall be provided at DCDB / control room or in ECS to monitor the extent of leakage current in the system.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (34) Electronic cards of system like UPS, battery charger, VFD, SCADA, Heater control system shall be ISA-G3 compliant as per Std. S.71.04
- (35) Copper cables shall be used in Battery Charger DCDB & Battery Charger DCDB to downstream distribution systems.
- (36) Complete redundant configuration shall be provided with Dual battery chargers, Dual battery banks & Dual DCDB sections. Two independent DC systems with individual DCDB shall be provided. Two feeders from individual DCDB using diode O ring shall be employed at critical utility point.
- (37) In DC - UPS System, for Ni Cd battery sizing, the end cell voltage must be taken as 1.16 Volt.

6.10 UNINTERRUPTED POWER SUPPLY SYSTEM (UPS)

- (1) Uninterrupted power supply system shall be provided, (as required) for meeting critical loads that cannot withstand a momentary interruption in voltage (e.g critical instrumentation, control, Human machine interface (HMI) for numerical relays, fire alarm, LAN system etc.)
- (2) The UPS shall have duty and ratings of feeders adequate for the application and shall be suitable for indoor use. UPS system shall be sized to take care of the crest factor of the load current.
- (3) UPS shall be of redundant (non-parallel) configuration with 2 x 100% capacity and with dual battery banks. UPS system shall be provided with ACDB with two I/C & one B/C scheme with 100% redundancy of feeders on each section. Each module shall consists of rectifier transformer, rectifier-cum charger, inverter, filter circuit, static switches, bypass transformer, facility for manual transfer between inverter supply and bypass line, facility for bypassing inverter and static switch for maintenance, set of batteries adequate to supply required rated output for one hour. UPS with Dual ACDB configuration shall be provided (**Refer Annexure-18: Schematic Drawing 7.C2**).
- (4) ATS based fast load transfer scheme shall be provided at downstream DCS PDB end. Each ATS at DCS PDB end shall be have two incoming feeders two different sections of UPS ACDB at upstream end. Outgoing feeders of ACDB to have suitable rating of isolation transformers.
- (5) It shall be possible to select the preferred source for each ATS. Preferred Sources shall be selected such that the load on both UPS systems at upstream end remains almost balanced. In case of failure of one of the preferred source from upstream, ATS shall transfer the load to standby source without break.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (6) Failure of any one UPS system or ACDB section shall not initiate tripping of process unit or any equipment. It shall be possible to take shutdown & carry out preventive maintenance of any one of the UPS at a time or any one ACDB section in plant running condition without affecting the reliability of the overall UPS system & plant operation.
- (7) Also, It shall be possible to take shutdown & carry out preventive maintenance and load testing of any one of the battery bank at a time in plant running condition without affecting the reliability of the overall UPS system & plant operation. It shall be possible to carry out load testing & boost charging of the battery in UPS loaded condition. The UPS shall be provided with controlled online battery load test & charging facility.
- (8) 3-Ph 415V Bypass (SCVS) input supply of both the UPS systems shall be from the common source so that 110VAC output of both UPS systems shall remain synchronized with each other and synchronized (no break) transfer (<4ms) can be achieved at downstream ATS in case of failure running/preferred source of the ATS.
- (9) All the incoming power supply sources to the UPS system (UPS-1 / UPS-2 / Bypass) shall not fall on the same primary Generation / distribution source at HV level. It is preferable to provide the bypass incoming supply from a different substation/ PCC. **(Refer Annexure-17: Schematic Drawing no. 7.C1)**
- (10) Also, preferably, changeover switch shall be provided between 3-Ph 415V incoming sources of both chargers to facilitate shutdown of upstream PCC/MCC section shutdown in system running condition
- (11) Under normal operating conditions, the rectifier cum charger shall feed the inverter and charge the battery set. In case of mains failure, the battery shall supply the necessary power to the inverter. Inverter in turn shall feed the load through the static switch. If the inverter malfunction or get overloaded, the load shall be instantaneously transferred to the bypass line through the static switch. Normally, the inverter shall be operated in synchronised mode with the bypass line and manual transfer forward/ reverse shall be effected without any break. The overload capacity & current limiting shall be adequate for the application. Harmonic filters if required shall be considered at input side
- (12) Each branch circuit of the UPS distribution system shall have a fused disconnect switch. The fuse shall be fast clearing type in the fuse rating shall be co-ordinated with the rating of the UPS system. Normally the largest branch circuit load shall not exceed 25% of the UPS system rating.
- (13) UPS system shall be sized to have at least 20% capacity for future load growth.
- (14) Each UPS ACDB shall have at least 20% spare feeders for future by owner.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (15) The UPS shall be provided with fault diagnostic feeders.
- (16) Separate dedicated UPS system for each process unit (associated units) is to be provided.
- (17) All the input supplies to the UPS shall be provided from SFU's/ Circuit breakers & not from the contactor-controlled modules.
- (18) Proper UPS supply Protection coordination from UPS ACDB level to the downstream distribution level (in the instrumentation panels) is to be provided to avoid complete outage of supply due to coordination mismatch.
- (19) All UPS alarms at the manned location / control room is to be provided.
- (20) UPS systems are to be installed in only dust free air-conditioned atmosphere.
- ~~(21) The power supply to auxiliary equipments e.g. tube light, fans, space heater etc. shall not be a UPS supply and shall be supplied from the normal plant supply.~~
- UPS supply shall not be used for external auxiliary requirements like lighting, fans, space heater etc.
- (22) Outgoing cables to ACDB shall be copper cables.
- (23) Sea worthy packing with external lifting arrangement to be provided.
- (24) Electronic cards of system like UPS, battery charger, VFD, SCADA, Heater control system shall be ISA-G3 compliant as per Std. S.71.04.
- (25) Copper cables shall be used in UPS ACDB & ACDB to downstream distribution systems.
- (26) Contactor change over schemes shall not be provided in the UPS ACDB and ACDB to downstream distribution system output supply.
- (27) UPS ACDB shall be dual redundant fed from independent UPS system and two feeder (one from each ACDB) shall feed the parallel redundant load of instrument for reliability. For single load service, automatic transfer switch (ATS) may be used.
- (28) DC-DC converter (Buck-Boost) not to be used to achieve the required DC Level or inverter DC requirement.
- (29) Voltage stabilizer shall be Servo -controlled or static (solid state) type.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (30) In UPS System, for Ni Cd battery sizing, the end cell voltage must be taken as 1.16 Volt.

6.11 VARIABLE FREQUENCY DRIVE (VFD)

- (1) In view of reliability getting more concern over the energy conservation (in case when there is single equipment used for a particular service and tripping of which may result in tripping of process unit) use of VSDs shall be avoided.

“OR”

In case it is not possible to do away with VSDs, redundant VSD's in hot standby mode to be provided

“OR”

Two motors with VSDs in parallel, at 50% load on each, for critical applications is to be provided. It is to be ensured that suitable damper / isolation arrangement exists between the parallel running drives to prevent reverse rotation in idle condition.

- (2) Suitable damper / isolation arrangement as required shall be provided to prevent reverse rotation in idle condition.
- (3) “Distance between the drive and the motor should be minimum possible and should be within the recommended distance for a particular model by OEM. The interconnecting cable between the drive & motor shall be joint free as it affect the life of IGBT due to reflected surge waves.
- (4) Output chokes in LV drive to be avoided. Sine wave filters to be mandatorily provided in LV VFD's.
- (5) All drive panels are to be installed in the dust free and air-conditioned environment with humidity control in order to protect the electronic components / PCB's of drives panels from dust & heat.
- (6) The drive enclosure shall have IP-42 class ingress protection for fan cooled type enclosure & IP-52 for self-ventilated enclosure.
- (7) All critical, semi critical motors above and including rating 55 KW and above shall be provided with PLC based logic only. Detail requirements and specification of PLC controller will be provided by EPCM/IOCL as per project requirement.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (8) Drives must be provided with “Power Off Ride Through feature” to maintain drive operation during voltage dips.
- (9) The auxiliary / Control supply of the drive panel shall be provided from reliable source e.g. UPS / DC source depending upon the requirement. (wherever control supply is not derived internally)
- (10) Only reputed make of relays with PTR for similar application shall be used for process interlock tripping.
- (11) Reliability in providing the critical “drive run signal” to the PLC is to be ensured & following measures are to be taken: -
 - Both Drive run and Drive fault signal shall be independently given to PLC for monitoring the status and better diagnostics purpose.
 - In order to prevent spurious tripping due to momentary loss of drive run signal (due to loose contact etc), feasibility of providing interlocks with the process parameters e.g. Furnace draft etc may be explored & implemented.
 - Analog 4-20 mA signals shall be provided through screened control cable.
- (12) For the latched type start / stop commands of the drives, necessary latching (holding of command) of start command shall be done at the drive panel end & only pulse type command shall be generated from the PLC / DCS to take care the possibility of tripping of drive due to momentary missing of contact due to any cable termination / contact looseness problems.
- (13) It is desirable to have Critical cards, which are essential for the successful operation of the VSD/ VVFD, be provided with redundancy with diagnostic feature. Provision shall be made for online replacement of defective card.
- (14) Microprocessor based variable speed drive shall be communicable type and shall be able to communicate with MMI / ECS / DCS
- (15) The earthing requirement for the VSD’s & motor should be strictly adhered as per OEM recommendations.
- (16) Only screened type signal cables are to be considered in VSD applications. The cables should be properly laid away from power cable to prevent interference.
- ~~(17) The drive should be self-cooled normally without ventilating fans. However in case ventilating system with fans is required, redundant ventilating fans must be provided.~~

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

Normally drives shall be without ventilating fans. If system demands, provision of ventilation with redundant fans and fan fail alarm may be explored & provided. VFD internal cooling Fans shall be fed from its internal supply only.

- (18) To minimize damage to cards / components from the environmental effects, the cards with Conformal coating is to be provided.
- (19) Separate control cable is to be considered for use in different voltage level of control supplies
- (20) Redundant power supply units shall be available for drives.
- (21) For effective troubleshooting, trending of VSD parameters & alarm logging through a dedicated PC/ DCS is to be provided for each drive.
- (22) Electronics cards of system like Battery chargers/UPS/VFD/SCADA/Heater control systems shall be ISA-G3 compliant as per Std. 71.04.
- (23) Redundant/ Duplex thermistors (temperature detectors) shall be provided on VFD driven motors and shall be wired up to VFD panel thermistor relay. Facility of display of motor temperature shall be made on VFD panel for breaker operated motors.
- (24) Minimum Speed (VFD frequency) limiter settings shall be done in VFDs to avoid over-heating of VFD motor on low speed
- (25) VFDs shall be provided with provision of Bypass (DOL) mode wherever possible with motor capacity.
- (26) PMC to ensure that supplied VFD is not undersized.
- (27) VFDs shall be provided with provision of Bypass (DOL) mode wherever possible with motor capacity. In case bypass facility envisaged in motor between 160 to 315 KW, same should be fed from HT feeder with suitable transformer.

6.12 POWER & STEAM LOAD SHEDDING

- (1) Automatic Power & Steam Load Shedding Schemes to be provided.
- (2) After actuation of all the steps of load shedding scheme, the amount of load available in the system (i.e. remaining plant load left out on the system after actuation of complete load shedding), shall be less than the smallest capacity machine.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (3) Load shedding scheme shall be adequate to take care of the simultaneous tripping of the largest power and steam generation sets.
- (4) Load shedding scheme shall be designed in such a way that it shall automatically take care of climatic impact, any variation in machine response from designed values during emergency etc.
- (5) System Disturbances / transient phenomenon shall not cause nuisance tripping of the scheme.
- (6) Additional provision of Manual load shedding from TPS control room to be additionally provided for non-critical load / units as a backup for manual intervention.
- (7) For improved reliability, logic / ECS based schemes should be backed up by under frequency-based load shedding schemes. **(Refer Annexure-19A/B: Schematic Drawing No. 1 EL-5).**
- (8) The load-shedding scheme shall have predefined order for the various steps to be shed during a particular type of emergency.
- (9) Command from two redundant outputs / relays shall be used to trip a particular step of load shedding scheme.
- (10) Scheme shall be provided with reliable & redundant control supply so that scheme shall remain operational in case of failure of one control supply.
- (11) Critical loads like UPS, battery chargers and critical process equipments should not be covered under the load shedding scheme.
- ~~(12) In under frequency based load shedding schemes following points to be taken care~~
 - ~~• Loading resistance in PT secondary shall be available during system transients / disturbance at the locations where PT secondary voltage has been used for frequency sensing.~~
 - ~~• It is recommended to block Frequency Based load shedding during under voltage conditions.~~

In case of under frequency based load-shedding schemes following points to be taken care:

- Loading resistance in PT secondary shall be available during system transients / disturbance at the locations where PT secondary voltage

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

has been used for frequency sensing. For new projects, HT PTs shall be provided with tertiary winding loaded with suitable resistance.

- It is recommended to block Frequency Based load shedding during under voltage conditions.

- (13) For actuating load shedding to achieve faster normalization of the system, Self-reset contact and hand reset flag type relays to be provided.
- (14) All alarm / annunciation/ indications related to healthiness and operation of load shedding should be made available in the power plant control room or nearly manned substation.
- (15) Alarm / Indication for load shedding operation also be provided in the Process control room for immediate information.

6.13 POWER AND CONTROL CABLES

- (1) Cables shall be sized considering the following factors.
 - Maximum continuous load current
 - Voltage drop
 - System voltage
 - Laying conditions
 - (Derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil etc. shall be taken into account)
 - Short circuit withstand criteria for HT cables
- (2) In general, all HV cables shall be with stranded aluminium conductor, dry cured XLPE insulated, insulation screened, PVC inner sheathed, armoured & FRLS PVC outer sheathed.
- (3) Generally all LV power cables shall be with stranded aluminium / copper conductor, XLPE insulated, PVC inner sheathed, armoured & FRLS PVC outer sheathed. Copper conductor shall be used for sizes up to and including 10 sq. mm, and for higher sizes aluminium conductor shall be used.
- (4) All control cables shall be XLPE, armoured type with copper conductors, FRLS PVC outer sheath twisted pair overall shielded type.
- (5) All control cables shall have minimum 10% spare cores, except that control cables having upto seven cores may have one core as spare. Cores shall be identified by numbers printed on them, and not by colours.
- (6) All LV (415 V) power cables shall be 3.5 core / 4 core. 3.5 core cables can be considered above 25 sq. Mm except for motor where only 3 Core power cable shall be considered.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (7) Cables connected in parallel shall be of the same type, cross-section and terminations.
- (8) As an exception within substation areas, unarmoured cables may be used, if specifically agreed upon.
- (9) All power and control cables shall be in single continuous lengths (except for long feeder where the length of such feeder is above the manufacturing range of approved cable manufacturers) without any splices or intermediate joints. In no case the joint shall be located in hazardous area. The cables & wires in PVC conduits used for lighting shall have appropriate junction boxes with adequately sized terminals.
- (10) All incoming cables to switchgear/UPS/DC system/DBs and other equipment shall be sized for maximum anticipated load including 10% future growth. Cable for capacitor banks shall be sized for 135 % of the rated capacitor current.
- (11) The incoming cable for heat tracing power distribution panel shall be with four cores, the neutral conductor being of same size as the phase conductors.
- (12) Proper sizing of the outgoing cable from AVR to exciter is to be ensured by considering the allowable voltage drop
- (13) Separate control cables shall be used for each of the following :
 - (a) CT secondary circuit.
 - (b) PT secondary circuits.
 - (c) Interlocking circuits.
 - (d) DC signals between instrumentation & electrical equipment.
 - (e) AC signals between instrumentation & electrical equipment.
 - (f) Switchboard to each local control stations.
- (14) Cable detail chart for HV & LV is tabulated below

Cable Details

S. No	Design Criteria	EHV	HV	LV -415 volts
1	Loads located beyond 1 km	NA	1-core cable/ 3-core Cable	1-core / 3 1/2-core cable
2	Loads located 200-1000 m	NA	1-core cable/ 3-core	1-core / 3 1/2-core

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

			Cable	cable
3	Loads located upto 200 m	NA	1-core cable/ 3-core Cable	1-core / 3 1/2-core cable
4	Loads beyond 1000A rating and located near the transformer.	NA	Bus duct /1 core Cable	Bus duct /1 core cable
5	Recommended limiting size of multi-core cable (sqmm)	NA	300	300
6	Short-circuit withstand time (seconds)	NA	1.Incomer from transformer:1 2.Incomer from Other switchboard:0.6 3.Plant feeder:0.6 4.Motor/Transformer feeder:0.2	Not Applicable
7	Insulation voltage grade	NA	Unearthed	Earthed
8	Type of cable insulation	NA	XLPE-FRLS	XLPE-FRLS
9	Fire survival (Resistant) cable for Fire proof MOV	NA	NA	Yes
10	Power Cable for Motors/MOV	NA	3 core	3 core
11	Cable Conductor	NA	Copper/ Aluminum	Copper/ Aluminum
12	Power & Earthing cable	NA	Armoured	Armoured

6.14 CABLING WORK

- (1) The cables shall in addition to complying with the relevant British Standards and also comply with EEMUA Publication No 133 Specification for underground armoured cables protected against solvent penetration and corrosive attack.
- (2) Cables installed in aboveground enclosed areas shall be fire retardant and have non-propagating, self-extinguishing characteristics in accordance with IEC 60332 and IS 10810 Part 61-64.
- (3) The cable trenches shall be sized depending upon the number and voltage grade of cables. The trenches in hazardous areas shall be filled up with sand. Where underground cables cross road ways, pipe sleepers at grade etc. they shall be protected by being drawn through sleeves/ducts to provide a permanent crossing.
- (4) RCC cable trenches shall be sealed against ingress of liquid and gases wherever the trenches leave or enter a control room or substation. Pipes laid for mechanical protection shall be sealed at both ends. In case of direct burial, cable

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

route markers shall be installed at 30 m interval all along the cable routes and where the direction of cable trench changes. Additionally, markers shall be provided at cable straight through joint locations.

- (5) Above ground cables shall be well supported on cable trays and suitably protected against mechanical damage. Routing shall be decided to avoid interference with hot surfaces or places subject to undue fire risk.
- (6) Cable trays shall be run in either cable trenches / on overhead cable rack or along the pipe rack to suit the site conditions.
- (7) Separate cable trays shall be selected for:-
 - HV cables
 - LV power cable
 - LV control cable
 - Instrumentation cables/communication cable
 Cable trays shall be sized considering single layer of cables.
- (8) The trays shall not show deflection / bend / deformation after laying of cables.
- (9) All cable trays and accessories shall be prefabricated, G.I. ladder type. For tray system design, in addition to self-load and wind forces, following guidelines for design shall be considered.
 - a) Maximum Support span 3000 mm
 - b) Cable load for
 - i) 150 mm wide cable tray 30 kg/linear meter
 - ii) 300 mm wide cable tray 60 kg/linear meter
 - iii) 600 mm wide cable tray 75 kg/linear meter
 - iv) 750 mm wide cable tray 75 kg/linear meter.
 - c) In addition to this, 70 kg concentrated load at center span shall be considered. All structural steel design shall be as per Indian Standards. and shall be suitable / designed to withstand fire for a minimum period of 30 minutes.
- (10) Bends, tees, reducers, crosses, droppers etc. shall have the required bending radii as recommended by the manufacturer with 10% allowance for various cable sizes with a minimum of 300 mm.
- (11) Cable trays, racks and trenches shall be sized to allow for 10 % space for future cables. Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer. Separate trays shall be provided for HV cables, MV power, and control and plant communication cables to the possible extent. However, where specifically agreed upon in exceptional cases, HV and MV power, control cables may be laid together, with a barrier plate separating HV and MV cables.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (12) Separate cables shall be provided for AC and DC signal/control circuits, except for cables to Local control stations/ local control panels.
- (13) Cables connected in parallel shall run together so that their length remains the same.
- (14) All cables shall carry the cable tag numbers for easy identification.
- (15) Signal cables i.e. Instrument, communication, fire alarm, LAN and data highway, etc. cables shall preferably not be laid in the same trench/ tray along with electrical cables. In case these are laid in the same trench/ tray, a clearance of minimum 300 mm from electrical cables shall be provided. The overall cable layouts shall be designed for minimum interference between signal and power cables.
- ~~(16) The armour and semiconductor screen of single core cables shall be earthed at one end. The continuity of armour and semi-conductor screen shall be broken at each joint. The unearthed end of armour and screen shall be insulated. Proper TRIFOIL formation of the single core cables of the different phases is to be done by using clamps with transposing of the cable bunch at regular intervals.~~

In case single core armoured cables are provided, only single earthing (preferably source side) of the cable end terminations shall be done with proper marking on panel. Proper TREFOIL formation of the single core cables of the different phases is to be done by using non-magnetic clamps with transposing of the cable bunch at regular intervals. Transposition of screen with armour (with proper insulation) of the single core cables along with provision of sheath voltage limiters is also to be done at cable straight through joints (if exists) to minimize armour potential/ sheath voltage in new projects.

- (17) GI or FRP cover shall be considered for top most cable tray and bottom of the lowest cable trays shall also be covered with GI or FRP sheet. GI or FRP type sheet shall be selected based on the type of cable trays. Tray cover shall be provided for the outermost trays of vertical droppers
- (18) Wherever pipe rack is not available, cable tray support shall be sized to ensure lowest tray level to be minimum 2.7 m above grade.
- (19) Cables inside process units, and for off-sites and utilities, shall in general be run through sand filled RCC trenches with removable covers / overhead cable trays wherever provision on pipe rack for cable tray supports is available.
- (20) GI conduits shall be used between trenches and field equipment like motors, control stations etc. Necessary supports shall be provided for the same. Care shall be taken to give sufficient space in the trench to give required bending radius for the cable and spare loop.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (21) Concrete lined trenches shall have suitable drainage arrangement to avoid water collection, or these trenches shall be connected to nearest storm water drain. These trenches shall be sealed against ingress of liquids and gases.
- (22) The top of cable trenches before entering the substation shall be maximum 1 m above the ground level. All cutouts shall be properly sealed by a sealing compound. Pipes laid for mechanical protection shall be sealed at both ends.
- (23) All entry and exit openings for cables crossing in substation, control room etc shall be provided with fire barrier and it shall have minimum three hours rating.
- (24) Fire proofing of cables shall be done for 3 m length at indoor equipment entry point, and similarly for outdoor equipment entry point. Fire barriers shall be installed at substation building cable entry points. All cables shall have FRLS outer sheath.
- (25) Fire protection for cables shall be provided as per IS12459.
- (26) Lighting cables shall be run along the structures/cables, buried between cable rack and equipment using conduit.
- (27) Cable glands shall be used for termination of cables in all equipment. Single compression glands and double compression glands shall be used for indoor & outdoor use respectively. The material of glands shall be nickel plated brass and aluminium for multi core and single core cables respectively. The lugs shall be of tinned copper type. Lugs shall be of the same type as that of cables and bus bars. If cables & bus bars are of different metals, then bimetallic lugs have to be used to avoid junction heating.
- (28) End termination kit for HV cable shall be 'heat shrinkable' type or 'push-on' type.
- (29) All cables and cable joints shall be rated for unearthed system.
- (30) There shall be no cable joint in substation, cable cellar and process unit. All cable joints shall be properly identified and marked.
- (31) All removable cable trench cover joints inside the battery area shall be sealed with bituminous compound to prevent ingress of any liquid hydrocarbon in the trench.
- (32) The GI earth strip for earthing grid shall be anchored inside the wall of the concrete cable trench at approachable height.
- (33) GI earth strip of earthing grid shall run along the cable trays.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (34) All cables i.e. HV and LV in concrete cable trenches shall be laid on cable trays only.
- (35) Separate concrete chamber shall be provided for all cable joints.
- (36) Cable terminations shall use compression type glands.
- (37) Non magnetic cable glands and gland plates shall be used with single core power cable.
- (38) Where long runs of single core high voltage cables are required, an evaluation of the installation shall be carried out to determine if intermediate cross-bonding of armouring is required to avoid the heating effect of sheath losses.
- (39) Plant communication, fire alarm and telephone cables shall be laid in instrumentation overhead cable duct / instrumentation trenches as far possible. In case these are not available. Cable shall be laid in electrical routes along berm of the roads.
- (40) All power cables are to be properly supported by clamps at the panel entry to avoid tension on cable lugs.
- (41) **Cable Laying philosophy**

S.No.	Description	Philosophy
1	Process area	RCC trench with sand filled
2	Offsite paved area	RCC trench without sand filled and with Racks
3	Offsite unpaved area	Above Ground cable tray/RCC trench without sand filled & with racks
4	Type of cable trays	Galvanized prefabricated
5	Road Crossings for underground cables	Cable culvert
6	Road Crossings for Above ground cables	Overhead cable bridge

- (42) Cables crossing under the roads shall be through culverts with separate partitions each for HV, LV, Control & Signal cables in that sequence with the Signal cables being farthest from the power cables.
- (43) Fire proof coating shall be applied to the cable passing through electrical store room/ battery bank room.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

6.15 EMERGENCY POWER SUPPLY SYSTEM

- (1) The emergency power supply system, wherever envisaged, shall feed the following:
 - (a) Electrical loads essential for the safe shutdown of the plant.
 - (b) Emergency lighting.
 - (c) Communication system.
 - (d) Fire detection and alarm systems.
 - (e) D.C supply systems.
 - (f) UPS systems.
 - (g) Fire fighting equipment excluding main firewater pump.
 - (h) Loads critical for process, plant and personnel safety.
- (2) Emergency power supply could be from a different power source or emergency generator as per project design data sheet. Where emergency generator is envisaged, emergency power supply shall be made available within a time period of 30 second from the instant of failure of normal supply.
- (3) The emergency generator shall, generally, not be required to run continuously in parallel with the normal power supply system. However, short time paralleling facility shall be provide for transferring load to normal power supply or other operational needs as required.

6.16 LIGHTING SYSTEM DESIGN

- (1) Plant lighting system shall comprise:

- a. Normal lighting
- b. Emergency lighting
- c. Critical lighting.

Normal lighting shall be fed by AC supply (415/240V, 3 phases, 4 wires). Emergency lighting shall be fed from separate 3-phase source indicated. For this purpose separate ELDB shall be provided.

Critical lighting shall be fed from separate 220 DC supply system comprising battery, chargers & DCDB

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (2) All emergency and DC critical lighting (if specified) fixtures and associated Junction Boxes in Hazardous areas shall be Flameproof type.
- (3) All lighting shall be hooked up with centralized lighting system. Control from centralized lighting system will be provided from the nearest existing substation. This will be in the form of potential free control contact.
- (4) Plant lighting circuits (excluding level gauge lighting) for open to sky areas shall be designed for auto/manual switching through timer. In addition, it shall be possible to switch ON/ OFF entire lighting from ECS and local switchboard.
- (5) Lighting control scheme shall also be designed to trip the entire lighting system in case of air raid warning. Tripping signal for the lighting system shall be wired from the nearest existing substation.
- (6) Normal lighting system shall provide enough illumination so as to enable plant operators to move safely within the accessible areas of plant to perform routine operation including reading of field instruments, operation of all valves etc. and to carry out all the necessary maintenance and adjustment to equipment.
- (7) Normal lighting shall comprise 75-80 % of total lighting. Emergency lighting shall comprise of 20-25% of total lighting. Also, critical lights shall be provided in addition to above for entry points & escapes routes as required.
- (8) Critical lighting shall be fed from battery charger & battery system through DCDB, and shall employ LED lamps.
- (9) Areas requiring AC emergency lighting shall include, but not be limited to, the following:
 - All Areas requiring DC critical lighting.
 - Strategic locations in process, utility areas where specific safety/shutdown operation are to be carried out.

Generally 20-25% of the total lighting fixtures shall be fed from AC emergency supply.

- (10) Areas requiring DC critical lighting shall include, but not be limited to, the following:
 - Control rooms
 - Substations
 - DG shed
 - Central fire station
 - Fire water pump house
 - First aid center

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (11) DC critical lighting shall be provided in the pipe rack, exit/entry point only in case considered for process units
- (12) Adequate number of self contained portable hand lamps and battery operated emergency lighting units shall be provided for immediate use for buildings where no DC supply is available.
- (13) Telescopic tubular high mast shall be provided for illumination of outdoor process / tank area, and other strategic areas for general illumination. The high masts shall be of continuously tapered polygonal cross section and fabricated out of steel plates. The masts shall be provided with motorized racking mechanism for lowering and hoisting lantern carriage. The mast shall be minimum 30 metre height and shall have a capacity of 24 fixtures, but fitted with a maximum of 10 nos. fixtures in each mast keeping the rest for future expansion.
- (14) LED lighting shall generally be used for indoor & outdoor plant lighting as per area classification. DC critical lighting shall employ LED lamps. Tall structures shall have LED aviation obstruction lighting as per statutory requirements.
- (15) Lighting system shall consist of lighting transformers, lighting distribution boards (LDBs), lighting and power panels, fixtures, junction boxes etc. as specified. All outdoor lighting shall be automatically controlled by means of photoelectric cell/synchronous timers with manual overriding control as specified. Lighting and power panels shall be fed from LDB through 415/415V, Dyn-11, dry type lighting transformer having taps upto $\pm 5\%$. The lighting and power panels shall be provided with MCB and ELCB as incomer and Miniature Circuits Breakers (MCBs) for outgoing feeders control and protection of lighting circuits. ELCBs shall not be provided at the incomers of lighting and power panels, in case ELCBs are provided in the outgoing feeders of LDBs/ASBs feeding to these lighting and power panels. MCBs shall not be loaded beyond 80% of rated capacity. A minimum of 20% of miniature circuit breakers of each panel shall be left as spares. In general, the load on each circuit shall be limited to 1.5 kW. In areas having less lighting load, lighting transformer can be avoided
- (16) The sensitivity of ELCB provided in the lighting Panels shall be 100mA.
- (17) A minimum of 20% MCB outgoing feeders shall be left as spare in all lighting & power Panels.
- (18) Each lighting transformers shall be sized to feed the entire plant normal lighting load with 30 % as a minimum spare capacity.
- (19) Lighting distribution board shall have two incomers and one buscoupler. One Incomer shall be fed from PCC and other from LEPCC where available otherwise from the other bus section of PCC

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (20) Normally both the incomers shall be 'ON' with buscoupler in open condition. In case of any problem to any of the incomer, tripping of the affected incomer followed by closing of bus coupler shall be done manually. Under voltage relay contacts of both the bus sections wired in parallel shall be used to switch on the DC lighting circuits. Where second incomer is from emergency PCC, Normal running condition normal incomer and bus coupler shall be in closed condition. During the fault on normal incomer, Bus coupler shall open and emergency incomer shall be switched 'ON'.
- (21) Adequate Numbers of LPs, PP's shall be provided for complete lighting adequate for the plant. No. of LPs shall be considered based on location / area served and total loading.
- (22) Plant lighting circuits shall be fed from dedicated lighting distribution boards installed in a safe area. For LPs, incomer shall be provided with switch fuse unit / MCB and outgoing shall be with MCBs for control and protection of lighting circuits. ELCB shall be provided in each LDB outgoing circuits to lighting panels.
- (23) Plant lighting circuits shall be single phase (P & N) rated 240 V AC. Each circuit shall be rated to 16A but not loaded more than 8 A. A minimum of 25% of MCBs of each board shall be left as spares. Normally about 8-10 fittings shall be wired in each circuit
- (24) Plant lighting distribution board shall include 25% spare outgoing circuits
- (25) Adjacent lighting fittings shall not be fed from the same circuit.
- (26) Lighting system design shall be based on average illumination levels as specified below measured at 1 m above floor level:

<u>Area</u>	<u>LUX</u>
a. Roads and tank farm	20
b. Pump house, Sheds	100
c. Main operation platforms and access stairs	60
d. Ordinary platforms	20
e. Process area, pipe racks, heat exchanger, Heater, cooling tower, separators etc.	60
f. Switchgear room, Rack room	200
g. UPS/ Operator room	300
h. Cable cellar	70
i. Battery room	150
j. Control room (Console area), Laboratory	500
k. Switchyard	20
l. Warehouse	100
m. Office	300
n. Compressor area	150

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (27) Auxiliary relays as required for remote switching ON / OFF of lighting system shall be included in lighting distribution board.
- (28) Lighting design shall conform to relevant Indian and International Codes and Standards, IES Hand Book and shall take into consideration the requirements from point of view of safety and ease in operation and maintenance. A maintenance factor of 0.7 shall be assumed for lighting illumination level calculations for normal areas. However for dusty areas, maintenance factor as per relevant codes and standards shall be considered.
- (29) For indoor lighting, minimum lux level shall not be less than 80% of the average illumination level. For outdoor lighting, minimum lux level shall not be less than 40% of average value and 25% of maximum value.
- (30) Wiring for lighting and convenience outlets in outdoor areas and plant buildings shall be carried out with copper conductor, PVC insulated, armoured and PVC sheathed cables, which shall run along the column/platforms and structures. Perforated GI / FRP trays can be used for this purpose. The armoured cable shall enter lighting fixture/JB through increased safety double compression gland in Zone-2 areas and through flameproof glands in Zone-1 area.
- (31) Concealed conduit wiring shall be provided in control room, and office area of the buildings. For buildings with false ceiling, concealed conduit wiring shall be used below the false ceiling and surface conduit wiring above the false ceiling. In substation concealed PVC conduit shall be provided in substation cable cellars & for switchgear rooms METSEC channels concealed conduits shall be used
- (32) Heavy duty PVC conduits shall be provided for concealed conduit.
- (33) Battery room shall have fixtures mounted on wall in order to facilitate easy replacement of fused lamps. Switches controlling the lighting fixtures and exhaust fan shall be installed outside the battery room.
- (34) Locally mounted lighting fixtures on platforms, walkways, stairs shall be mounted in such a way that, relamping can be done without use of ladders.
- (35) Adequate number of pull boxes shall be used to aid wire pulling and inspection. No joints shall be allowed inside these pull boxes.
- (36) Adequate numbers of 5A/15A, 3 Pin sockets, shall be provided in all the buildings
- (37) Power supply to auxiliary services board where single phase / lighting loads are connected shall be through lighting / isolation transformer only.
- (38) Aviation Obstruction Lighting

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

In accordance with local requirements, the aviation obstruction lighting shall, where applicable, provide indication of the location of high structures in the process plants. The luminaires shall be provided with a fixed red light and shall be fed from the normal plant supply and shall be fed through separate miniature circuit breakers and / or fuses. Each aviation obstruction light shall be of long life LED cluster based with 3 separate circuits.

Obstruction lights are generally required on structures and buildings taller than 45 m. The obstruction lights shall be placed at intervals of less than 45m vertically and /or horizontally as the case may be, in a manner that indicates the general definition and extent of the obstruction.

In case of flue gas stack, a flare or a structure of similar function the lights shall be placed so far below the top that the generated heat cannot damage the luminaries and the installation.

The above is subject to approval of DGCA.

- (39) All chemical handling facilities shall be provided with chemical resistant fixtures.
- (40) All Lighting fittings shall be of energy efficient type.
- (41) Following types of fixtures shall generally be used:

a) Indoor areas:

Control room, administrative building, security office, canteen	8-20 W LED tubelight, 12-42 W LED downlight as per lux requirement.
Substation, MCC room, store, workshop	18 W LED industrial
DG room, compressor room etc with mounting height more than 6 m	75 W LED medium bay or high bay

b) Outdoor areas

Platforms, pump bays, skids etc where mounting height is 3 m to 3.5 m	40 W LED or 45 W LED well glass fittings for all areas
Transformer bay, tank farm, switchyard	LED lighting fittings

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (42) Fittings to be installed in the hazardous area shall be suitable for the zone and CMRI certified with CCE approval.
- (43) The material of construction shall be as follows: -
- Body –aluminium alloy pressure die-cast LM6/ADC12/LM24 for outdoor and flameproof lighting fixtures. CRCA/PC/Aluminium extrusion housing for indoor non-weatherproof fixtures.
 - Generally Industrial and outdoor fixtures must have secondary lens / optics of type PMMA/ Borosilicate glass / Polycarbonate.
 - However outdoor industrial luminaires like well-glass, flat glass may not have secondary lens optics. Indoor lights like bulbs, tube, down-lighters may not have secondary lens.
 - Cover type- toughened glass or UV stabilized polycarbonate for outdoor type fixtures and UV stabilized polycarbonate for indoor non-weatherproof type fixtures.
 - Impact resistance- IK-05 or better for outdoor fixtures, not required for indoor type fixtures.
 - The technical specifications of the fittings should comply with the IOCL LED policy
- (44) All DB/ JB/ Fixtures for emergency lighting & critical lighting to be color coded for distinct identification.

6.17 EARTHING SYSTEM

- (1) It is recommended that all electrical equipment be suitably earthed. Earthing system shall, in general cover the following:
- Equipment earthing for personnel safety.
 - System neutral earthing
 - Protection against Static and Lightning discharges.
 - Separate clean earth system for UPS, Instrumentation, DCS, ECS etc. as per specified requirements
- (2) Plant earthing design shall generally be carried out in accordance with the requirements of Indian Electricity Rules and IS: 3043. The earthing system shall have an earthing network with required number of earth electrodes connected to it. The following shall be earthed:
- System neutral

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- Current and potential transformer secondary neutral\
 - Metallic non-current carrying parts of all electrical apparatus such as transformers, switchgears, motors, lighting / power panels, terminal boxes, control stations, lighting fixtures, receptacles etc.
 - Steel structures, loading platform etc.
 - Cable trays and racks, lighting mast and poles.
 - Storage tanks, spheres, vessels, columns and all other process equipment.
 - Electrical equipment fencing (e.g. transformer, yard etc.)
 - Cable shields and armour.
 - Flexible earth provision for wagon, truck.
 - Pump handling Hydrocarbon if its base Plate is separate from motor's base plate.
 - Turbo driven pump handling hydrocarbon
- (3) System Earthing for incoming supply & primary/ secondary HV distribution system shall be as per design data. The 415V system neutral shall be solidly earthed.
- (4) Where installed, lightning protection shall be provided as per the requirements of IS IEC-62305. Self-conducting structures having metal thickness of more than 4.8 mm may not require lightning protection with aerial rod and down conductors. They shall, however, be connected to the earthing system, at least, at two points at the base. OISD-STD-180 may be referred for details on lightning protection
- (5) The resistance values of an earthing system to the general mass of earth should be as below:
- For the electrical system and equipment a value that ensures the operation of the protective device in the electrical circuit but not in excess of 4 Ohms. However, the generating stations and large sub stations, this value shall not be more than 1 Ohm.
 - 10 Ohms in the case of all non-current carrying metallic parts of major electric apparatus or any metallic object. For lightning protection, the value of 5 ohms as earth resistance shall be desirable but in no case it shall be more than 10 ohms.
 - Earthing of Tanks shall comply to OISD-STD-173
 - All joints in pipelines, valves, plants, storage tanks and associated facilities and equipment for petroleum shall be made electrically continuous by bonding or otherwise; the resistance value between each joint shall not exceed 1 Ohm.
- (6) Earth rods and conductors shall be designed to cope with the conditions imposed. The earth conductor shall be adequately sized to carry the applicable maximum earth fault current without undue temperature rise. All joints shall be protected against corrosion.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (7) All the electrical equipment operating above 250 volts shall have two separate and distinct connections to earth grid. Transformers shall be provided with two dedicated earth electrodes for earthing of neutral and transformer tank earthing.
- (8) All earth connections should be visible for inspection to the extent possible. In all cases, connection to earth should be made in accordance with IS: 3043.
- (9) The main earthing network shall be used for earthing of equipment to protect it against static electricity. An independent earthing network shall be provided for lightning protection and this shall be bonded with the main earthing network below ground, minimum at two points.
- (10) An approach for removing fire or explosion danger is to provide means for adequate dissipation and prevention of accumulation of static electricity, thereby ensuring that static discharges do not occur. One of the methods to eliminate risk of static electricity build up is grounding and bonding.
- (11) The subject of static accumulation caused by flow of petroleum products and the mitigation methods are dealt in detail in OISD-STD-110 and same should be followed.
- (12) Normally earthing system shall comprise of main earth grid along with suitably located disconnecting plates to provide multiple earth connections between earth grid and equipment and for connections between main earth grid and electrodes.

All connections shall be adequately secured against loosening.

Connections between earth electrode and the disconnecting plates shall be done by GI strip. Connection between the disconnecting plate and various equipment shall be done by GI strip, GI wire or GI wire rope.

- (13) All exposed conductive parts of all electrical equipment shall be bonded to the earth network. If there is no nearby network, they shall be connected to one or more earth rods or equivalent.
- (14) Tanks, piping and process vessels and equipment containing flammable liquids or gas shall be earthed by a connection to the earth network, or by bonding to an earthed metal structure.

Metal enclosures in intimate contact with the ground (for example, tanks) may be considered to be adequately protected without additional bonding.

Bonding straps shall be applied across in-line insulating devices on lines handling materials which give rise to significant amounts of static.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (15) UPS,DCS, PLC, and other electronic instruments, including electronic relays, shall be provided with copper plate clean earth. This shall be kept galvanically isolated from the system and safety earthing.
- (16) All utility / process pipelines shall be bonded to a common conductor by means of earth bars or pipe clamps. Steel pipe racks shall be earthed at every 25 m. Earth continuity shall be ensured across all flanges.
- (17) Earthing strip Shall be laid along cable trays, welded to the main cable tray support, and shall be connected to the earthing grid at every 20 m interval.
- (18) Metallic sheaths, screens and armour of all multicore cables shall be earthed at both equipment and switchgear ends. Sheath and armour of single core cables shall be earthed at switchgear end only.
- (19) At least two nos. of earth strips of adequate size shall be tapped from the main earth grid and taken to the top of all tall structures, platforms, and a ring shall be made at the highest point.
- (20) Cadmium coated nuts and bolts shall be used at tapping points where welding is not envisaged.
- (21) In plant area all stair cases, railings, monkey ladders shall be earthed at least at two points.
- (22) Proper wrapping and coating shall be given to the underground welded earthing joints to avoid any corrosion.
- (23) Earth electrodes shall be galvanized after fabrication. No welding and drilled holes are to be left without galvanization.
- (24) All earth pits shall be marked with earth pit number for easy identification. In addition, metallic tag is also to be fastened with the earth electrode inside the pit as a permanent identification.
- (25) Separate earthing shall be provided for transformer neutral.
- (26) Standard Installation Drawing for Earthing Pits & Earthing conductor schedule is attached as per Annex-B.

6.18 HT CAPACITOR BANK

- (1) Capacitor banks shall be provided, as specified in project design data sheet, to improve the power factor to meet the minimum stipulated power by the power authorities.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (2) HV Capacitor bank shall be connected on HV bus to improve the power factor of the system.
- (3) HV Capacitor shall comprise appropriate nos. of basic single phase units (minimum 4 nos. basic units in parallel per phase) which shall be connected in star formation
- (4) Capacitor banks shall be with necessary discharge resistors to reduce the terminal voltage of each unit to a value equal to or less than 50 V in 5 minutes
- (5) Necessary rack assembly for housing Capacitor units with necessary post insulators, Discharge resistors, series reactors, etc. shall be provided for outdoor assembly. For indoor assembly, necessary panel to accommodate the basic capacitor units, interconnecting busbars, insulators, discharge resistors, series reactors, switching units, metering, protection units etc. The panel shall have minimum IP 55 protection and shall be constructed with sheet steel of minimum thickness 2.0 mm.
- (6) Necessary series reactor shall be provided to limit inrush current and suppress harmonics.
- (7) Capacitor dielectric medium shall be MPP or mixed dielectric. Impregnant in the capacitors shall be non – toxic.
- (8) Necessary protections include IDMTL over current with high set element for protection against short circuit, Instantaneous earth fault, under voltage, Over voltage, Built in fuse for each element, neutral unbalance voltage, current.
- (9) The capacitor bank feeders shall generally be tripped on bus under voltage / over voltage conditions. Necessary interlock / timer shall be provided for blocking re switching operation to take care of capacitor residual voltage.
- (10) The continuous current rating of fuses and switching devices for capacitors shall be 30 % higher than the normal full load current

6.19 SCADA SYSTEM

- (1) The SCADA system shall be vendor-independent, future augmentable, IEC 61850 protocol based system.
- (2) All annunciations shall be hooked up to the numerical relays and all relays shall be hooked up to SCADA on IEC protocol.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (3) All numerical relays of all types shall be communicable and connected to SCADA on IEC protocol with time stamping and time synchronization.
- (4) SCADA system shall have memory backup to avoid reprogramming after any power interruption.
- (5) Only RTUs shall be used for remote substation data processing. Remote processors will not be permitted.
- (6) All the critical alarms of power plant sub-station (viz, Incomer/ Bus Coupler Trip / Critical PCC Status /Control Supply Status / UPS Status/ Battery Chargers Status/Status Of Load Shedding etc) should be extended to the power plant control room, in addition to Generator related alarms.
- (7) Electronic cards of system like UPS, battery charger, VFD, SCADA, Heater control system shall be ISA-G3 compliant as per Std. S.71.04.

6.20 LOCAL CONTROL STATIONS

- (1) Each motor shall be provided with a control station/control panel in the field with canopy, unless otherwise agreed upon.
- (2) The control station shall include the following equipment as per individual requirement:
 - Start/stop push button (spring return to normal)
 - Ammeter (for motors rated 5.5 kW and above)
 - Auto/Manual or Local/Remote selector switch(if specified)
 - Indication lamps etc. (if specified).
 - Stop push button shall generally have stay put feature except in the case of critical drives such as lube oil pump etc.
 - One number control switch station with start / stop push button shall be provided at ground level in addition to the push button on operating platform for air fin fan coolers.
- (3) Stop push button shall be of stay put type, however it can be of momentary type in case of drives such as lube oil pump etc which are critical
- (4) The local control stations shall be of aluminium alloy (LM6) construction. Enclosure of the control station shall be suitable for site conditions such as weather proof,dust proof, flame proof, corrosion resistant etc. All outdoor control stations shall be with canopy.
- (5) Two numbers of stop push buttons shall be provided for the motors, which are installed at elevated platforms, such as cooling tower fan etc. One of the push buttons shall be installed at ground level and the other near the motor

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (6) Weatherproof, break glass type emergency push button station shall be provided near transformers to trip the transformer feeder in case of emergency. Emergency trip push button shall also be provided for motors above 1000 kW rating
- (7) Local control station shall be provided with ammeter for motors rated above 5.5 kW. Local control station for aux. Lube oil pumps, heater etc. shall be provided with ammeter irrespective of motor rating. LCS for all emergency / critical drives shall be provided with ammeters.
- (8) All outdoor distribution boards/LCS/Receptacles must be provided with 3 side cover canopies.

6.21 CONVENIENCE AND WELDING RECEPTACLES

- (1) All enclosed spaces like columns, vessels, furnaces, boilers etc. shall be provided with 24 V AC power supply circuit having sufficient power points near each manhole for S/D lighting purpose.
- (2) Each process unit shall be provided with 2 nos. 3 phase 415 V 250 A flameproof power supply DB for hydrojetting and other miscellaneous utilities.
- (3) These shall have the necessary mechanical interlocks and earthing facilities. The enclosure shall have suitable protection for site conditions specified (flame proof, weather proof, dust proof, corrosion resistant, etc.).
- (4) Adequate number of welding receptacles shall be provided at suitable locations to ensure accessibility with a 50 m length of trailing cable to any point in the process area. These shall be rated for 63A suitable for 415V, 3 phase system with a scraping earth.
- (5) Adequate number of three-pin sockets for lamps and portable tools shall be provided at suitable locations to ensure accessibility with a 15 m length of cable to all manholes of process equipments and other important areas in the process units. These shall be rated for 15A, 240 V single phase with earth connection. Hand lamps and portable tools shall be earthed through flexible cords. In hazardous areas, flameproof hand lamps shall be rated for 24V. Accordingly 240/24V transformers shall be provided either in the hand lamp assembly or in a separate flameproof socket outlet.
- (6) In Zone 1 and Zone 2 Areas welding sockets shall have type of protection Ex d and an interlocked switch. In non-hazardous areas welding sockets shall have standard industrial, weatherproof, enclosures.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (7) In indoor, non-operational areas, (e.g. Administration Offices, Workshops, etc). Convenience sockets shall be 240V, 15A, two wires, three pin. They may be on ring, or radial distribution systems.
- (8) Adequate number of industrial type socket outlets (20A) shall be provided in substations.
- (9) The power outlet for hydro blast cleaning shall be rated 415V, 200A, three phase. The power outlet shall be suitable for the area classification in which it is situated.
- (10) All power receptacles like 240 V, 24 V, 415 V shall be supplied from power DB and not from lighting DB.
- (11) Source cubicle tag no. shall be marked on the cover of all field receptacles for easy isolation.

6.22 PAGING SYSTEM

- (1) PA system shall meet the requirements of plant operations. It shall consist of:
 - IP/Microprocessor based exchange,
 - Master station with external loudspeaker, microphone etc.
 - Desk type call stations alongwith external loudspeaker for installation in buildings,
 - Wall mounted call stations suitable for area classification with horn type loudspeaker.
- (2) The exchange shall have redundant CPU.
- (3) Stand alone systems shall be provided for different process units, substations etc. which shall be suitable for interfacing with Fire alarm system, EPABX system, Radio Paging system, existing system if any. System shall also be designed such that it can be integrated to centralised control room.
- (4) Paging speakers provided in areas having ambient noise levels shall produce a paging sound level at least 10 db above the anticipated ambient noise level. Where it is not possible to achieve the sound level of above 10 dB above the ambient, rotating beacons shall be installed such a way that that the operator is alerted in the area. The typical area where the provision of rotating beacons are envisaged as compressor house, generator house etc. Acoustic hoods shall be provided for call stations located in high noise areas
- (5) The system shall have features like status monitoring, fault diagnostics and report generation.
- (6) Each paging system shall have atleast 30% spare capacity after meeting all requirements of the process units.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

(7) ~~Separate UPS with batteries shall be provided for each exchange~~

Separate UPS with batteries shall be provided for each exchange. Separate UPS shall be the UPS of respective unit, where the paging exchange is being installed.

- (8) The design of the system shall be such as to provide two channel communication i.e. Page & Party in each zone. Page & Party system shall comprise of one channel for paging & one channel for party talk.
- (9) In the Party mode, conversation shall not be heard over the loud speaker but it shall be carried out on the handsets. This mode shall be used for actual conversation, exchange of information etc.
- (10) It shall be possible to make a paging call by lifting the handset, off the hook switch & pressing the "press to page" switch. The paging message shall get transmitted over all the loud speakers when the paging person speaks in the microphone of the handset. While paging, it shall automatically mute the loud speaker near the paging handset to eliminate the acoustic feedback.
- (11) It shall be possible to communicate between two field stations without the interference of the MCS / operator. Also it shall be possible to have direct communication with the MCS
- (12) The equipment shall be sturdy, impact resistant, dust & damp proof generally conforming to minimum IP 55 degree of protection. For classified hazardous areas flameproof equipment shall be provided duly certified by recognised certifying authority for the area of installation. The equipment for outdoor shall be weatherproof type conforming to IP 55 degree of protection & shall be provided with canopy. All equipment & accessories shall be given tropical protection against fungus, insects & corrosion. Equipment shall be made tamper proof by use of non standard screws, which can be opened only by means of special keys supplied by the manufacturer. Solid state components shall be used throughout & assembled in plug-in type modules
- (13) Paging system shall have battery backup for 8 hours in case of power failure.

6.23 TELEPHONE SYSTEM

- (1) The process plant, energy centre, substations, control rooms, administration building & other non-process/plant buildings etc. shall be provided with sophisticated microprocessor based intercom telephone system to facilitate intercommunication. This consists of an Electronic Private Automatic Branch Exchange (EPABX), where existing EPABX is not available.
- (2) The EPABX system shall have battery backup for 8 hours in case of power supply failure. Ni-Cd Battery shall be provided.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (3) Telephones installed in classified hazardous area shall be flameproof type suitable for the area classification, gas group & temperature class
- (4) All telephone instruments shall be push button type with redialing facility.
- (5) Telephone sets in noisy area shall have beacon light for ring recognition.
- (6) All local telephone sheds in the field shall be provided with yellow paint.

6.24 FIRE DETECTION & ALARM SYSTEM

- (1) Fire Alarm system shall be microprocessor based, intelligent, analogue addressable type
- (2) System shall be stand alone for entire plant area consisting of individual process units, utility areas, substation, control rooms etc. System shall be designed to provide necessary audio visual signals at the main control panel with mimic panel and repeater control panel. The system shall be hooked up with main fire control panel located at fire station control room.
- (3) However system shall be suitable for integration with CCTV, PA, EPABX, Gas Detection system, Fire suppression system and HTAC system.
- (4) The fire detection and alarm System shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke/heat detectors, main panel, zonal panel, hooter, battery, battery charge and other hardware. The system shall be designed to provided audio visual indication at the main panel to be located in fire station and zonal panels. Repeater panel shall be provided as specified in project design data sheet.
- (5) Electrical sirens shall be provided to cover entire plant area.
- (6) Each panel and each loop / Zone shall have atleast 30 % spare capacity.
- (7) The fire detection system shall be interfaced with fire suppression system, HVAC system and plant communication system, wherever specified.
- (8) Fire resistant armoured pink colour cables shall be used for the system.
- (9) Response indicators shall be provided for detectors located in hidden locations such as control room / substation.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

(10) DC supply / UPS AC supply shall be provided to Fire Alarm panel.

6.25 MAN MACHINE INTERFACE (MMI)

- (1) MMI shall include CPU, Keyboard, Monitor, Mouse, Printer etc. Two number Man Machine Interfaces shall be provided in the substation, one number laptop for engineering workstation and one number PC for operator's workstation. System configuration shall be latest proven model and upgradable. The minimum configuration for this project shall be of Pentium IV, 1.6 GHz, 120 GB HDD, 1 GB RAM, DVD writer, FDD, 21" TFT monitor with laser jet colour printer. Power supply for Substation MMI shall be obtained from emergency / critical source available in the substation / nearby substation / control room.
- (2) MMI shall allow minimum of the following functions
 - Feeder status monitoring
 - Data Logging
 - Relay parameterisation
 - Event recording
 - Annunciation
 - View of historical data and trends
 - Preparation of maintenance schedule.
- (3) Data concentrator for HV & LV system relays shall be such as to get faster and effective communication for control, monitoring and supervising the electrical system. Suitable switching hardware shall be provided for selection of required data concentrator with click of a mouse from MMI.
- (4) User-friendly windows based software shall be provided for interactive display of substation data in multi-window feature. Software shall have the capability to display substation single line diagrams, display for electrical system parameters, reports, alarm annunciation, daily and monthly data logging, continuously polling, relay programming, relay monitoring, data logging, relay supervision, tripping features, fault disturbance record of each relay, graphic representation and trending of data etc. The display shall have electrical system overview and detailed information about its sub system. All softwares shall be written for operating on a common operating system platform plant wide and shall be able to communicate with existing ECS. A change of operating platform for MMI, CPU during detail engineering shall not have any commercial implications. Audio / Visual Alarm annunciation shall be provided along with hooter.
- (5) MMI system shall have two distinctive passwords one for viewing of data metering etc. and second for authorisation for change in relay setting etc.
- (6) All numerical relays shall communicate to its data concentrator serially on dual redundant RS 485, mod bus / proprietary protocol. Data concentrator shall have dual redundant architecture including internal bus and processor for the reliability of data communication. Scan time of Relay LAN shall be less than one second.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

Data not available on relay LAN shall be acquired through hardwired connections to MMI /ECS-RTU.

- (7) Data concentrator shall be interfaced with RTU of integrator's system on dual redundant RS485, mod bus protocol. In case relays are communicating serially to data concentrator on proprietary protocol, suitable protocol converter shall be supplied as a part of supply of data concentrator. Signals, data as required for MMI/ ECS system serially and through hard wiring as designed elsewhere shall be wired upto RTU panel.
- (8) The system shall be complied with standard IEC 60073 -Basic and safety principles for man-machine interface, marking and identification
- (9) All hardware and software shall be suitable for substation operation and integration with ECS-RTU and to achieve minimum but not limited to the requirement as defined elsewhere.
- (10) Each relay / MMI system shall be time synchronised.
- (11) MMI shall be provided where SCADA system is not available/not considered.
- (12) ECS Standard IO's list is as per Annex-A and communication between ECS and DCS will on OPC. Required points on the DCS from ECS system will be finalized as per project requirement and mutually agreement between EPCM and IOCL.

6.26 JUNCTION BOXES

- (1) The Junction boxes/Telephone Tag boxes shall be MS with epoxy paint for safe areas or die cast aluminium alloy construction with IP 55 degree of protection suitable for installation in classified areas, hazardous areas. It shall be suitable for terminating or looping armoured signal/power cables. JB's shall be provided with earthing stud. It shall be suitable for wall/column/structure/ceiling mounting.
- (2) Junction boxes installed in classified hazardous area shall be explosion proof or increased safety type depending on area classification.

6.27 ACTUATORS FOR MOTOR OPERATED VALVES

- (1) MOVs shall be provided with an integral control box consisting of starter, local/remote selector switch, start/stop switches or push buttons, torque switches, limit switches etc. The mechanical design shall be such that in case of torque or limit switch failure, the motor shall be protected. Anti-condensation heater shall be provided for the actuator. The power supply for the control circuit shall be AC.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (2) The MOV shall be designed to start with 75% of the motor terminal voltage. The motor insulation class shall be class F, but the temperature rise shall be limited to a temperature equivalent to class B.
- (3) MOV position sensing will be through absolute encoder. The actuator should have Non-Volatile position verification device. True position will not lose if power supply lost or the system moves while power (main) switched off. Its update the position through the travel of the actuator or at any particular position without any power.
- (4) For locating MOV in tank farm area following points to be complied
 - a) Separate Push buttons for MOV operation should be brought just outside the dyke
 - b) The push button assembly should be mounted at a place where it is easily visible to the operator
 - c) Main emergency shutdown switch should also be located in the control room should also activate the MOVs to close.
 - d) The cable leading to the control room should be fire safe.
 - e) Open close status of MOV to be provided in control room through indication.

6.28 CATHODIC PROTECTION

- (1) When the soil is recognized as highly corrosive and / or the soil resistivity is low (around 10 ohm. meters), the Entire underground pipe work including the hydrant system and the steel structures including reinforcements bars of reinforced concrete (within battery limit), Tank bottom, earthing grid etc. shall be provided with Cathodic protection.
- (2) The cathodic protection can be either sacrificial anode type or impressed current type or both as per process requirement. The selection of the type of protection shall be based on the effectiveness of system and overall economy. The scope of LEPCC contractor shall include, site survey to collect required information, design, supply ,Installation, commissioning, maintenance, Monitoring and performance guarantee of impressed current cum distributed anode hybrid cathodic protection system as per relevant IS / IEC /BS/ NACE standards and codes of practices.

7.0 PROTECTION & CONTROL SYSTEM DESIGN PHILOSOPHY

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (1) The protection & control systems shall be selected and coordinated to ensure the following:
 - a) Selective, sensitive and reliable protection of equipment against damages which can occur due to Internal or external short circuit, or atmospheric discharge.
 - b) Uninterrupted operation of those parts of the system which are not affected by the fault.
 - c) Personnel and plant safety.
- (2) A graded system of protective devices shall be applied as far as reasonably practical. Devices shall be selected and co-ordinated so that the circuit interrupting device nearest to a fault operates first, and within the rating of the protected equipment.
- (3) The protective system shall provide, as far as possible, main and back-up protection.
- (4) The back-up protection for equipment shall be provided by the main protection of the upstream equipment. The back-up protection shall clear faults, as far as possible, within the rating of the equipment.

7.1 BUS DIFFERENTIAL PROTECTION SYSTEM

- (1) All HV (6.6KV and above) feeders shall have feeder differential protection, working on pilot wire protection principle on fibre optic cable, failure of which shall not trip the feeder and give an alarm.
- ~~(2) The alarms of pilot wire supervision schemes shall be provided at manned locations.~~

It is to be ensured that the OFC pilot cable supervision scheme with alarm at manned location is provided for the cable differential protection.

- (3) Each HV(6.6KV and above) distribution bus section shall have bus differential protection with overlap across bus coupler and shall cover the entire switchboard including breaker.
- (4) All Incoming and outgoing breakers of a particular switchboard section shall trip on operation of bus bar differential protection.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (5) Incomer and bus coupler master trip relay shall be operated on operation of bus differential protection.
- (6) Upstream breaker tripping shall be provided on actuation of bus bar differential / REF/ Cable Differential protection of respective downstream switchboard section. Dedicated reliable relay shall be used for this purpose, and auxiliary relay shall not be used as contact multiplier. **(Refer Annexure-11: Schematic Drawing No. – 2C.12)**
- (7) Feeder and bus differential protections shall overlap. Zone crossover of cable differential with busbar differential protection shall be provided in upstream / downstream switchboards.
- (8) The location of relay shall be on respective feeders, i.e. cable differential relay on respective incomer and busbar differential relay on respective bus PT.
- (9) All” PS “class CT’s installed for differential scheme should be suitable with respect to knee point voltage considering the existing maximum fault level or the design fault level of the switchgear.
- (10) All the CT’s in the differential scheme should have similar characteristics e.g. V_k , secondary resistance, magnetizing current etc. to ensure uniform behavior.
- (11) Use of ICTs for matching of CT ratios in Bus / cable Differential protection is not desirable for reliability of the scheme.
- (12) Differential / REF CT’s shall generally be used for this specific protection only. In case the use of separate CT is not practicable then it is to be ensured that a dedicated core of the same CT is used for Differential/ REF application.
- (13) The CT’s for the Bus differential scheme are to be prominently marked to differentiate with other CT’s of the same panel.
- (14) The sectionalizing breakers provided in the Generation Bus should be protected only by Bus Differential Protection with crossover zones between two adjacent buses.
- (15) The Bus Differential scheme is to be so engineered that No portion of the HT switchgear is left out of the differential zone including the outgoing breakers. **(Refer Annexure-9: Schematic Drawing No. – 2C.9)**
- (16) Differential scheme shall have cross over zones with bus coupler, Generator, Radial feeder’s incomers, transformer feeders etc. **(Refer Annexure-10: Schematic Drawing No. – 2C.10A)**

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

~~(17) Bus Bar Differential protection shall be based on proven & reliable high impedance scheme principle ~~

Bus Bar Differential protection shall be based on proven & reliable high impedance scheme principle. Alternatively, Low impedance Bus Differential Protection scheme can also be considered. Bus Differential Protection scheme is to be provided with Check Zone protection.

- (18) Differential schemes shall be adequate w.r.t. stabilizing resistance.
- (19) Differential protection relays shall be numerical type and shall display spill current. The relays shall have dedicated control supply.
- (20) Numerical relays for differential protection with the spill current measurement display feature or periodic spill current measurement practice to be adopted.
- (21) The calculation for stabilizing resistance value shall be done properly based on the maximum / designed fault current. The suitable resistance shall be used in both versions of relays i.e. electromagnetic as well as numerical.
- (22) Control supply to the differential relay should be derived from a separate source with proper identification (not from the normal panel supply in which the relay is mounted).
- (23) The inter panel wiring of differential CTs shall be looped from the same side of the CT TBs in a particular feeder and the differential CT wires of the feeder shall be connected at the other side of the TB for ease of isolation.
- (24) Suitable stabilizing resistance and metrosils shall be provided for restricted earth fault (REF) protection of transformers, bus differential protection etc. Suitable stabilizing resistance shall be provided for earth fault protection of motor feeders and earth fault protection of transformer feeders.
- (25) Use of ICTs for matching of CT ratios in Bus and cable Differential protection shall not be used.
- ~~(26) The alarms of pilot wire supervision schemes shall be provided at manned locations.~~

CT supervision shall be provided in bus differential protection.

7.2 CABLE DIFFERENTIAL PROTECTION SYSTEM

- ~~(1) All HV radial feeders shall have instantaneous cable differential protection for instantaneous clearing of the fault.~~

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

All HT radial feeders within Refinery shall have instantaneous cable differential protection with OFC pilot cable for instantaneous clearing of the fault.

- (2) The feeders for which it is not possible to provided Feeder Differential Protection due to long cable lengths and non-critical feeders must be provided with Instantaneous O/C and E/F protection in addition to IDMT protection.
- (3) Cable differential protection shall have zone cross over with the upstream/ downstream bus differential protection.
- (4) Same electrical specifications of CT's at both the ends w.r.t. ratio, resistance, knee point voltage, polarity for ensuring stability of the scheme is to be provided.
- (5) The HV cable differential protection shall be connected to the Unit Master trip Relay (86U), if provided separately
- (6) Differential protection relays and feeder differential relays shall be numerical type and shall display spill current.
- (7) Soft link of OFC based Cable differential relay shall be used for Inter-tripping of incomer breakers & upstream breakers to avoid spurious tripping due to control cable failures wherever OFC based Cable differential relays are provided.

7.3 OTHER PROTECTIONS & CONTROL IN HV, LV SWB & TRANSFORMERS

- (1) Only window type CT's for both protection / metering in the HV switchgears is to be provided. Only CT's with low ratio (400 Amps) shall be of wound type construction if window type CT's are not available for that application. It is to be ensured while procurement that the PD value of the CT's shall be less than 20 pc.
- (2) No control / CT wiring is to be routed through the main HT bus chamber. In case it is not possible to reroute/ modify the wiring then proper dressing & clamping of the wiring is to be ensured.
- (3) In order to achieve complete isolation of fault, master relay operation of any downstream breaker should also trip the upstream breaker. **(Refer Annexure-11: Schematic Drawing No. – 2C.12)**
- (4) The healthiness of "Trip Circuit" is to be ensured through a suitable "Trip Circuit Supervision scheme with continuous monitoring" in all the HT switchgear panels with alarm at manned locations.
- (5) Numerical relays are normally using interrogation voltage feature (24v, 48 v) for interlocks / remote tripping. In such cases, it is desirable to use direct contact in place of contact through relay for critical interlocks. If dedicated contact is not

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

feasible then It is recommended to use 220 or 110V interposing relays with energise to trip logic instead of using low voltage signals as binary inputs for inter-tripping interlock purpose particularly for intertripping of long distance breakers. It is also desirable to have shielded cable for low voltage applications.

- (6) Watchdog timer alarm (Numerical relay faulty) to be wired up to control room / manned location.
- (7) Clean & dedicated earthing for the numerical relays is to be provided.
- (8) ~~Breaker is to be tripped directly without using any intermediate numerical / auxiliary relay for ensuring reliability / integrity of tripping the circuit breaker in the event of numerical relay failure.~~
Breaker is to be tripped directly on Emergency PB trip, LCS stop etc. (other than the protections in numerical relay) without using any intermediate numerical / auxiliary relay for ensuring reliability / integrity of tripping the circuit breaker in the event of numerical relay failure.
- (9) The breaker service position contact should not be included in the tripping logic of breakers.
- (10) HV switchgear at TPS i.e. generation bus and distribution bus shall be rated for short circuit current of preferably 3 second duration for better protection coordination. The short circuit current rating of HT cables from TPS to downstream sub-station shall also be rated for 1 Second.
- (11) It is recommended to provide a minimum time gradation of about 0.15 to 0.2 sec. between bus coupler and incomer to avoid simultaneous tripping of incomer and bus coupler under fault conditions.
- (12) Master trip relay should be VAJH type only.
- (13) Time synchronization of sequence of event recorders (SOE), generator relays, distribution relays is to be provided.
- (14) REF protection and cable differential scheme shall allow downstream change-over.
- (15) Under voltage tripping of any breaker shall be direct and not through the master trip relay.
- (16) All under/over voltage/frequency related protection/logic schemes shall have PT fuse/MCB fail protection scheme incorporated, wherever applicable, for adequate protection against mal-operation.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (17) The secondary wiring of three-phase CTs shall be carried out in the respective R, Y, B colour wires. The CT wires shall be at least 2.5 sq. mm and the control circuit wires shall be of 1.5 sq. mm.
- (18) Only ring type lugs shall be used in CT secondary connections at the CT end and the relay end.
- (19) The star point of a set of CTs shall be earthed at a single point only.
- (20) The CT TBs shall have provision for shorting and earthing the CT secondary winding.
- (21) Any feeder feeding a single-phase load, or can become single phase in the event of an abnormality in the course of operation, shall be provided with 4 CT configuration to avoid spurious earth fault operation.
- (22) The CTs in all incoming and outgoing feeders in HT and LT switchgear shall be easily accessible on opening the rear door for easy CT maintenance, primary injection and CT replacement.
- (23) CTs in HT switchgear shall have class B insulation and shall have a partial discharge value of less than 20 pico coulombs tested at government approved and recognised laboratories, with test certificates.
- (24) Secondary of line and bus PTs shall have PT MCBs and auxiliary contacts. The PT MCB auxiliary contacts shall be hooked up to the under voltage circuits to prevent mal-tripping / maloperation of U/V protection in the event of tripping of PT MCB.
- (25) Three-phase PT MCB shall have provision to switch OFF or ON / trip all the three phases simultaneously.
- (26) All the CT and PT dimensional drawings shall be provided with the switchboard drawing.
- (27) All breakers shall have trip circuit supervision through continuous monitoring, with provision of alarm at manned locations.
- (28) All breakers shall have separate master trip lockout relays.
- (29) The upstream breaker shall trip on actuation of master trip relay of downstream incomer.
- (30) Upstream breaker tripping shall be provided on actuation of bus bar differential protection of respective downstream switchboard section. Dedicated reliable

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

relay shall be used for this purpose & auxiliary relay shall not be used as contact multiplier.

- (31) Tripping of breaker from field PB or TNC switch shall be direct, without depending on numerical relay.
- (32) Tripping circuit should consist of breaker auxiliary contacts only. No multiplied contacts are to be used.
- (33) Process trip relays shall be self reset type with hand reset flag.
- (34) Multi-function meters with communication over RS-485 or fibre optic cable, preferably with IEC protocol shall be provided in all incoming and outgoing feeders up to LT PMCC level for energy management.
- (35) Critical alarms from each substation shall be provided to a manned location.
- (36) All fuses of the electrical panels shall be marked with fuse rating.
- (37) There shall be no constraint in the communication of numerical relays to the central SCADA on IEC protocol with time stamping and time synchronization.
- (38) The setting of numerical relay shall be possible from local HMI as well as local laptop PC. Numerical relays shall be provided with software password only. Hardware lock etc shall not be provided.
- (39) Numerical relay failure alarm (watchdog) shall be provided at manned location through self contact of the relay.
- (40) Fault data shall be displayed on local HMI.
- (41) Disturbance recording and fault traces shall be displayed on local laptop as well as remote location through SCADA. All digital inputs to numerical relays shall be wired with shielded cables.
- (42) Digital inputs to numerical relays shall work on the same voltage level as the auxiliary voltage of the relay.
- (43) Digital inputs to numerical relays from long distance signals shall be through multiplexer.
- (44) All breaker fed feeders shall be provided by numerical protection relays with IEC 61850 protocol and with IEC characteristic curves only. Electro mechanical relays shall be avoided.
- (45) A pair of portable numerical relay configuration workstations shall be provided in each substation containing numerical relays, for programming the relays.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (46) In general, quick acting relays (with time delays if required) shall be used and all fault tripping shall be done through high speed tripping relays. The tripping relays shall be manual reset type.
- (47) The breaker service and test position limit switches shall be wired up to the TB and then be hooked up in the circuit.
- (48) Considering that the requirements of ungrounded system are different from that of grounded system, the following points are need to be ensured are as under:
- Bus PT and line PT should have tertiary windings also along with loading resistance. The same to be also ensured in the design basis for any expansion.
 - Surge arresters of suitable ratings are to be used in motor feeder having VCB. Minimum Continuous Operating Voltage (MCOV) should be at least equal to or greater than highest system voltage.
 - Voltage factor for the PT for HT system should be 1.9 for 8 hrs.
 - For detecting earth fault in the feeder, CBCT must be used in conjunction with sensitive earth fault relay for all HT feeders.
 - Armour of the cable should not pass through the CBCT. If it is passing through the CBCT, then, it must be brought out through CBCT only and then grounded.
 - Cable is to be selected one grade higher w.r.t. the system voltage.
 - Zig Zag transformer + ground fault neutralizer should be provided for capacitive current compensation. Sufficient capacitive current (25A) must be left uncompensated for earth fault detection.
 - Setting of earth fault protection of a particular feeder should be 120% of its own capacitive current contribution.
- (49) Direct contact of breakers, master trip relays etc shall be used for interlocking, tripping, closing, auto change over etc and should not be taken from the multiplying contactors / auxillary relays.
- (50) Armour of any cable should not pass through the CBCT.
- (51) In case of numerical relay applications it is ensured to directly trip the breaker without using any intermediate numerical / auxiliary relay/ PLC intervention etc.
- (52) Dynamic setting / doubling feature of numerical motor protection relay should be avoided.
- (53) All digital inputs to numerical relays shall be wired with shielded cables.
- (54) Conformal coating should be provided on relay cards, if they are to be located near process units for protection against sulphur corrosion.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (55) Transformer Differential Protection is to be provided for Transformers having HT voltage in primary and secondary side.
- (56) All the transformer feeders for PCC shall be provided with Instantaneous (high set) over current, three phase IDMT Over Current, and Earth Fault protection. The Earth fault protection shall be provided by CT connections in residual mode.
- (57) All PCC/PMCC incomer Transformer should have REF protection.
- (58) All the transformer auxiliary protections (Bucholz, Oil temp. / Winding temp / Minimum oil gauge) shall be provided with alarms / tripping. It is desirable to use Reed Switch type Bucholz Relays in place of Mercury Switch type relays in seismic prone areas.
- (59) In order to achieve complete isolation of fault, it is desirable that master relay operation of any downstream PCC incomer breaker should also trip the upstream HT breaker.
- (60) In case of transformers feeding to PCCs, the HT breaker of transformer must be provided with Instantaneous (High Set) over current protection.
- (61) Transformer feeders shall be provided with at least the following protections: high set O/C protection, IDMT O/C, instantaneous earth fault, REF, SEF, transformer differential protection (in case of transformers with HV primary and secondary windings), Buchholz alarm & trip, OTI alarm & trip, WTI alarm and trip, MOG alarm & PRV trip (if provided). Alarm and trip protection shall be in Buchholz relay.
- (62) The standby E/F CT shall be connected in the neutral – NGR / ground bus. The standby E/F shall trip both HT and LT breakers through their respective master trip lockout relay. REF protection relay shall be provided in the respective transformer feeder or respective incomer whichever is closer to the transformer. REF protection relay shall trip the upstream breaker through its master trip lockout relay and not be hooked up to the master trip relay of the downstream incomer.
- (63) Each HV bus section is to be provided with Diode based dual DC control supply for the each panel. The redundant DC control supply shall be designed for auto / manual changeover to the alternate backup DC supply as per the requirement.
(Refer Annexure-8A/B: Schematic Drawing No. – 2C.7 & 2C.8)
- (64) Separate DC system shall be provided for switchgear protection & control
- (65) The auxiliary power supply of the numerical relays should be drawn separately and not from a common control supply switch of the breaker panel. Each numerical relay shall have independent control supply tapped from upstream of control supply switch of respective feeder.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (66) Control supply failure alarm shall be available at manned locations for prompt remedial action.
- (67) Complete DC distribution system to ensure proper fuse coordination between the upstream & downstream sections.
- (68) Failure of the DC control supply should not trip any breaker / process equipment. The contacts used for providing interlocks in the breakers mainly for the tripping logics should not be taken from the multiplying contactors / auxillary relays.
- (69) Individual control fuse rating in the panels/ module doors is to be marked in order to eliminate chances of improper fuse selection by operation at the time of replacement.
- (70) The control supply to MCCs shall only be AC. In view of the reliability of the plant it is desirable to have control supply derived from the individual modules in MCC with a dedicated transformer.
- (71) The control supply to PCCs may either be DC supply or AC control supply. In case of AC it should be derived from before the incomer breakers through control transformer forming a control bus.
- (72) There should be a suitable control supply change over scheme available in all PCCs.
- (73) All the critical alarms in unmanned sub stations (viz. tripping of incomers, bus coupler change over, control supply status, UPS trouble, charger trouble, critical VSD trouble and tripping of any other very critical equipment) shall be extended to nearest manned substation / location for initiating quick action by electrical personnel.
- (74) In case of HV vacuum circuit breaker, adequate provision shall be made for motor switching to limit the over voltage to 2.2 per unit of rated peak line to earth voltage. Required surge arrestors may be provided for this purpose.
- (75) All transformer feeders shall be provided with CBCT for sensitive Earth Fault protection. Residual E/F connection not to be used.
- (76) Hard contacts of the breaker shall be used for providing interlocks in the schemes mainly for auto change over, tripping, feedback, closing and process interlocks. In the absence of sufficient hard contacts, latched contactors/ relays to be used for contact multiplication.
- (77) In PMCC/MCC, for conversion of common control supply (through transformer) to distributed control supply from respective module neutral connection shall be made at least at 4 points to avoid breaking of the neutral continuity.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

(78) All panels to be manufactured with LOTO (Lock Out and Tag Out) provision.

7.4 HV MOTORS PROTECTION AND CONTROL SYSTEMS

- (1) Critical contacts used for providing process interlocks should be direct hard contacts and these shall not be taken from the multiplying contactors / auxiliary relays.
- (2) Relay setting of the distribution bus incomer shall be done suitably considering the maximum current flow due to simultaneous re-acceleration of the motors connected on that bus during power system voltage dips.
- (3) In view of the safety of the HV motor, all standard protections for HV motors shall be provided.
- ~~(4) The Earth fault protection for motors should have "Instantaneous Tripping". A suitable stabilizing resistance is also to be used to prevent mal-operation on account of spill currents.~~

The Earth fault protection for motors should have "Instantaneous Tripping". All HT motor feeders shall be provided with CBCT for sensitive Earth Fault protection. Residual E/F connection not be used.

- (5) All process trip relays should have self reset Contacts or reset facility from control room through PLC/ DCS. Relay flag will be reset by manually.
- (6) In numerical relays, all unwanted protections (high-high, very high etc.) to be kept disabled
- (7) In numerical relay applications, breaker is to be tripped directly without using any intermediate numerical / auxiliary relay/ PLC intervention etc. for ensuring reliability / integrity of tripping the circuit breaker in the event of numerical relay failure.
- ~~(8) Winding / bearing temperature measurement connection to respective motor feeder numerical relay for alarm shall be considered.~~

For critical motors (having Winding / bearing temperature measurement), winding/ bearing temperature measurement is to be routed for alarm & tripping.

- (9) All motor feeders shall be provided with IEC type 2 co-ordination.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (10) Hard contacts of the breaker shall be used for providing interlocks in the schemes mainly for auto change over, tripping, feedback, closing and process interlocks.
- (11) Two NO contacts shall be provided in Emergency push button & LCS STOP PB of all breaker fed HT & LT Motors, one NO contact shall be wired to trip breaker directly & other shall be wired to binary input of numeric motor protection relay.

HV MOTORS- AUTO START SYSTEM

- (1) The critical motors of power plants should have a reliable auto-changeover / Auto-start scheme. The auto-changeover shall be activated both by pressure interlock as well as contactor/ breaker interlock (The low-pressure signal for auto-changeover is desirable from redundant low-pressure switches, based on 1 out of 2 logic or 2 out of 3 logic.
- (2) The control supply for auto-change over scheme should be provided from a reliable source.

HV MOTORS- UNDER VOLTAGE TRIP SCHEME SYSTEM

- (1) All HV motors shall be provided with a Time Graded (e.g.0.5,1.0, 2.0, 3.0 Sec etc) under-voltage trip scheme to ensure recovery of the system after voltage dips and to safe guard the health of motors.
- (2) The setting of under voltage relays should not be less than 60% for tripping of HV motors.
- (3) The voltage input to under voltage relay shall be derived from the Bus PT of the switchgear section from which the motors are connected.
- ~~(4) Blocking of under voltage tripping scheme of motors to be provided in case of fuse failure. Only Fuse Failure relays shall be used for providing Blocking of scheme.~~

Blocking of under voltage (U/V) tripping of motors to be provided in case of PT fuse failure. Fuse Failure relays/ PT supply MCB contact shall be used for Blocking of U/V trip.

- (5) Contact multiplication of under voltage relay, if required, for the purpose of tripping of various HT motors, shall be provided through self reset type relays / auxiliary relays.
- (6) Under voltage command for trip motors shall be direct to breaker and not through the motor feeder Master Trip Relay.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

7.5 MV & LV MOTORS PROTECTION AND CONTROL SYSTEMS

- (1) All PMCC/MCC modules shall be designed for type 2 co-ordination. The degree of enclosure for LV switchgear shall be minimum IP 42
- (2) Motors below 18.5 kW shall have earth fault protection through CBCT and earth fault relay, and motors above 55 kW shall be fed through ACB with numerical motor protection relay.
- (3) The protection devices for air circuit breaker in PCC shall be numerical relays. Use of releases shall be avoided.
- (4) MCC modules i.e. motor, starter / contactor with holding coil type shall have its control voltage derived from individual module phase and neutral. Individual module isolation transformer may be used for limiting fault current value.
- (5) All process trip relays shall be self reset type contacts with hand reset flags or reset facility from PLC / DCS.
- (6) All unwanted protections and high set protection features provided in numerical relays should to be kept disabled.
- (7) All motor feeders shall be provided with IEC type 2 co-ordination.

LV MOTORS- RE –ACCELERATION/ AUTO START SYSTEM

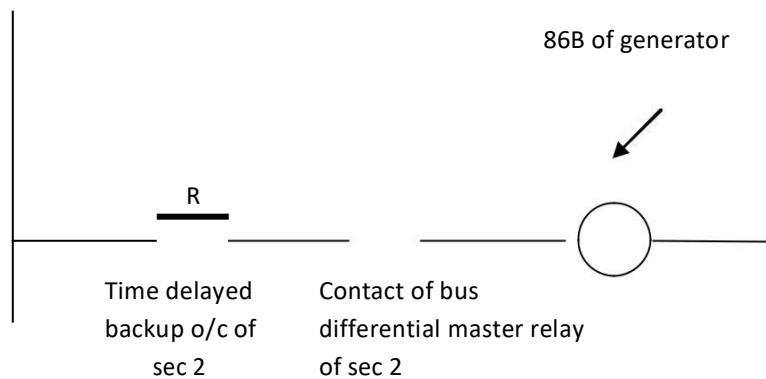
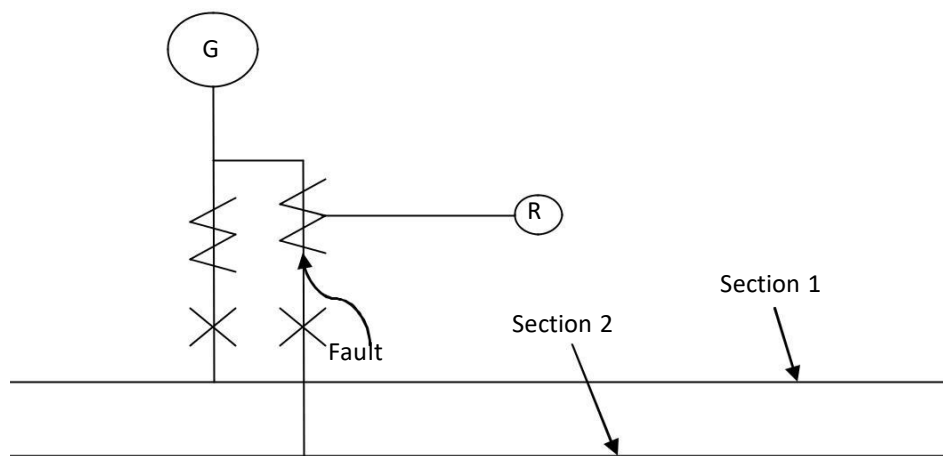
- (1) Re-acceleration scheme shall be provided for the selected extremely critical motors
- (2) Only PLC / DCS based re-acceleration schemes is to be provided in view of ease of implementation.
- (3) The critical AC drives should have a reliable auto-changeover scheme in addition to the re-acceleration scheme. The auto-changeover shall be activated both by pressure interlock (Process Interlock) as well as contactor/ breaker interlock. The low-pressure signal for auto-changeover shall be taken from a system of redundant low-pressure switches.
- (4) The control supply for auto-change over scheme should be either DC or UPS.
- (5) In case UPS / DC control supply is not used, reacceleration scheme shall be provided with stay put / latched contact from a timer / PLC / DCS. In such case, it is to be ensured that the contact gets de-energized in case motor field stop / trip command is generated

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

7.6 GENERATORS PROTECTION AND CONTROL SYSTEMS

- (1) Differential protection scheme for the complete Generator including Bus Duct, HV cables & generator breaker is to be provided. The scheme shall have overlapping protection zone with the bus differential scheme at switchgear level. **(Refer Annexure-4: Schematic Drawing No. 1C.4)**
- (2) Numerical relays are to be used in the Generator Differential protection with 3-phase online monitoring of spill current
- (3) The HV cable differential protection shall be connected to the Unit Master trip Relay (86U), if provided separately.
- (4) Separate back up over current and earth fault protections for individual generator breaker is to be provided to have better coordination. **(Refer Annexure-5: Schematic Drawing No. 1C.5)**
- (5) The under voltage tripping of generator is to be provided based on the under voltage coordination with downstream incomers and maximum time allowed for the re-acceleration of motors.
- (6) Brushless excitation systems are to be provided with continuous detection type of schemes for insulation resistance measurement for Rotor Earth fault detection. To prevent spurious tripping of the Rotor Earth fault protection, it is desirable to provide a suitable time delay in the alarm & tripping.
- (7) The DC control supply to Generator Controls & Relay Panel shall be redundant with supply failure alarm.
- (8) Two numerical type generator protection relay are installed in parallel mode with provision of Generator Numerical relay faulty alarm in control room.
- (9) The protection provided in generators for field failure plus under voltage should trip the generator instantaneously without any time delay.
- (10) Following scheme is to be provided to trip the generator and avoid wide spread affect during fault on incoming pole of the generator breaker as bus differential relay operation will not isolate the fault.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	



Note: Current transformer (CT) – ‘R’ normally should be on the downstream side of the circuit breaker for achieving overlapping. However, it is observed that in most cases, it is provided in the upstream of the breaker and hence, the above mentioned scheme is desirable as overlapping is not available.

Proven schemes are to be used for generator differential/overall differential protection. If high impedance scheme is used, stabilizing resistances of correct ratings are to be used.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (11) Proven schemes are to be used for generator differential/overall differential protection. If high impedance scheme is used, stabilizing resistances of correct ratings are to be used.
- (12) Differential protection scheme shall be provided for the complete Generator including Bus Duct, HT cables & generator breaker.
- (13) Trip commands from the generator master relay and TNC switch to the breaker shall be separately wired.
- ~~(14) Time delay of 2.5- 3.0 sec. shall be provided in the DAVR's auto- manual changeover logic during under voltage condition.~~

It is recommended to incorporate a time delay of 2.5- 3.0 sec. in the DAVR's auto-manual changeover logic during under voltage condition. For DAVRs having dual AUTO channels, 100ms time delay may be provided for AUTO to AUTO changeover.

- (15) Alarm for AVR internal power supply failure is to be provided at manned location.
- (16) Generator should be provided with instantaneous trip in case of AVR stage-3 faults (AVR Trip condition).
- (17) "AVR changeover from Auto to manual mode on PT fuse failure shall be provided.
- ~~(18) Provision of separate emergency channel to take care of excitation requirement in case of operation of stage-3 fault shall be provided.~~

Provision of "Dual Auto channel with manual channel" DAVR's shall be provided.

- (19) DVR dual auto channel with dual PLC to be considered for enhanced reliability.
- ~~(20) Harmonic suppression filters in the PT input circuits to take care the harmonics in the power supply as recommended by BHEL shall be provided~~ ⚠

Harmonic suppression filters in the PT input circuits to take care the harmonics in the power supply as recommended by BHEL shall be provided Harmonic suppression filters to be provided in the AC input supply of to the DVR.

- (21) Separate back up over current and earth fault protections shall be provided for individual generator breaker to have better coordination.
- (22) In Brushless excitation systems provided with insulation resistance measurement type Rotor Earth relay, It is desirable that schemes provided with periodic detection facilities to be converted to continuous detection type of schemes. To

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

prevent spurious tripping of the Rotor Earth fault protection, it is desirable to provide a suitable time delay in the alarm & tripping.

- (23) The DC control supply to Generator Controls & Relay Panel shall be redundant with supply failure alarm.
- (24) Two nos numerical type generator protection relays are to be installed in parallel mode, if feasible or otherwise one standby relay to be kept to meet emergency. Generator Numerical relay faulty alarm must appear in control room.
- (25) The protection provided in generators for field failure plus under voltage should trip the generator instantaneously without any time delay. Critical alarms from each substation shall be provided to a manned location.
- (26) Local breaker back-up (LBB) protection for circuit breaker failure at generation bus should be provided to prevent collapse of the system during non-tripping of any circuit breaker in the generation bus on faults.
- (27) For ensuring reliability of generator breakers, and for 33KV circuit breakers double trip coil with different DC control supply to be provided.
- ~~(28) In order to capture the data of MW, MVAR, Voltage, Frequency during transient conditions of faults which normally is not possible from ECS, it is recommended to provide chartless recorders for each generator and in the generation bus.~~

During transient conditions of faults/ disturbance, frequency recording is normally not possible from ECS. Hence it is recommended to provide chartless recorders / Numerical disturbance recorder (NDR) for each generator and in the generation bus.

- (29) For emergency tripping of generator, two Emergency Push buttons (with a protective cover) in series at Generator Control Panel shall be provided.
- (30) Generator breakers and for 33KV circuit breakers shall be provided with double trip coil.
- (31) The generator shall trip directly through Gas Turbine trip command instead of tripping the generator on reverse power protection.
- (32) Unit Master Trip Relay (86U) "NO" contact of relay is to be used for turbine tripping in Mark-IV/V.
- (33) The manual opening of the field breaker shall be blocked if either of both the generator breakers is ON.
- (34) In case of Generator High Temperature trip, the 100 deg C tripping contact in series with the 80deg shall be provided. C alarm contact or incorporate the logic 2 out of 3 (2-o-o-3) of the temperature sensors.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

~~(35) The protection coordination of the generator voltage restrained/ controlled over current protection (CDV) to be ensured with the over current protection of the outgoing feeders.~~

The protection coordination of the generator voltage restrained/controlled over current protection (CDV) to be ensured with the over current protection of the outgoing feeders.

Wherever generator transformer is provided, Impedance based back up protection may be provided as backup to CDV protection.

(36) DAVR shall be provided with dual auto channel with dual PLC processor & redundant I/O modules for enhanced reliability.

(37) Generators above 10 MVA shall be supplied with online PD monitoring system with alarm

(38) Direct Air cooled generators shall be preferred.

(39) Humidity sensors shall be provided in Generator air cooler ducts with continuous monitoring with alarm facility where water air coolers used for generator cooling.

(40) RF based Wireless Temperature monitoring with alarm shall be explored and provided in generator terminals and generator bus incomers.

(41) Redundant power supply to PLC cards of DAVR from reliable 110V DC/ 110V AC (UPS) to be provided.

(42) Power system stabiliser (PSS) function in DAVR where provided is to be kept disable for islanded mode of operation of power plant.

(43) 50BF (Circuit breaker failure) scheme is to be provided in critical buses viz Generation & power plant distribution buses.

7.7 PROTECTION DEVICE SELECTION CHART FOR HV & MV SYSTEMS

Protection devices for power distribution system shall be as indicated below

(Figure inside bracket refers to note below) (YES - Applicable)

SI	Relay Description	Relay No	HV Tr. Fdr. Sec Wdg Volt=> 3.3 KV	HV Tr. Fdr. Sec Wdg Volt<= 3.3 KV	HV Motor Fdr.	O/G Bkr. HV Plant Fdr.	O/G Bkr. MV PCC/ PMCC	I/C EHV/ HV	I/C MV PCC/ PMCC
1	IDMTL Over-current relay	51	YES	YES	-----	YES	YES	YES (1)	YES

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

2	IDMTL- Earth fault relay	51N	YES (2)	YES	-----	YES	YES	YES (1)	YES
3	51G backup earth-fault relay(Earthed neutral)	51G (11)	YES (23)	YES (23)	-----	-----	-----	-----	-----
4	Motor protection relay with(50, 50N, 46, 49, 50L/R,86,95)	99	-----	-----	YES (3)	-----	YES (3)	-----	-----
5	Instantaneous restricted earth-fault relay(Earthed side)	64R (11)	-----	-----	-----	-----	-----	YES (24)	YES
6	Instantaneous us over- current relay	50	YES	YES	-----	-----	-----	-----	-----
7	Instantaneous us earth-fault relay	50N	YES (4)	YES	-----	-----	-----	-----	-----
8	Differential protection relay	87	YES (5)		YES (6)	YES (7)	-----	-----	-----
9	High speed tripping relay	86 (20)	YES	YES	YES	YES	YES	YES	YES
10	Trip circuit	95 (20)	YES	YES	YES	YES	YES	YES	YES
11	Supervision relay								
12	Transformer auxiliary relay	63	YES	YES	-----	-----	-----	-----	-----
13	voltage relay with timer and under frequency protection	27/2	-----	-----	YES	-----	-----	YES (9)	YES (9)
14	synchronisation relay	25	-----	-----	-----	-----	-----	YES (10)	YES (10)
15	Busbar differential	87B & 95B	YES (16)	YES (16)	YES (16)	YES (16)	-----	YES (16)	-----

Note	Philosophy
1	In case of HV switchboards with continuous parallel operation of incomers 67 and 67N(Directional IDMTL over current and earth fault) relays for the incomers shall be provided
2	Instantaneous earth fault (50N) shall be provided only for transformer with delta primary.
3	For breaker fed motor feeders, Relay 50 shall not be provided for contactor controlled feeders.
4	Directional IDMTL earth fault (67N) shall be provided for transformer with star primary.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

5	For transformer rated 5 MVA or above
6	For motors rated 1500 KW and above, excluding VFD fed motors
7	For critical/long feeders and plant feeders connected to main power generation and distribution bus. A plant feeder implies outgoing feeders from one switchboard to another switchboard of same voltage level
8	Trip circuit supervision relay 95 shall be provided as part of the numerical relay for HV/ MV feeders wherever numerical relays are provided
9	Where ever auto transfer feature is provided.
10	For switchgear where continuous or momentary paralleling of incomer is envisaged, check synchronizing relay shall be provided
11	51G and 64R relays for input transformer of VFD system shall be decided by VFD Manufacturer.
12	The bus tie feeders in HV switchboards shall be provided with 51, 51N, 86 and 95 relays.
13	HV capacitor bank feeders shall be provided with 51, 51N, 59 (over voltage), 60 (Neutral displacement), 86 and 95 relays.
14	The following feeders shall be provided with timers for delayed tripping of bus under voltage while the under voltage relay shall be common for the bus a. HV and MV capacitor feeders b. HV and MV breaker controlled motor feeders c. Contactor controlled motor feeders with DC control supply. Numerical relays where ever provided for motor and capacitor feeders shall use in built under voltage relay and timer for delayed tripping on bus under voltage
15	One no. DC supply supervision relay (80) shall be provided for each incoming DC supply to the switchboard.
16	One set of bus differential relays (87B) and bus wire supervision relay (95 B) for each HV switchboards.
17	In case of numerical relays, all relays shall be comprehensive units including all protection, metering and control.
18	Under voltage and over voltage function along with associated timer shall be part of the numerical relays.
19	Auto changeover logic between Incomers and bus coupler shall be built in the numerical relay.
20	Tripping relays (86) & Trip Circuit supervision relay (95) shall be part of numerical relay.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

21	2 Nos. of 86 relays shall be considered for HV and MV breaker fed motors for ease of differentiating between process & electric trip. Process trip relay shall be electromechanical, self reset type
22	Breaker control switch shall be hardwired type.
23	Stand by earth fault relay 51G shall be provided in the incomer of switchboard fed from transformers where transformer & switchboard both are located remotely from HV substation.
24	Restricted earth fault relay 64R shall be provided for transformer rating ≥ 1 MVA in the incomer of switchboard fed from transformers
25	Relay 51V voltage controlled over current relay shall be provided on specific requirement considering the rating of the outgoing feeders with respect to the Incomer rating. Generally this relay shall be provided wherever CT primary current of outgoing feeders is exceeding 40% of the CT primary current of the Incomer. 51V shall be provided in all incomers and outgoing feeders of 11kV primary generation board.
26	415V DG set shall be provided with protection but not limited to 51V, 51G, 40, 46, 86, 95, 80, 64R etc. for generator rated above 500KVA and Generator rated less than 500KVA shall have 51V, 51G, 40, 46, 86, 95, 80 unless otherwise agreed with the owner
27	For directly connected generators
28	For large transformers as per manufacturers standard.
29	Relay 87 and 64R shall be separate numerical relay. Hence shall not be part of main comprehensive numerical relay. CT for 87 and 64R can be clubbed, as two core of single CT.
30	Numerical relays in all HV motor feeders shall be suitable for RTD/BTD inputs.
31	Each bus section shall be provided with separate under voltage relays and under frequency protection

7.8 PROTECTION DEVICE SELECTION CHART FOR GENERATORS

Minimum protection relays for Synchronous generator (GTG/STG), generator transformer Grid power supply shall be as follows: (YES - Applicable)

SI	Relay Description	NEMA Code	Generator	Gen. Tr	EHV Incomer	EHV Tr.	Syn. Motor
1	Distance Protection	21			YES		
2	Synchronous check	25	YES (27)	YES	YES		
3	Under voltage with timer	27	YES		YES		YES

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

4	Reverse power	32	YES				YES
5	Low power flow	37	YES				
6	Loss of excitation	40	YES				YES
7	Negative sequence	46	YES				YES
8	Over current	50				YES	YES
9	Earth fault relay	50N				YES	YES
10	Over current	51			YES	YES	
11	Voltage restrained	51V	YES	YES			
12	Earth Fault back up	51G	YES	YES		YES	
13	Over current E/F	51N		YES	YES	YES	
14	Over voltage with timer	59	YES		YES		YES
15	VT failure	60					YES
16	Auxiliary relay for transformer	63TX		YES		YES	
17	Transformer Restricted Earth Fault	64R	YES (26)	YES		YES	
18	Stator back up earth fault	64G	YES				
19	Generator Rotor Earth fault	64R	YES				YES
20	Directional O/C	67			YES		
21	Directional E/F	67N			YES		
22	Under frequency /df/dt	81	YES		YES		YES
23	Tripping relay	86	YES	YES	YES	YES	YES
24	Gen differential	87G	YES				
25	Gen and Transformer differential	87GT		YES			
26	Transformer differential	87T		YES		YES	
27	Feeder differential	87F				YES	
28	Bus bar differential and check	87B/87CH		YES			
29	Trip circuit supervision	95	YES	YES	YES	YES	
30	Dead bus charging relay	98	YES (27)	YES	YES		
31	Over fluxing	99	YES	YES (28)			
32	Out of step	78	YES				

8.0 METERING SYSTEM

- (1) Metering instruments shall be provided to keep a record of power consumption & supervision of all concerned parameters like current, voltage, power etc. All instruments shall be flush mounted.
- (2) All metering shall be a part of comprehensive relay, if accuracy for metering in LAN can be obtained within 1.0%. If not, separate digital meters or comprehensive metering unit shall be provided in various feeders. These meters

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

shall also be communicable type with open protocol, suitable to communicate with SCADA/PMS/ECS system.

(3) The metering devices in EHV, HV and MV switchboards shall be as below:

Type of metering : Analogue/As part of the Numerical relay
(Figure inside bracket refers to note below) (YES - Applicable)

Sl	Feeder type	A	V	HZ	PF	MW	MWH	HM	MVAR	MVAH	MVA
1	Grid Incomers	YES	YES	YES	YES	YES (2)	YES	-	YES (2)	YES (2)	YES (1,2)
2	Grid Bus Tie	YES									
3	Grid Transformer	YES				YES	YES				
4	Grid Bus P.T		YES								
5	HV Incomer	YES	YES	YES	YES	YES	YES	-	YES	YES	YES
6	HV Bus Tie	YES	-	-	-	-	-	-	-	-	-
7	HV Transformer	YES	-	-	-	YES	YES	-	-	-	-
8	HV Bus P.T.	-	YES	-	-	-	-	-	-	-	-
9	HV Plant Feeder	YES	-	-	-	-	YES	-	-	-	-
10	HV Motor	YES	-	-	-	-	YES (kWh)	YES	-	-	-
11	HV Capacitor	YES	YES	-	-	-	-	-	YES	-	-
12	PCC/PMCC Incomer	YES	YES	-	YES	-	YES (kWh)	-	-	-	-
13	PCC/PMCC Bus Tie	YES	-	-	-	-	-	-	-	-	-
14	PCC Bus P.T.		-	YES	-	-	-	-	-		-
15	ACB Outgoing (Non motor)	YES	-	-	-		YES (kWh)			-	-
16	MV Motor (>55kW)	YES	-	-	-		-	-		-	-
17	MCC/ASB Incomer	YES	YES	-	-	-	-	-	-	-	-
18	MCCB O/G(250A)	YES	-	-	-	-	YES (kWh)	-	-	-	-
19	LDB Incomer	YES	YES	-	-	-	YES (kWh)	-	-	-	-

Note	Philosophy
1	MVA meter in EHV external power supply Incomers shall include maximum demand indication also.
2	Separate MW, MVAR, MVA and MVAH meters shall be provided for EHV external power supply Incomer
3	Separate 3 nos. voltmeter and 3 nos. ammeter shall be provided for EHV external power supply incomers

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

4	Field Ammeters are to be provided for all motors rated above 5.5kW.
5	Metering shall be part of numerical relays.
6	Ammeter (size 48mmX48mm) shall be provided in space heater circuit of breaker fed HV & MV motors.
7	Digital multi function meters shall be provided in incomers, bus coupler, outgoing plant feeders (except motor feeder)
8	Multi-function meters with communication over RS-485 or fibre optic cable, preferably with IEC protocol shall be provided in all incoming and outgoing feeders up to LT PMCC level for energy management.
9	Multi function relays with communication over RS-485 or fibre optic cable, preferably with IEC protocol shall be provided in each incomer of UPS ACDB
10	Power factor meter shall be provided for synchronous motors in addition to the metering provided for induction motors.
11	Where ever 4-20 mA motor current feedback is required for DCS, current transducers shall be mounted in switchgear panel
12	Following alarms signals shall be provided in respective process unit control room • Load Shedding operated • UPS trouble & UPS critical alarm • Battery charger fail/Boot charging

(4) METERING FOR GENERATOR AND GENERATOR TRANSFORMER

S.No.	Description	Philosophy
1	Ammeter (3 nos.)	YES
2	Voltmeter (3 nos.)	YES
3	MW meter	YES
4	MVAR meter	YES
5	MVA meter	YES
6	MWH meter	YES
7	MVARH meter	YES
8	Power factor	YES
9	Frequency meter	YES

9.0 SUBSTATION BUILDING DESIGN

- (1) The substation shall be located in a safe area but close to the load center to the extent possible. Consideration shall be given to vehicular traffic or any other factor that might affect the operation of the substation.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (2) The main entry for operating personnel shall be provided with double door system and airlock lobby. The substation shall also have an emergency door opening outwards.
- (3) The air conditioned portion of substation shall be provided with double door air curtain. If the Substation is in a Zone 2 Hazardous Area, the installation shall be designed in accordance with IEC 60079-13 (IS 5572) and as per recommendation of Institute of Petroleum Model Code of Safe Practice Part 15.
- (4) The substations shall be sized to house MCCs, auxiliary switchboards, variable speed drives, battery charger, DCDB, RTU panels etc along with the OWNER/OSBL Contractor equipment, such as power transformer & 6.6 kV switchboards, distribution transformers, PMCC etc.
- (5) Sub-station floor shall be raised above grade level and the space below the switchgear room shall be utilized as cable cellar. The cable cellar floor shall be 500 mm above the approach road level and shall be paved and cemented. The cable cellar shall have a minimum clear height of 2.5 m and shall house all cable trays, supports etc. The roof shall be given adequate water proofing treatment to ensure that rain water does not seep into the substation.
- (6) In addition to the entry to substation for operating personnel, a separate entry of minimum 3m x 3m with rolling shutter shall be provided for drawing in all equipment for installation. The main entry for operating personnel for pressurized substations shall be provided with double door system with an airlock lobby. The Sub-station shall also have an emergency door opening outwards.
- (7) Sub-station wall adjacent to the transformer bays and walls separating transformers shall be 355 mm thick (inclusive of plastering) in case of brick construction or 230 mm thick in case of RCC construction.
- (8) Sub-station building shall be without any columns within the switchgear room to the extent possible to ensure optimum space utilization, unless otherwise specified.
- (9) Battery banks shall be located in a separate adequately ventilated room in the sub-station buildings, along with the necessary exhaust system and water connection with sink. Floor of the battery room and walls upto 1.5m height shall have acid/alkaline resistant protective epoxy coating. Light fittings in this room shall be chemical resistant and flameproof type.

The battery rooms shall be provided with minimum two
FLP exhaust fans and louvered opening in opposite wall/door. The light fitting shall be FLP type

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (10) Electronic equipment like UPS, excitation panels for synchronous motors, heater control panel, RTU panels, variable speed drives etc., shall be located in a separate air conditioned room.
- (11) Sub-station shall have fire extinguishers, first aid boxes and other safety equipment as per statutory requirements. Insulating mats of required voltage rating shall be provided in front of switchboards.
- (12) Separation walls between transformers in all substations and safe inter transformer distances for switchyard transformers shall be as per OISD-STD-173.
- (13) Equipment like oil filled transformer shall be located in bays adjacent to the substation building. Transformer bays shall have well drained floor, surfaced with gravel or other suitable material. Each bay shall be provided with 2.5 m high removable chain link fence with a lockable gate at the open side. Partition walls between transformer bays and the end wall of the last bay shall be of fireproof type and shall extend at least 600 mm above the height of the equipment. Height of the bay shall be decided so as to facilitate maintenance and easy removal of equipment and requirements of natural ventilation. Minimum 1000 mm clearance shall be provided all round the transformer. Fire extinguishers and round bottom fire buckets filled with clean dry sand shall be provided in each transformer yard.
- (14) In order to prevent oil, whether from a small leakage or outflow from transformer tank, from reaching and polluting the water bearing stratum, transformers shall have the following provisions, depending on the oil capacity of the transformer

1. Oil Capacity upto 2,000 litres:

Transformers installed adjacent to sub-station/buildings or in Switchyards shall be provided with a layer of 100 mm deep stones of about 40 mm granulation, all around the transformer, for a width of 20% of the transformer height subject to minimum width of 800 mm.

2. Oil Capacity exceeding 2,000 litres:

Transformers installed adjacent to sub-station/building or in Switchyards shall be provided with oil containing pits.

The oil containing pit may be shaped as per OISD STD-173. The pit shall extend all around the transformer for a width of 20% of the transformer height, with a minimum width of about 800 mm around the transformer tank/radiator. In case oil capacity exceeds 9,000 litres, in any chamber, provision shall be made for draining away of any oil, which may escape or leak from the tanks, to a waste oil tank.

- (15) The substation building shall be sized to maintain adequate clearances between equipment for ease of maintenance. The following minimum clearances around various equipment shall be maintained:

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

SL	Location	Clearance
a)	Front clearance for HV switchboard	2500 mm
b)	Front clearance for all other switch boards/panels	2000 mm
c)	Rear clearance for panels having maintenance access from front only	Less than 200mm or more than 750 mm
d)	Rear clearance for panels requiring maintenance from rear	1500 mm (HV swbd) & 1000 mm (MV swbd)
e)	Side clearance between two switch boards or from nearest obstruction	1000mm after considering space for future panels
f)	All around clearance for transformers	1000 mm
g)	All around clearance for NGR 1000 mm on two sides,	200 mm on other two sides
h)	All around clearance for capacitor bank/ series reactor	1000 mm
i)	Battery rack to wall clearance for - Single row, single/double tier - Double row, single tier - Double row, double tier - Multistep racks	100 mm 100 mm 750 mm 750 mm
j)	Battery rack to rack clearance	750 mm
k)	Head room clearance below bus ducts or any other overhead equipment	2000 mm
l)	Front clearance for wall mounted equipment	1000 mm
m)	Front clearance for operation station/ annunciation/control panel	2500 mm

Vertical clearance above the top of the highest equipment shall be minimum 1500mm measured from bottom of roof slab (except transformer bay where same shall be 1000 mm) and minimum 500 mm measured from the bottom of the lowest roof beam. However for the areas with false ceiling, minimum clearance of 750 mm shall be provided between false ceiling and top of any equipment.

- (16) In all Substations/ MCC rooms, space for future extension of switchboards shall be provided. One panel extension space on each side (for each Bus section) or two panel extension space on one side (in exceptional cases) shall be provided for all HV Switchboards, PCCs, MCCs and ASBs. In addition, space for future extension of the substation/ MCC room building shall be considered, as specified in project design data sheet.
- (17) The DG sets shall be preferably located in a separate building other than the substation, in a safe area to reduce noise level in substation. However in case the same is located in the substation building, the DG set foundation shall be

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

structurally delinked from the slab/floor of the rest of the substation building. Exhaust of diesel engine shall be kept away from the process/hydrocarbon handling areas and diesel day tanks shall be located outside the DG room. Suitable ventilation system shall be provided to avoid heat accumulation in the DG room

- (18) Fire protection for transformers and switchgear room shall be provided to comply to requirements of OISD-STD-173.
- (19) Substation shall be maintained at a positive pressure through pressurization system in the switchgear rooms. It is to be ensured that the inlet air of the pressurized system shall be free from moisture and hazardous mixtures. Positive pressure of 2 mm of Hg shall be maintained inside the substation.
- (20) The pressurization ducts shall not be laid above the switchgear panels. Air filtration unit air suction inlet shall be located at a higher elevation instead of ground level to minimize the ingresses of dust with hydro carbon detectors.
- (21) In the Substation Room, where Switchboards are installed suitably sloped ramp for transition between the floor and the switchgear bottom plate shall be provided to allow easy installation and removal of any drawout devices.
- (22) Substation lighting shall be controlled by push button stations located at the entrance and exit doors outside the individual rooms.
- (23) Switchgear room shall be provided with the following minimum equipment:
 - (a) Framed laminated shock treatment chart, conforming to IE rules, in English and local language. Name, address and telephone number of nearest doctor shall be mentioned in it.
 - (b) Easily accessible first aid box containing ointments and medicines for treatment of electrical burns, conforming to IE rules.
 - (c) Self contained portable hand lamp, complete with rechargeable battery.
 - (d) Portable battery operated emergency light.
 - (e) Adequate number and size of CO₂ fire extinguishers and dry chemical powder suitable for dealing with fire.
 - (f) Round bottom fire buckets filled with clean dry sand.
 - (g) Framed single line diagram (AC and DC).
 - (h) One no. earthing rod.
 - (i) Earthing truck (for both circuit and bus).
 - (j) HT line tester
 - (k) Insulation tester
 - (l) Battery impedance tester
 - (m) Caution notices shall be provided for all energized electrical equipment.
 - (n) HT megger
 - (o) LT megger
 - (p) Tong tester

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

- (o) Artificial respiration system
 - (p) Face shield
 - (q) HV and MV insulated gloves
 - (r) Breaker lifting trolley
- (24) In every transformer bay / yard one no. 100 A outlet shall be provided for oil filtration and other maintenance.
- (25) Fire barriers shall be installed at substation building cable entry points.
- (26) Smoke detectors and fire detectors shall be provided in substation cable cellar. Linear Heat Sensing Cable to be provided on all cable trays in cable cellar. Cable cellar shall be provided with exhaust fans for adequate ventilation.
- (27) All substations shall have provision of hooking up with central SCADA/PMS/ECS.
- (28) Transformer bay shall have clear approach road for movement of crane / Hydra.
- (29) Critical HT sub stations (Eg. Power plants, unit sub stations having low shutdown frequency) is to be provided with air conditioning system.
- (29) Specific equipment location in the substation

Sl.	Description	Selected Option
1	Batteries in substation and control Rooms	Separate room
2	Battery charger in substation	Air conditioned room
3	Battery charger in control room	Air conditioned room
4	Variable speed drive panels	Air-conditioned room in substation
5	Thyristor controlled panels	Air-conditioned room in substation
6	UPS System	Air conditioned room in control room
7	Lead-Acid and Nickel- Cadmium	Separate room
8	Location of VRLA battery	Air conditioned room
9	Annunciation panel	HMI in Operator room

1. Battery room shall be preferably located in corner side at switchgear floor of the substation building.
2. Battery charger for Instrumentation shall be placed in air-conditioned UPS room in control room.
3. Electrical equipment installed in battery room such as exhaust fan, lighting etc. shall be of flameproof and corrosion proof construction and certified for gas group II-C classified locations. Heat detectors installed in battery room shall be of intrinsically safe type.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

10 EQUIPMENT INSTALLATION, FIELD TESTING & COMMISSIONING

- (1) Installation of all electrical equipment shall be carried out with high standard of workmanship, neat routing / layouts, and clearances / access.
- (2) After installation, equipment shall be tested for pre-commissioning. Further, commissioning tests shall be conducted to prove agreed performance within specified tolerance, temperature rise, noise and vibration.

11 INSTRUMENT / ELECTRICAL CONTROL INTERFACE

A guideline which may be followed for Instrument/ electrical interface is provided in this section. These are the minimum requirements and may vary from project to project.

- Instrument/Electrical Interface cabinet (or IRP cabinet) to be considered as per project philosophy. In case IRP cabinet is considered same shall be placed in SRR/ RR.

Alternately, Remote I/O's can also be considered based on project philosophy for electrical/ Instrument interface with remote I/O's installed in Substation.

- Sufficient terminals shall be provided in the interface cabinet to allow the termination of all cores of cables entering the cabinet. This shall include a minimum of 10% spare cables and cores. Signal content and connection details of Instrument cables shall be included in the respective Cabinet Interconnection Diagrams.
- Minimum following contacts shall be hardwired between MCC and DCS/ESD
 - Motor Run Indication
 - Motor DCS and ESD Stop Command
 - Motor Local/ Remote or Auto/ Manual Indication
- Within each substation, a RTU/DCU shall be provided with dedicated communication link per unit group as a minimum. The RTU/DCU shall communicate with the motor starter & contactor feeder modules, for control and monitoring of drives and shall transmit the alarm & status signals generated by electrical equipment's to DCS for monitoring purpose.

The Link between RTU/DCU/ECS and DCS shall be non-fail safe and on any loss of communication drives must continue to run.

- All Interposing relays shall have indication for the contacts.
- All motor/ feeders should have a process relay for interface signals from DCS/ ESD and Provision of alternate contact of Process relay at MCC/ VFD end is to be considered for looping back the trip/ stop signals to ESD/ DCS for monitoring/ SOE.
- All Interposing relay coils shall be $> 1000 \Omega$ impedance and shall be fitted with diode suppression circuits.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

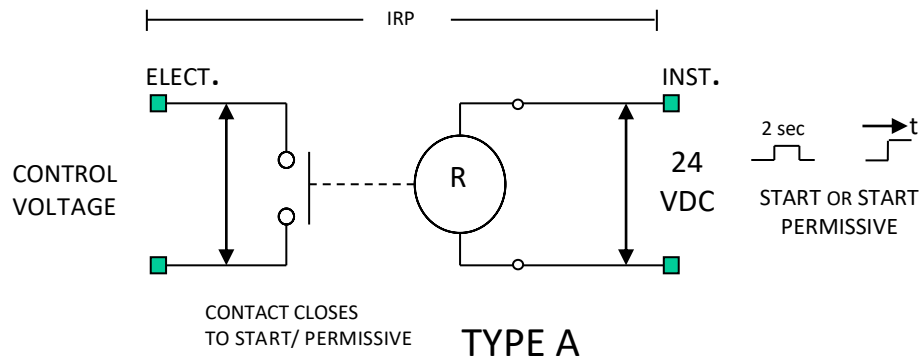
- All Interposing relay contacts shall be suitable for the Electrical control voltage (as per project spec/ feeder rating) and to be rated at minimum 5A to prevent burnout / sticking.
- There shall not be any remote start command from DCS/ESD unless specifically required by process and shown in P&ID. However, in case same is required signal shall be hardwired.
- Hardwired manual remote stop from DCS (in addition to automatic as per P&ID/ process requirement) shall be provided for each motor/load.
- UPS current and voltage indications and failure alarms shall be connected to DCS and made available to operator in control rooms.
- For Interface, Only Twisted pair cable with individual and overall shield shall be used.
- Multiple fuses in interface signals to be avoided. Fuse to be provided only at single location with proper coordination between upstream & downstream.

11.1 SIGNALS FROM INSTRUMENT TO ELECTRICAL

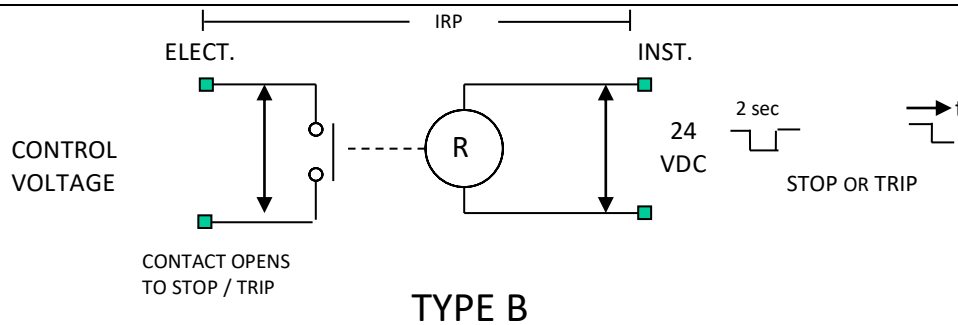
Refer following table and drawings for diagrammatic representation of interface signal requirements.

	SIGNAL TYPE	CONNECTION TYPE
A	SIGNALS FROM INSTRUMENT TO ELECTRICAL	
	DCS/ESD CONTROL START / START Permissive (All motors)	A
	DCS/ESD CONTROL STOP / TRIP (For Drive ≤ 55KW rating)	B
	DCS/ESD CONTROL STOP / TRIP (For Drive >55KW rating)	I
	CONTROL – ANALOGUE	E
B	SIGNALS FROM ELECTRICAL TO INSTRUMENT	
	MCC STATUS TO DCS/ESD	C
	NON MCC STATUS TO DCS/ESD	D
	UPS INDICATION - ANALOGUE	H

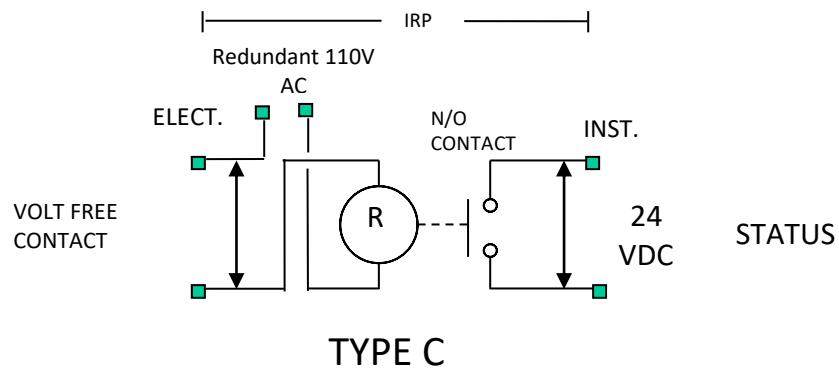
Electrical / Instrument Interface Schematics



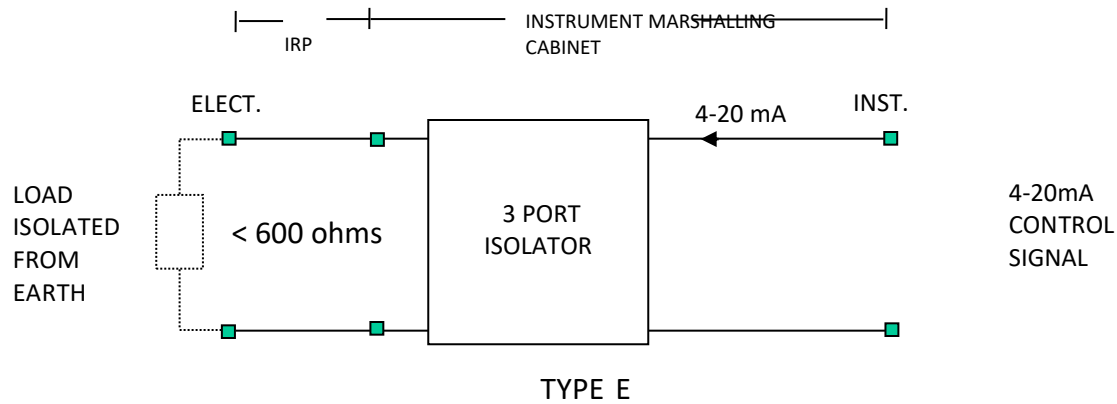
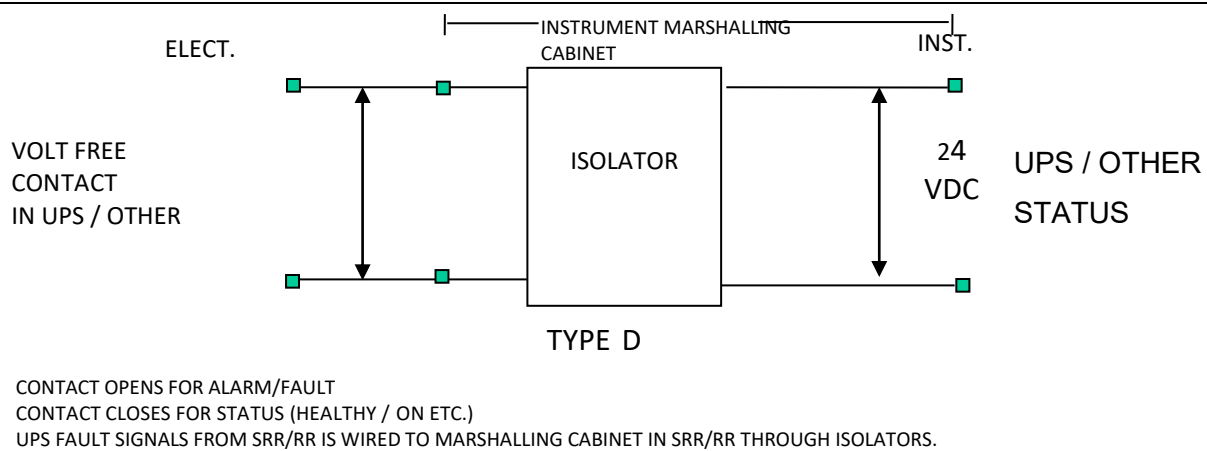
APPLICABLE FOR ALL DRIVES.



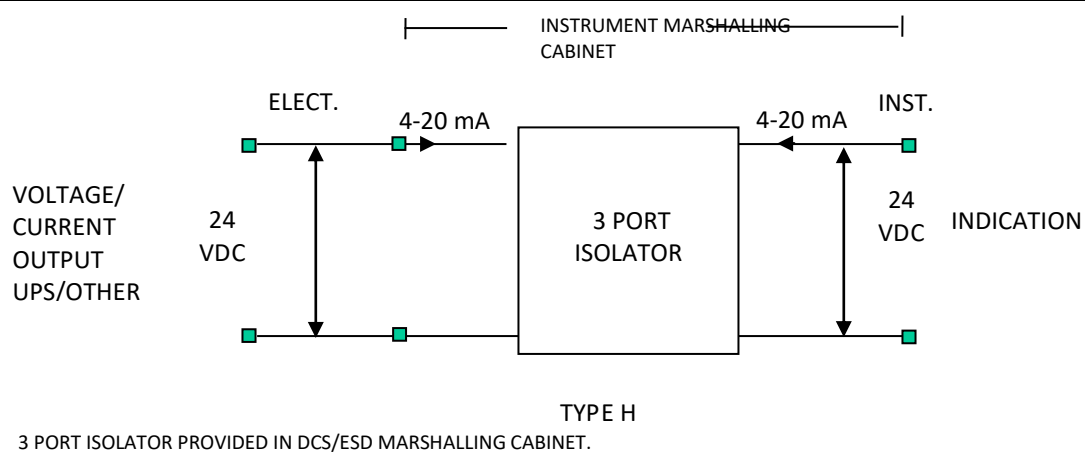
APPLICABLE AS STOP/ TRIP FOR DRIVES ≤ 55 KW

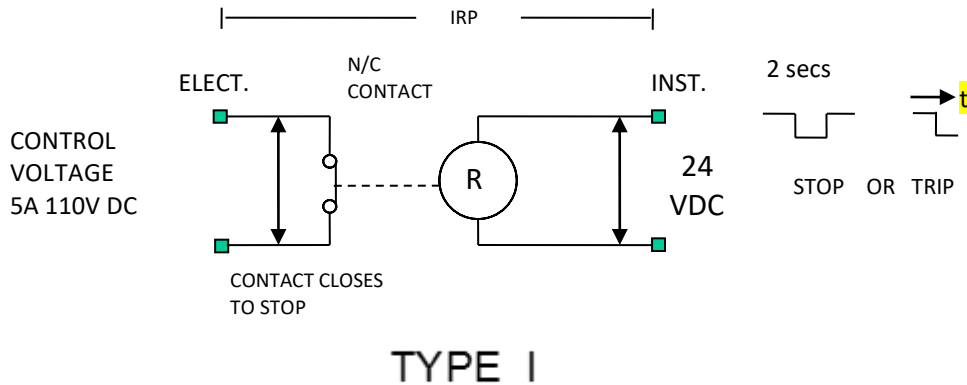


110V AC UPS POWER PROVIDED FOR POWERING CIRCUITS WITHIN IRP
APPLICABLE FOR ALL DRIVES. (INDIVIDUAL CIRCUIT FUSE PROTECTION REQUIRED).
CONTACT CLOSING FOR RUNNING/AVAILABLE AND OPENING FOR ALARM/FAULT.



3 PORT ISOLATOR PROVIDED IN DCS/ESD MARSHALLING CABINET. IRP IS PASS THROUGH ONLY.





APPLICABLE FOR LV/HV DRIVES OF RATING ABOVE 55KW ONLY

12 SPARE PARTS

Mandatory spares shall be procured along with the main equipment. Such spares for each equipment shall be as per the below table. These spares include only those spares, which are critical for equipment.

S.No.	Part Description	Description
1	Generator (one set of spare for each Generator)	
1.1	Generator relay	one set (each type & make)
1.2	DVR -all control card	One each type
2	Power Transformer (one set of spare for each power transformer)	Quantity is per transformer
2.1	Gasket	one set
2.2	Gauge glass	2 Nos of each rating & type.
3	Gas Insulated Switchgear	NA
3.1	Portable gas filling equipment/SF6 gas cart	NA

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

3.2	Handle for disconnect switch drive	NA
3.3	Handle for earthing switch drive	NA
3.4	Pre selection key for three position switch	NA
3.5	Power cable termination kit	NA
3.6	Tripping coil (Per Switchgear)	NA
3.7	Closing coil (Per Switchgear)	NA
3.8	Capacitive type voltage detectors	NA
3.9	Control fuses (Per switchboard)	NA
3.10	Network switches	NA
3.11	Relays Each type	2 Nos
3.12	CTs each type	3 Nos each
3.13	PTs each type	3 Nos each
4	33 kV Switchgear (one set of spare for each switchgear)	NA
4.1	Closing coil	NA
4.2	Shunt trip coil	NA
4.3	control fuses(all type & rating)	NA
5	11 kV & 6.6 Switchgear (one set of spare for each switchgear)	Quantity is per switchboard
5.1	Closing coil	1 No. of each Rating/Type
5.2	Shunt trip coil	1 No. of each Rating/Type
5.3	control fuses(all type & rating)	10 Nos. each rating & type
5.4	Relays (all models)	2 Nos
5.5	CTs (all ratings)	3 Nos each
5.6	PTs (all ratings)	3 Nos each
5.7	Ammeter and volt meter	2 nos each
6	415 V PCC/PMCC/EPCC or MV Switchboard (one set of spare for each Switchboard)	Quantity is per switchboard
6.1	Closing coil	1 No. of each Rating/Type
6.2	Shunt trip coil	1 No. of each Rating/Type
6.3	control fuses(all type & rating)	10 Nos. each rating & type
6.4	Relays Each type	2 Nos
6.5	CTs each type	3 Nos each
6.6	PTs each type	3 Nos each
6.7	Ammeter and volt meter	2 nos each
7	Variable Frequency Drive (one set of spare	Quantity is per VFD and PMC to be ensured for

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

	for each VFD or to provide spare VFDs instead of individual components as per economy)	the economy
7.1	Transistors/IGBT	One set of each rating & type
7.2	Control cards	One No of each type
7.3	Power supply cards	One No of each rating & type
7.4	Power & control fuses	20 % or one no (min) of each rating & type, whichever is more
7.5	All type of Fans	2 Nos each
8	Data concentrator panel/HMI (one set of spare for each)	
8.1	All cards such as input & output cards, power supply cards, processor cards etc.	One No of each type
8.2	All control fuse	10 Nos of each rating & type
9	UPS (one set of spare for each UPS system)	
9.1	Power transistors/IGBT	One No of each rating & type
9.2	Power supply cards	One No of each type
9.3	operating console card	One No of each type
9.4	All fuses	10 nos. of each rating & type
9.5	All type of Fans	2 Nos each
10	DC System(one set of spare for each DC System)	
10.1	All fuse	10 nos. of each rating & type
10.2	All cards such as input & output cards, power supply cards, processor cards etc.	1 no. of each rating & type
10.3	Thyristors	1 no. of each rating & type
10.4	fuse link	10 nos. of each rating & type
10.5	Blocker Diode	Two nos.
11	Synchronous motors (one set of spare for each rating & type)	
11.1	Fuses	10 nos of each rating & type
11.2	Bearing (DE & NDE) (as applicable)	one each
12	HV induction motors (one set of spare for each rating & type)	

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

12.1	Bearing (DE & NDE)	one each
12.2	Terminal studs/bushing assembly	one no.
13	MV induction motors 37 kW & above (one set of spare for each rating & type)	
13.1	Bearing set (DE & NDE)	one no of each type
13.2	Terminal/ bushing	one set each
14	Telephone exchange	
14.1	All line cards, Processing cards, power supply cards	1 no of each type
15	Fire alarm system	
15.1	All cards	one no. of each type
15.2	Fuses	10 nos. of each rating & type
15.3	Terminal blocks	20 nos
15.4	Fire detectors	5 % of total installed capacity of each type
15.5	Glass for Break Glass Boxes/ Manual call Point	10 %
16	Paging system / Plant Communication System	
16.1	All cards	one no of each type
16.2	All fuses	10 nos. of each rating & type
17	Thyristor control panel for heaters	
17.1	Rectifier control module(Control card fully assembled)	one no. of each type
17.2	Power supply card	one no. of each type
18	ECS	
18.1	Interposing relays (As applicable)	5 Nos. of each type
18.2	Power supply & control cards	1 nos. of each type

1. The word 'TYPE' means the Make, Model no., Type, Range, Size/ Length, Rating, Material as applicable.
2. Wherever % age is identified, Contractor shall supply next rounded figure.
3. The terminology used under 'Part Description' is the commonly used name of the part and may vary from manufacturer to manufacturer.
4. Mandatory spares as indicated above do not cover commissioning spares.
5. Mandatory spares as indicated above do not cover two year O&M spares.
6. Mandatory spares shall be applicable for electrical items of motors / sub-packages as per mandatory spares philosophy specified elsewhere in the bid document.

13 COMMISSIONING SPARES

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

Commissioning Spare Parts shall be procured along with the main equipment as per equipment manufacturer's recommendations. The list of such recommended spares shall be obtained along with the offer.

14 RECOMMENDED SPARE FOR NORMAL OPERATION & MAINTAINENCE

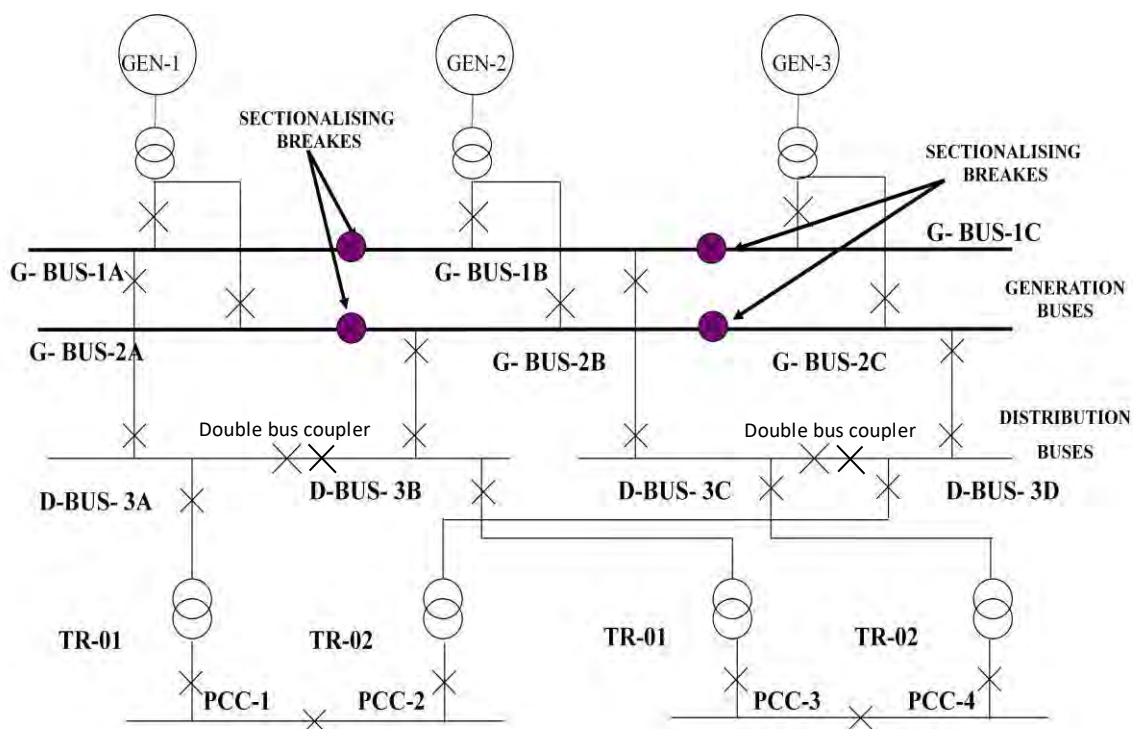
Quotation for two-years spares for normal operation and maintenance (over and above mandatory spares) along with unit price shall be obtained with the proposal for Client to order the same separately.

15 SPECIAL TOOLS AND TACKLES

Required Special Tools and Tackles shall be procured along with the main equipment as per equipment manufacturer's recommendations. The list of such recommended special tools/tackles shall be obtained along with the offer.

ANNEXURE – 1

(Only for illustration purpose)



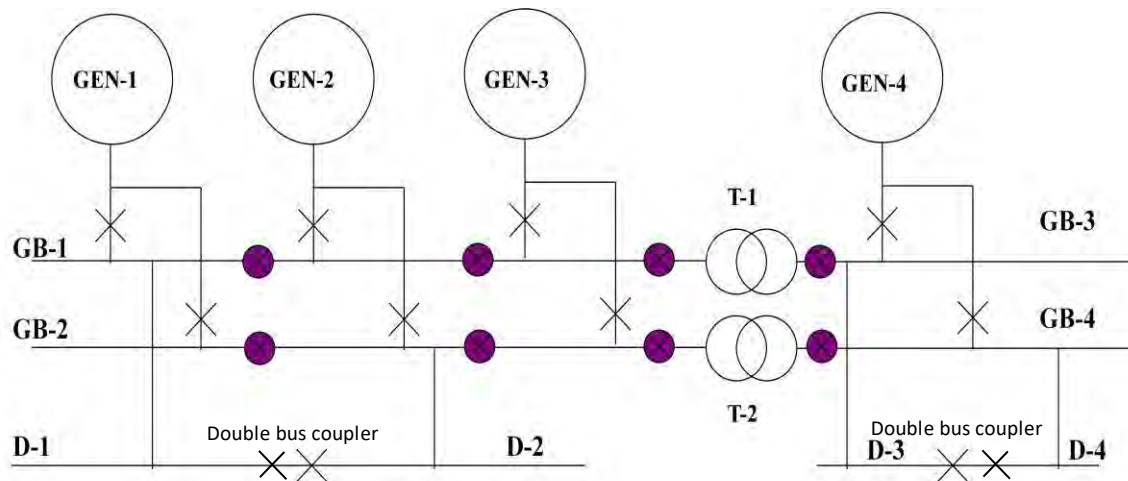
GENERATION & DISTRIBUTION SYSTEM WITH GEN. BUS SECTIONALIZING

DRG. NO. EL-1

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 2

(Only for illustration purpose)



- With the hookup of Gen-4, if the combined fault level is within the rated fault level of Gen. Buses G1 / G2 then new Generator can be directly hooked up to the Bus.(T1 & T2 are not required)
- In case the combined fault level exceeds the rated level of Gen. Buses G1 / G2, then a suitable fault level device e.g. transformer (T1 & T2) should be used for interconnection of new generator with the existing system.

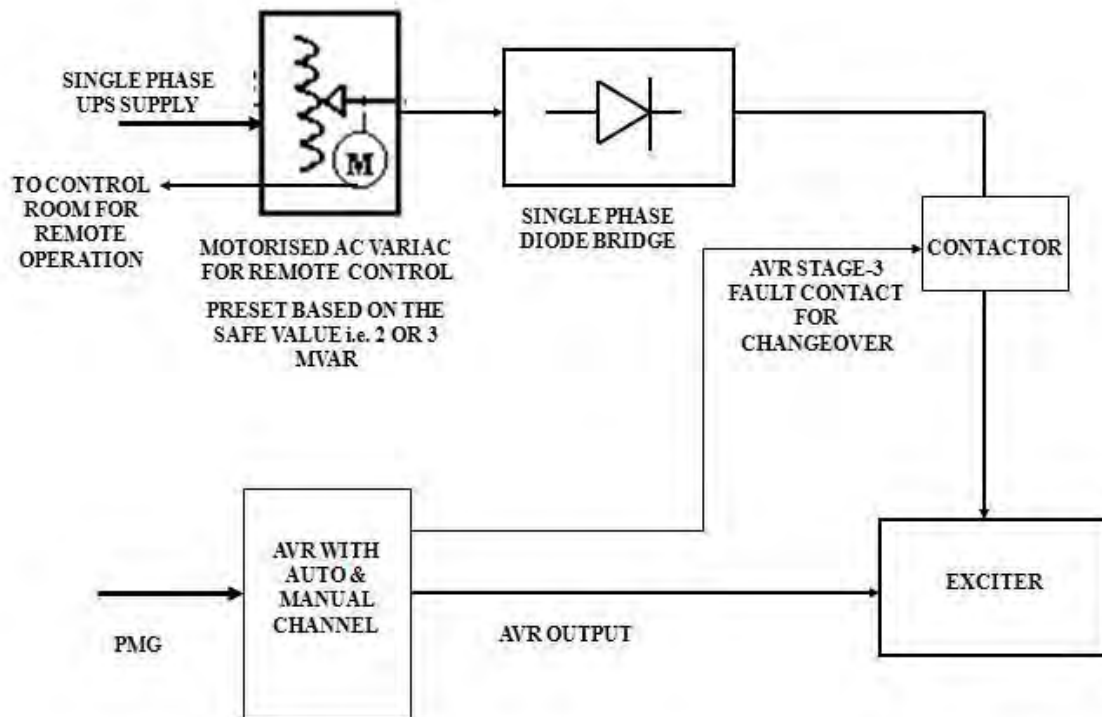
INTEGRATION OF NEW MACHINE AT PRIMARY SUBSTATION

DRG. NO. EL-2

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 3

(Only for illustration purpose)



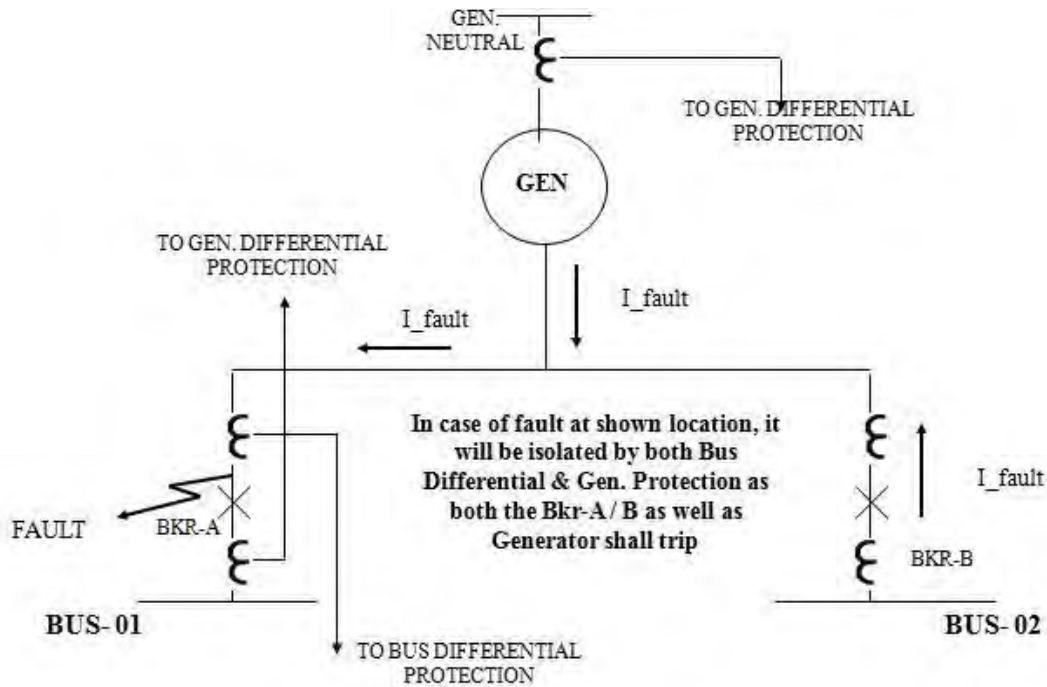
EMERGENCY CHANNEL FOR AVR / DAVR

DRG. NO. 1C.3A

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 4

(Only for illustration purpose)



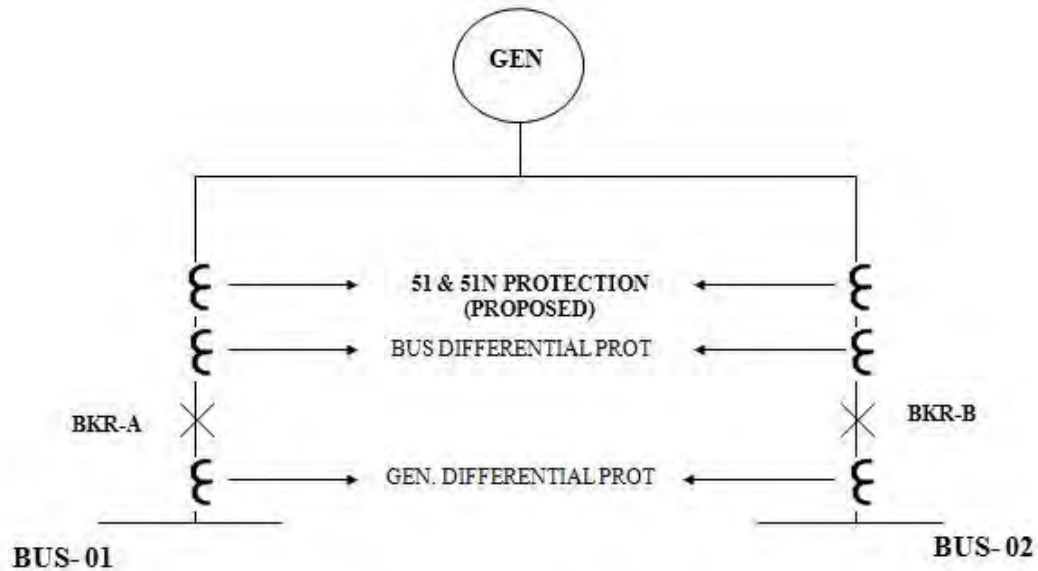
GENERATOR DIFFERENTIAL PROTECTION SCHEME

DRG. NO. 1C.4

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 5

(Only for illustration purpose)



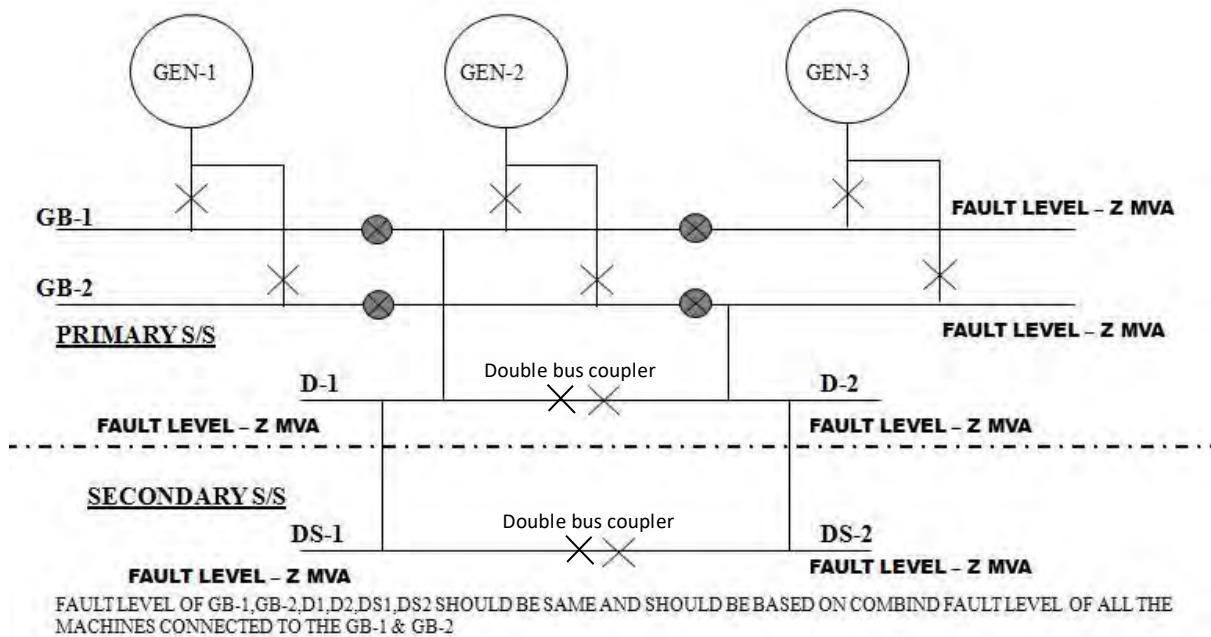
GENERATOR PROTECTION WITH DIFFERENTIAL AND BACKUP O/C ,E/F SCHEME

DRG. NO. 1C.5

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 6A

(Only for illustration purpose)



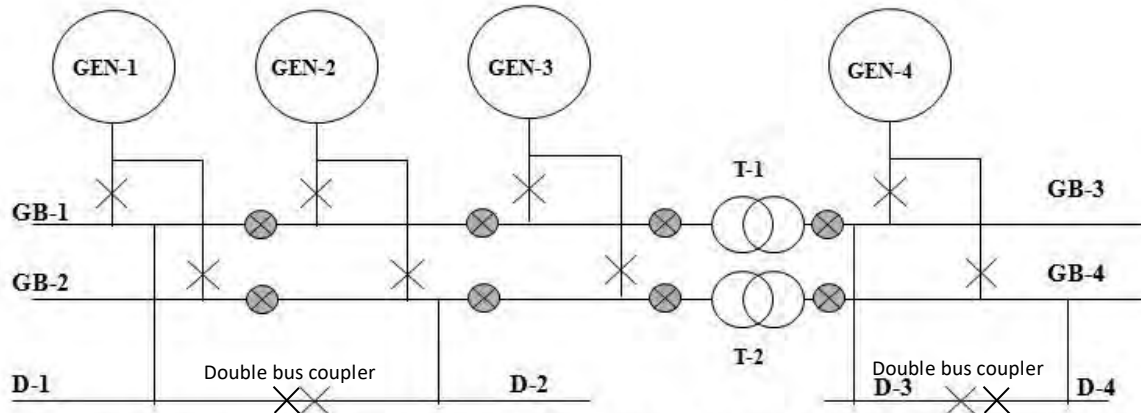
PRIMARY & SECONDARY SUBSTATION FAULT LEVEL ADEQUACY

DRG. NO. 2C.1

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 6B

(Only for illustration purpose)



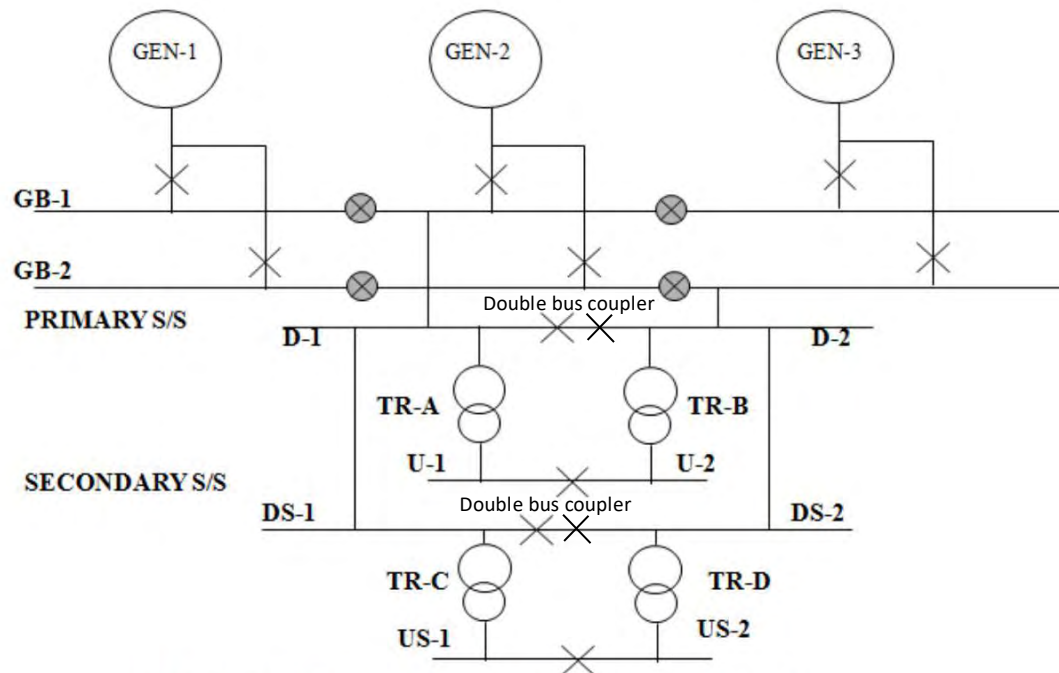
- With the hookup of Gen-4, if the combined fault level is within the rated fault level of Gen. Buses G1 / G2 then new Generator can be directly hooked up to the Bus. (T1 & T2 are not required)
- In case the combined fault level exceeds the rated level of Gen. Buses G1 / G2, then a suitable fault level device e.g. transformer (T1 & T2) should be used for interconnection of new generator with the existing system.

INTEGRATION OF NEW MACHINE AT PRIMARY SUBSTATION

DRG. NO. 2C.2

ANNEXURE – 6C

(Only for illustration purpose)



SECONDARY SYSTEM FAULT LEVEL ADEQUACY

DRG. NO. 2C.3A

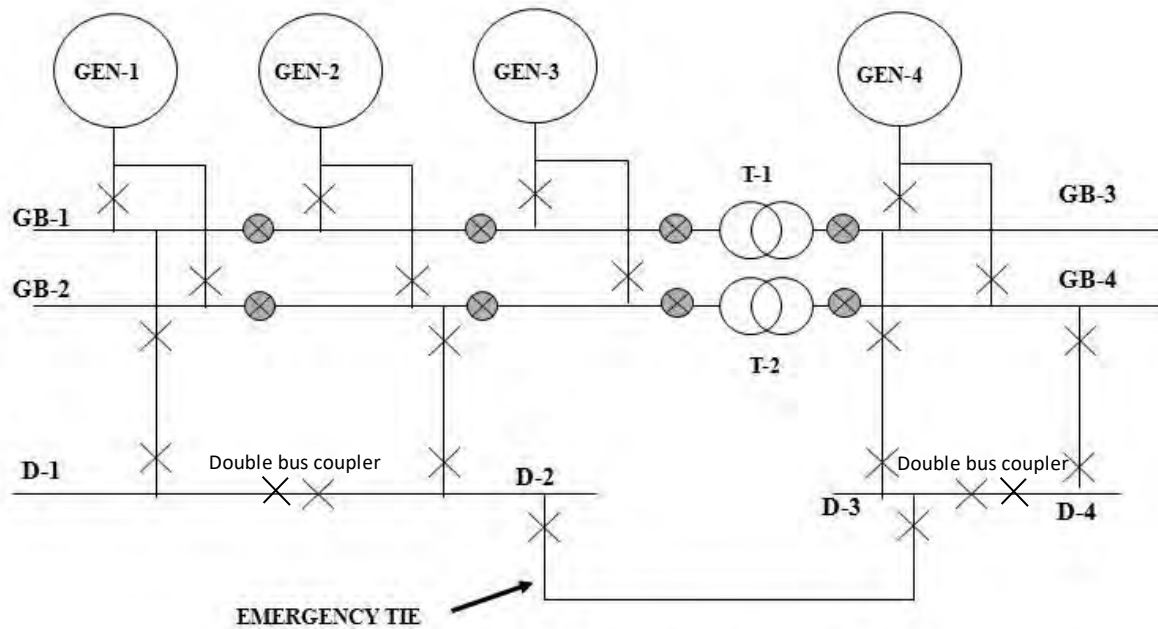
NOTE:-

- Fault level of GB-1, GB-2, D1,D2, DS-1,DS-2 shall be same
- Fault level of U1 & U2 shall be dependent on the impedance transformers TR-A & TR-B considering parallel operation of both the transformers.
- Similar shall be the case for US-1 & US-2, which shall be dependent on the parallel operation of the transformers TR-C & TR-D.

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 7

(Only for illustration purpose)

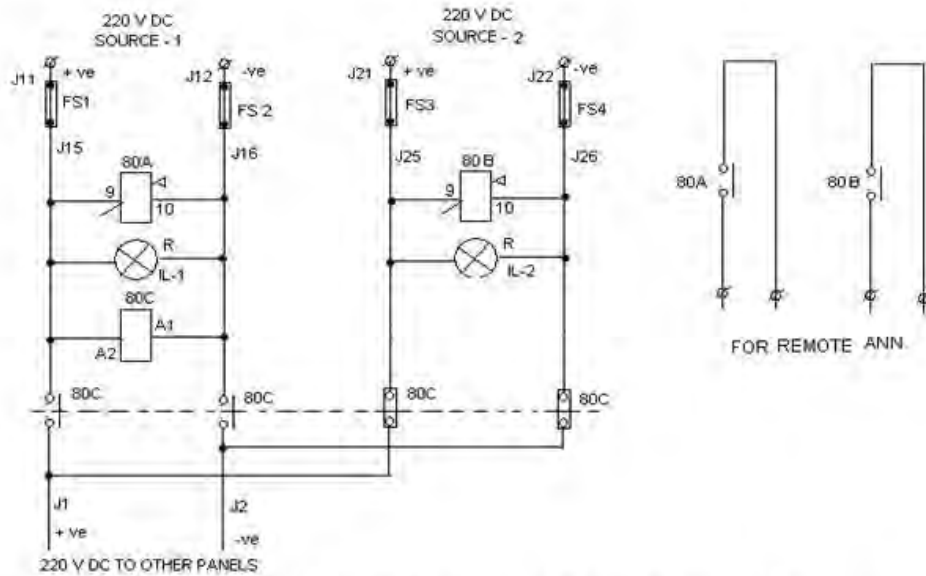


DISTRIBUTION SYSTEM WITH EMERGENCY TIES

DRG. NO. 2C.6

ANNEXURE – 8A

(Only for illustration purpose)



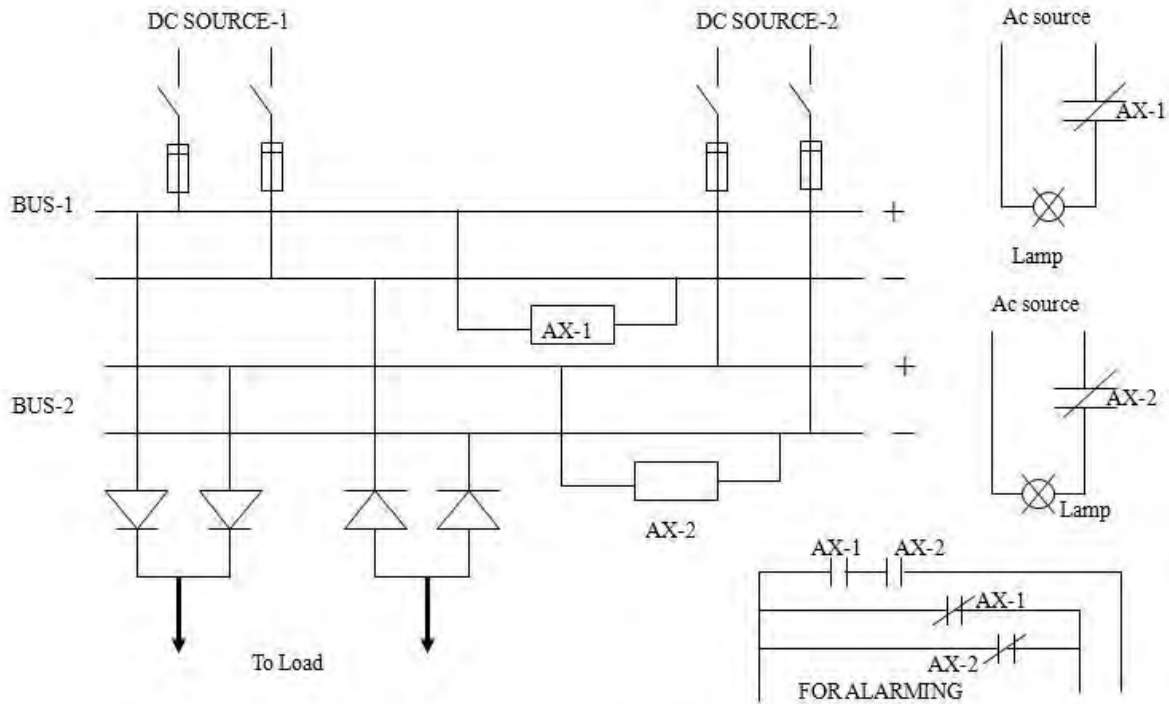
CONTROL SUPPLY CHANGE OVER SCHEME

DRG. NO. 2C.7

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 8B

(Only for illustration purpose)



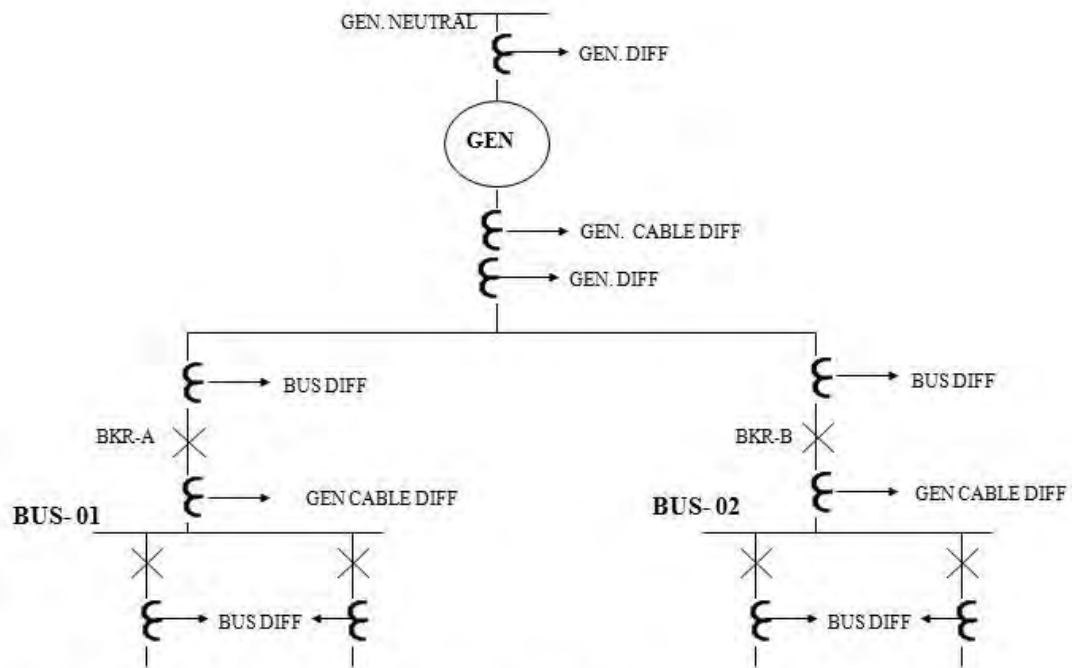
REDUNDANT DIODE TYPE CONTROL SUPPLY SCHEME

DRG. NO. 2C.8

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 9

(Only for illustration purpose)



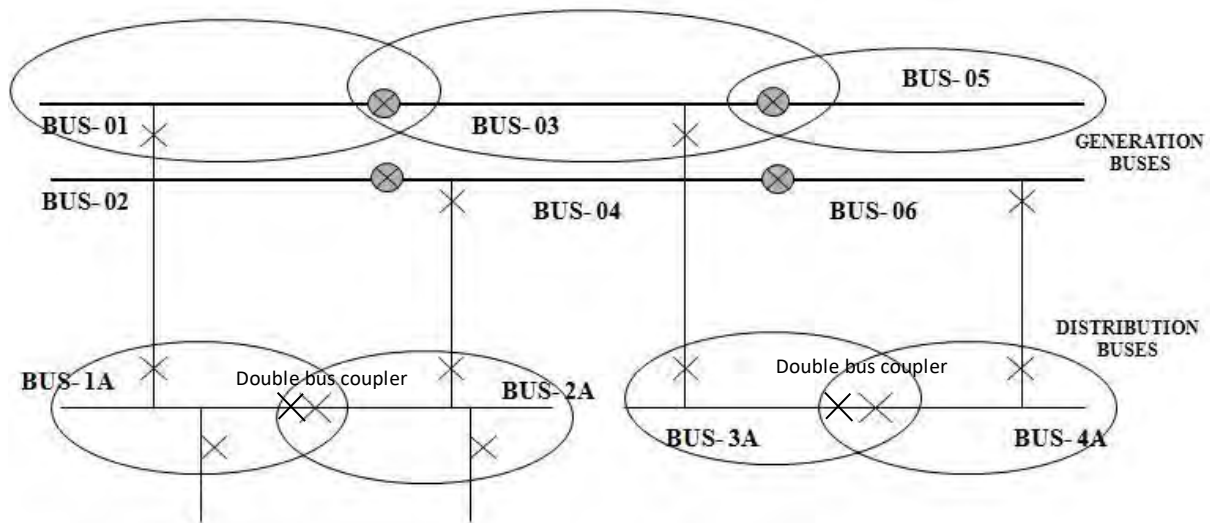
DIFFERENTIAL PROTECTION SCHEME FOR GENERATOR

DRG. NO. 2C.9

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 10

(Only for illustration purpose)



SCHEME FOR BUS-02 / 04 / 06 SHALL BE SIMILAR TO BUS-01 / 03 / 05

SCHEMATIC DISPLAY OF BUS DIFFERENTIAL SCHEME ZONE CROSSEOVERS

DRG. NO. 2C.10A

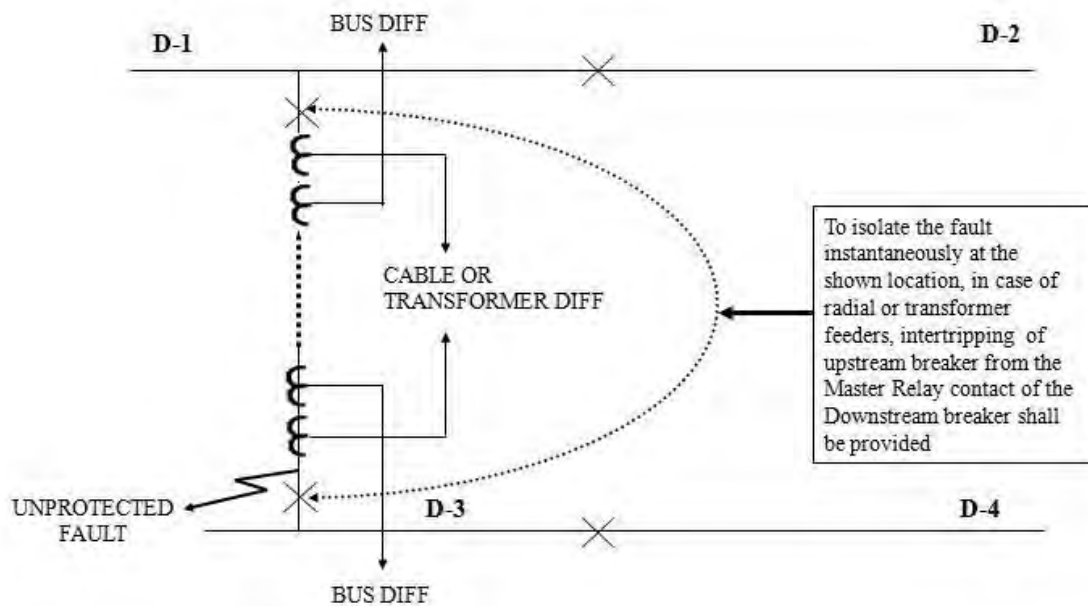
	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 11

(Only for illustration purpose)

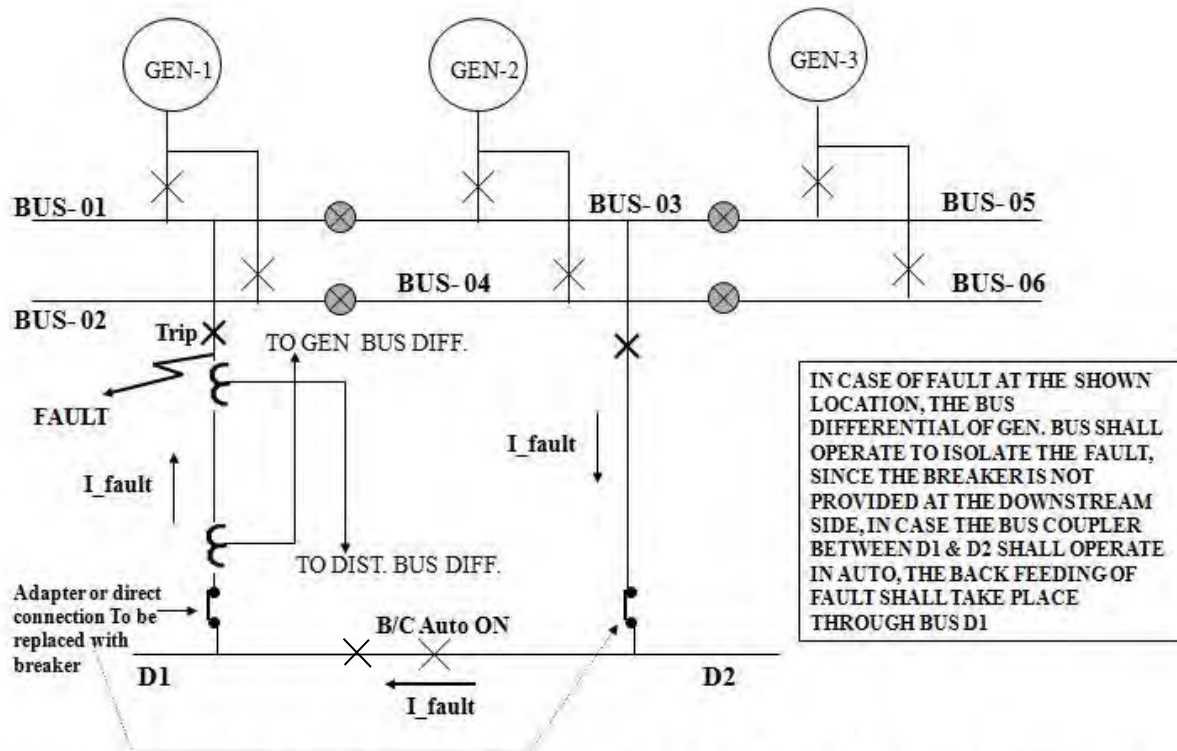
DISTRIBUTION SYSTEM WITH EMERGENCY TIES

DRG. NO. 2C.12



ANNEXURE – 12

(Only for illustration purpose)

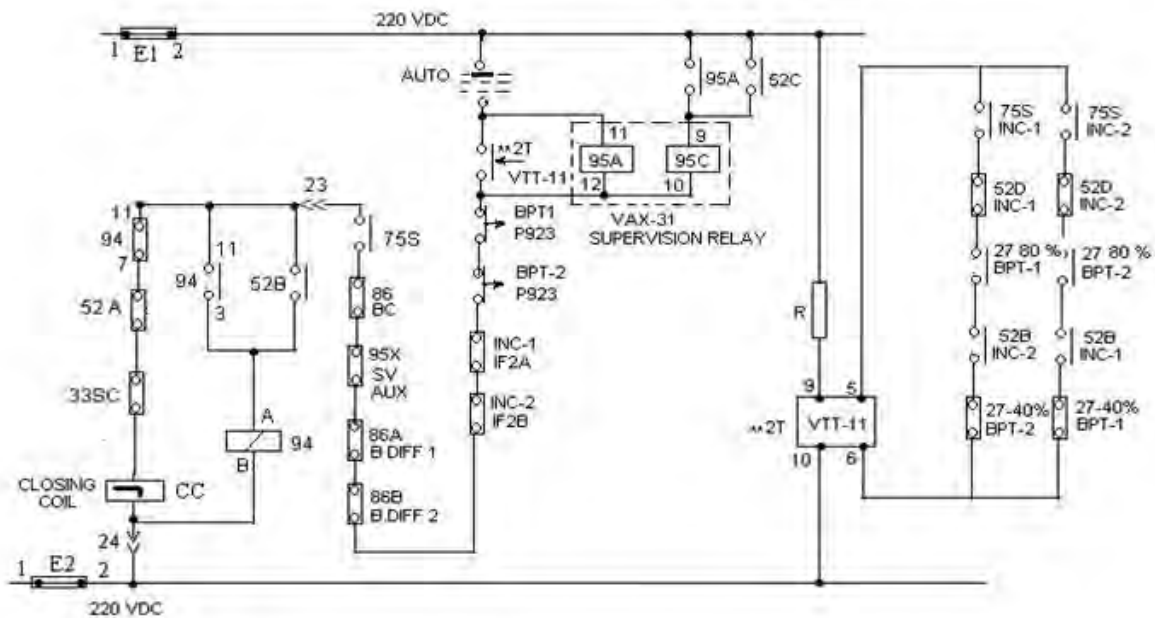


DISTRIBUTION BUS ARRANGEMENT WITHOUT BREAKER AT DOWNSTREAM

DRG. NO. 5C.1

ANNEXURE – 13

(Only for illustration purpose)



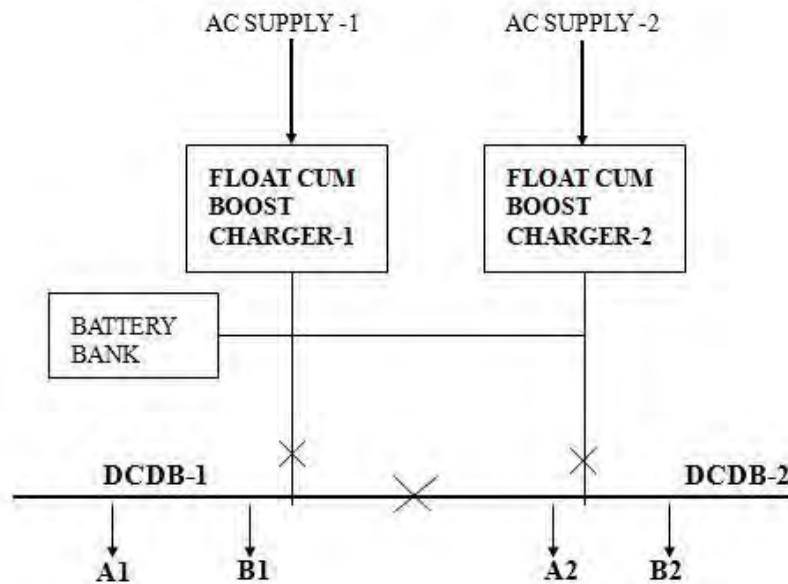
TYPICAL BUSCOUPLER AUTO CIRCUIT SUPERVISION SCHEME

DRG. NO. 5C.2A

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 14

(Only for illustration purpose)



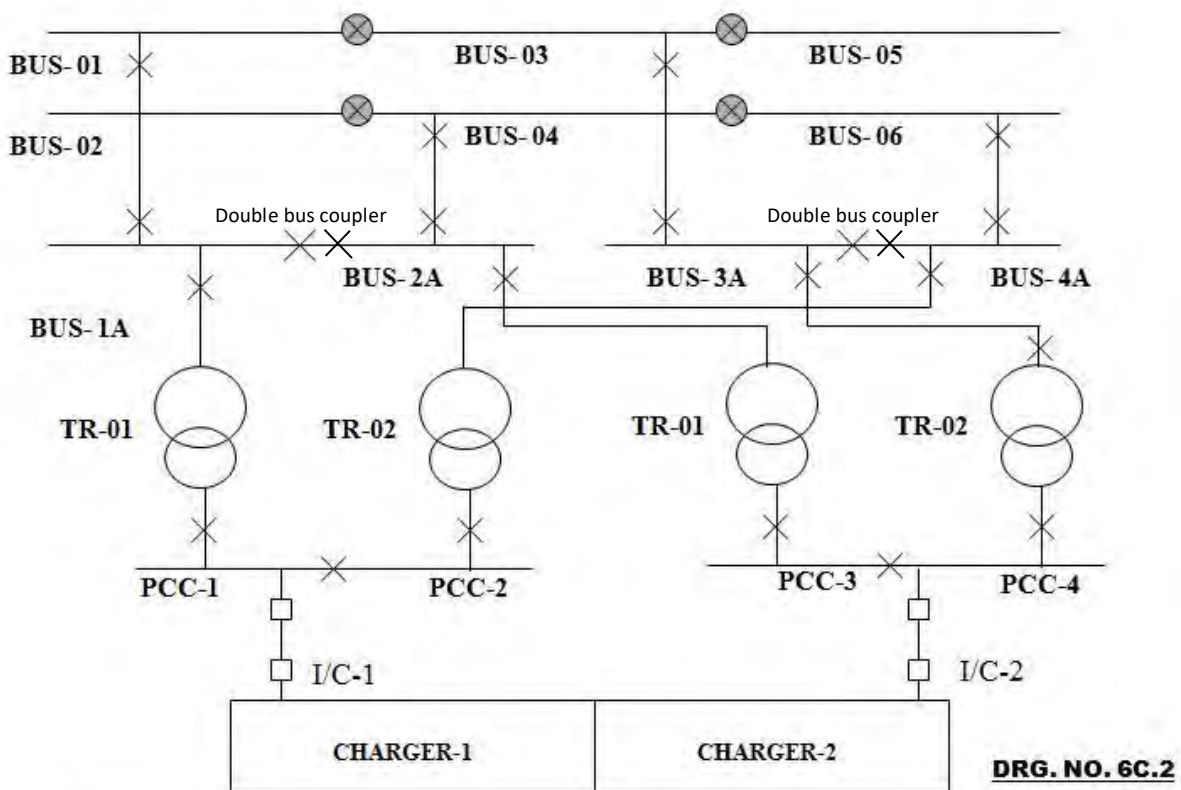
BATTERY CHARGER CONFIGURATION WITH DUAL BANK

DRG. NO. 6C.1

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 15

(Only for illustration purpose)

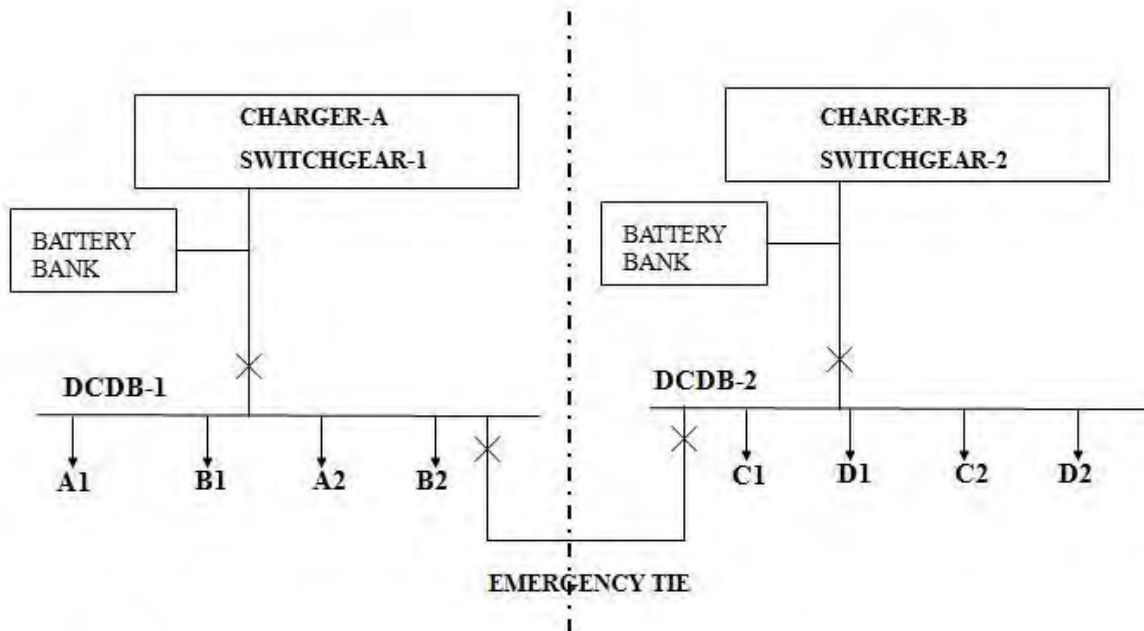


BATTERY CHARGER SUPPLY ARRANGEMENT WITH GEN. BUS SECTIONALIZING

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 16

(Only for illustration purpose)

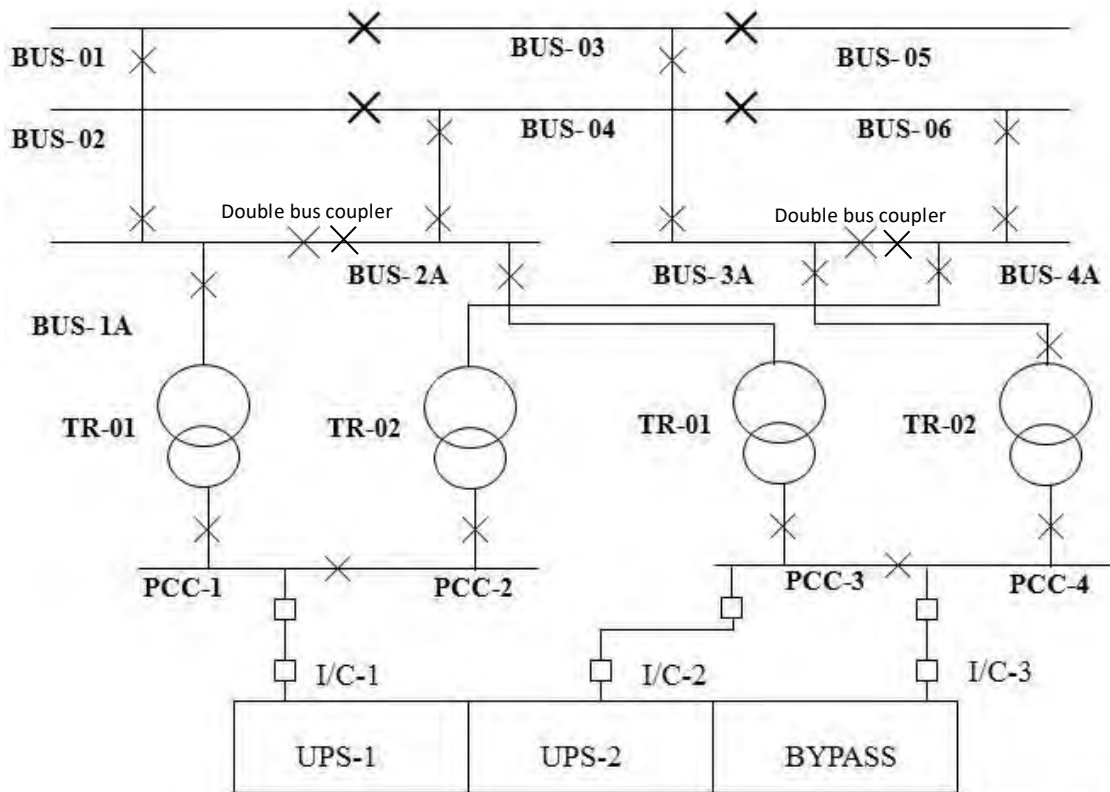


BATTERY CHARGER CONFIGURATION WITH EMERGENCY TIE

DRG. NO. 6C.3

ANNEXURE – 17

(Only for illustration purpose)



TYPICAL UPS INCOMING SUPPLY ARRANGEMENT

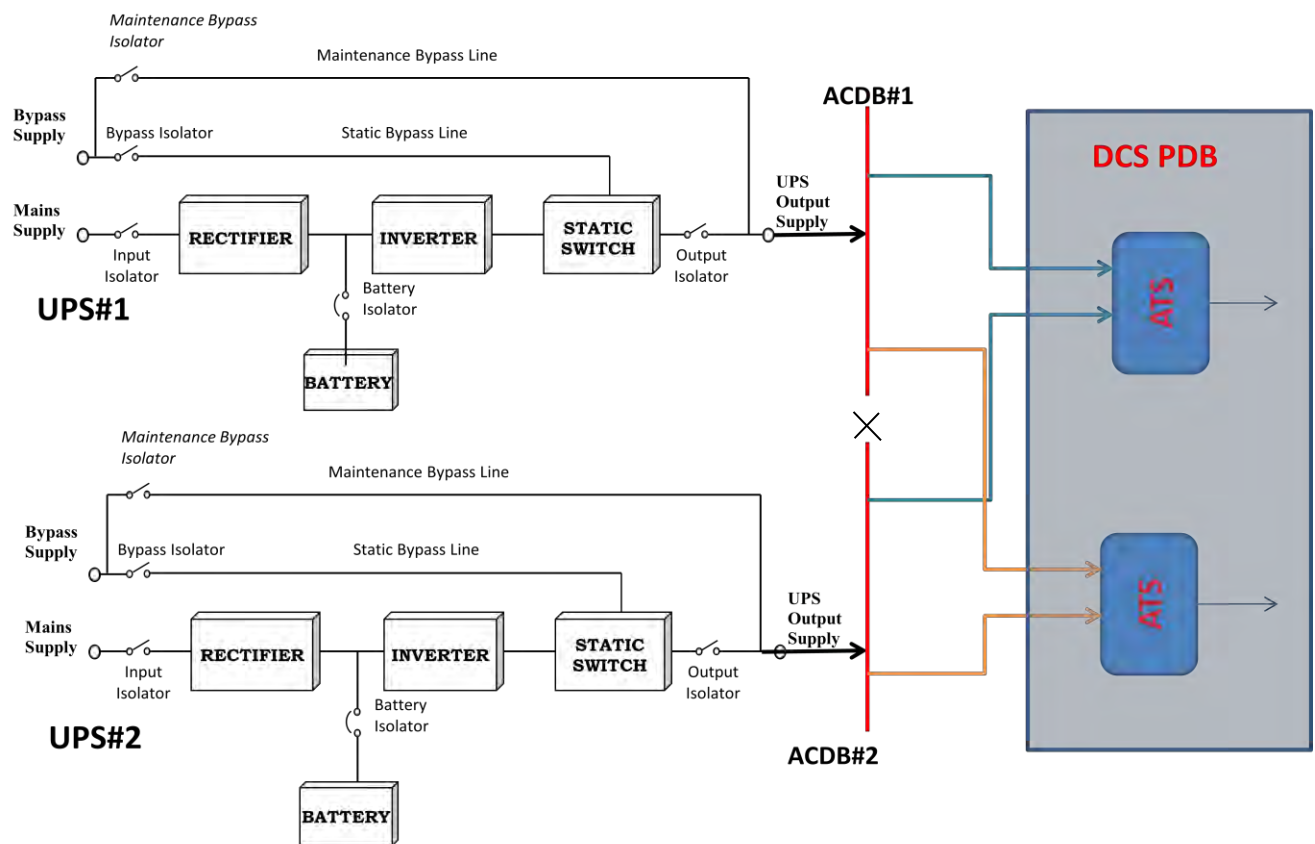
DRG. NO. 7C.1

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 18

(Only for illustration purpose)

Block Diagram of UPS system



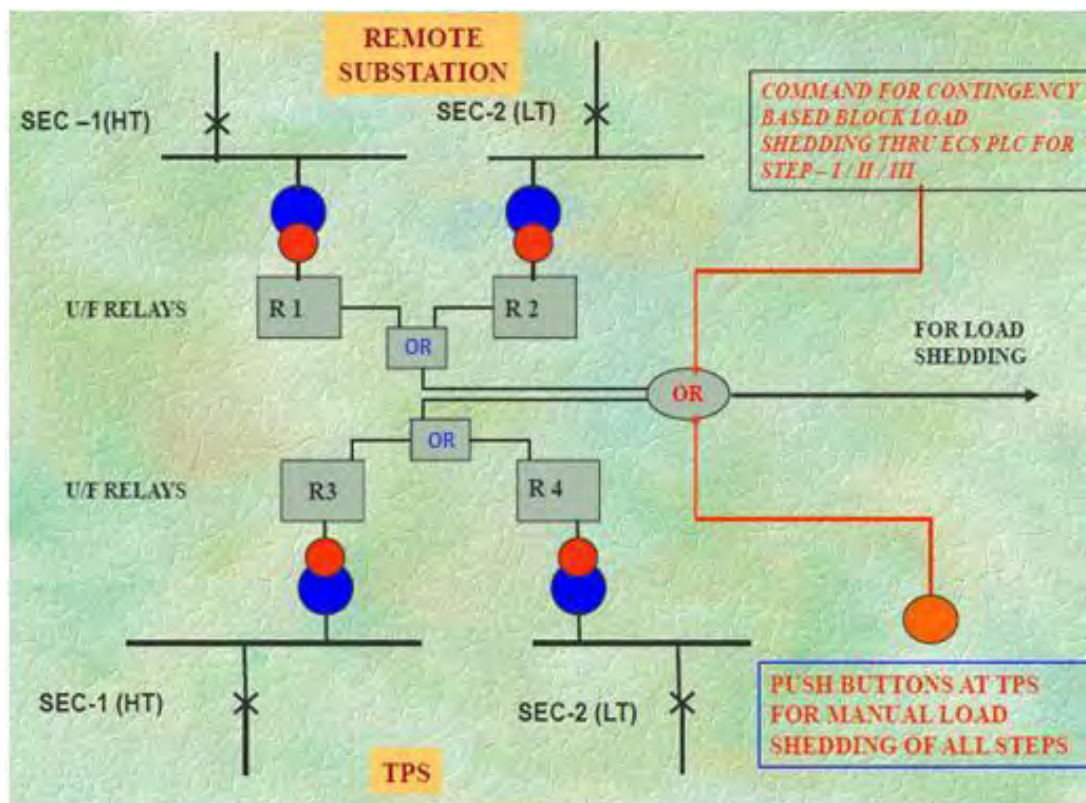
Drawing 7.C2

	DESIGN PHILOSOPHY FOR ELECTRICAL SYSTEM	RHQ-EC-EL-0001 REV-01
	RHQ- Maintenance & Inspection, Project	

ANNEXURE – 19A

(Only for illustration purpose)

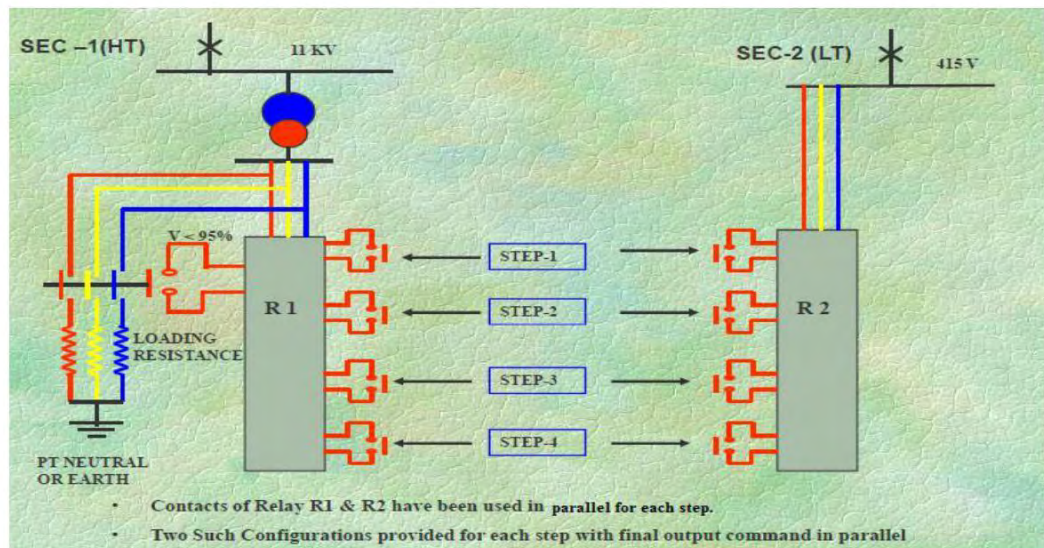
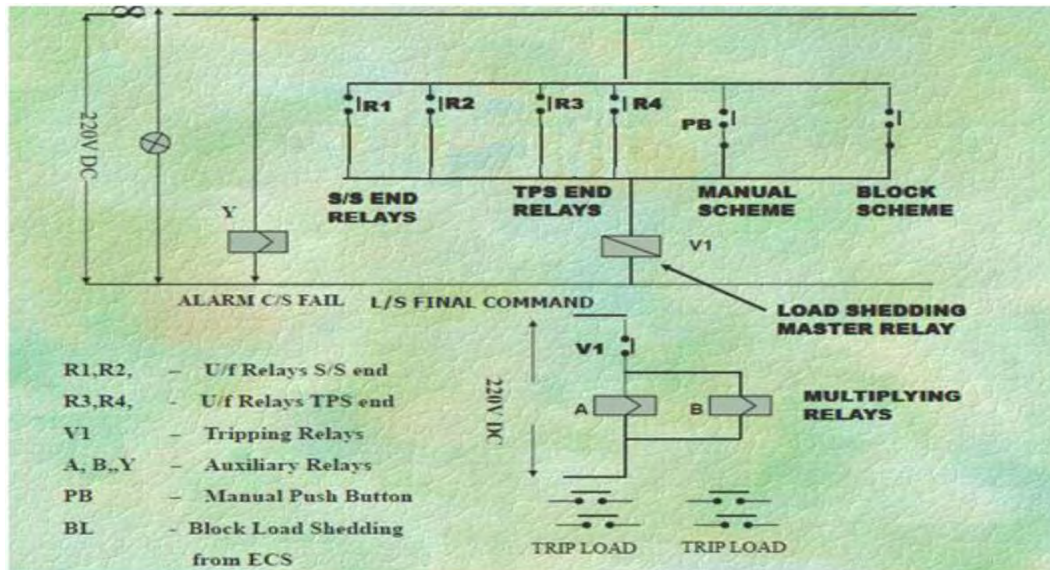
U/F BASED LOAD SHEDDING SCHEME



ANNEXURE – 19B

(Only for illustration purpose)

**Typical connection diagram for
Under frequency load shedding Scheme**



Section-4

ANNEXURE-A: COMPLIANCE CERTIFICATE OF TECHNICAL SPECIFICATION

The bidder shall confirm compliance to the following by signing and stamping this compliance certificate and furnishing same with the offer.

1. The scope of supply, technical details, construction features, design parameters etc. shall be as per technical specification & there are no exclusion/ deviation with regard to same.
2. There are no deviation(s) with respect to specification other than those furnished in the schedule of deviations.
3. Only those technical submittals which are specifically asked for in Notice Inviting Tender (NIT) to be submitted at tender stage shall be considered as part of offer. Any other submission, even if made, shall not be considered as part of technical offer.
4. Any comments/ clarifications on technical/ inspection requirements furnished as part of bidder's covering letter shall not be considered by BHEL, and bidder's offer shall be construed to be in conformance with the specification.
5. Any changes made by the bidder in the price schedule with respect to the description/ quantities from those given in 'BOQ' of the specification shall not be considered (i.e., technical description & quantities as per the specification shall prevail).

Date:

Bidder's Stamp & Signature

ANNEXURE-B: DEVIATION/ CHANGE REQUEST OF TECHNICAL SPECIFICATION

Bidder shall list out all technical potential deviation/ change request (s) along with clause with respect to technical specifications.

Sl. No.	Page No.	Clause No.	Deviation	Reason/ Justification(s)
---------	----------	------------	-----------	--------------------------

Any deviation not specifically brought out in this section shall not be admissible for any commercial implication at later stage. Except to the technical deviations listed in this schedule, bidder's offer shall be considered in full compliance to the tender specifications irrespective of any such deviation indicated / taken elsewhere in the submitted offer.

Date:

Bidder's Stamp & Signature

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR				
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
PART - A: SPECIFIC REQUIREMENTS						
	1	GENERAL				
1	2	Equipment Tag	During detail engineering stage			
	3	Equipment specification & standards	As per project synchronous motor specification & as per latest IS Code / IEC standards			
1	4	Quantity	During detail engineering stage			
	5	SERVICE CONDITIONS				
1	6	Design ambient temperature	46.6° C			
	7	Site ambient temperature range:min. to max.	(-)0.7° C Min, 46.6 ° C Max			
	8	Altitude (above msl)	< 1000 Mtrs			
	9	Relative humidity	95%			
	10	Seismic zone	Zone IV (IS - 1893)			
	11	Site environment	Tropical, humid and corrosive atmosphere			
	12	Location of installation	Indoor			
	13	Area classification	Unclassified safe			
	14	SWITCHGEAR DESIGN DATA				
	15	System voltage , frequency , phases	220kV/ 66kV, 50 Hz, 3Ø			
	16	Voltage variation	± 6 %			
	17	Frequency variation	± 3 %			
	18	System grounding	Solidly earthed			
	19	Fault level	Refer SLD for 220kV GIS and 66kV GIS			
	20	Maximum Service Voltage	245kV for 220kV system / 72.5 for 66kV System			
	21	Rated Insulation Level				
	i)	-at power frequency 1 min	460kV for 220kV System / 275kV for 66kV System			
	ii)	-at lightning impulse (1.2/50 µs wave)	1050kV for 220kV GIS / 650kV for 66kV System			
	22	Rated service current (minimum)				
	i)	- Bus bar	Refer SLD for 220kV GIS and 66kV GIS			
	ii)	- Input Feeder bay	Refer SLD for 220kV GIS and 66kV GIS			
	iii)	- Transformer bay	Refer SLD for 220kV GIS and 66kV GIS			
	iv)	- Bus coupling bay	Refer SLD for 220kV GIS and 66kV GIS			
	v)	- Sectionalizer bay	Refer SLD for 220kV GIS and 66kV GIS			
	23	Rated short time withstand current (Symmetrical)	Refer SLD for 220kV GIS and 66kV GIS			
	i)	- Duration	Refer SLD for 220kV GIS and 66kV GIS			
	24	Internal fault withstand time without burn Through	ms as per IEC-62271-203			
	25	Temperature rise at rated service current (indicative)				
	i)	- Conductor	°C as per IEC-60694			
	ii)	- Enclosure	°C			
	26	Rated SF6 gauge pressure at 20°C				
	i)	- Circuit breaker	as per standard			
	ii)	- Switchgear	as per standard			
	27	Enclosure design pressure				
	i)	- Circuit breaker	as per standard			
	ii)	- Switchgear	as per standard			
	28	Leakage rate of SF6 per annum for the whole substation	< 0.5 %			
	29	Maximum partial discharge level	≤ 5 pC			
	30	Factory Dielectric routine test 50Hz	460 kV for 220kV GIS			
	31	Site dielectric test	380 kV for 220kV GIS			
	32	Painting of switchgear				
	i)	- Coating design and execution	RAL as per detailed Specification/ Standard.			

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR				MCDERMOTT
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
	ii)	- Top coat colour				
	33	Surface protection of steel frames		Hot-dip Galvanizing with Zinc with 610gm/ square meter		
	34	Degree of Protection		IP 42		

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
PART - B: SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS FOR GAS INSULATED SWITCHGEAR (220kV GIS / 66kV GIS)						
	1	General				
	2	Name of manufacturer (OEM)				
	3	Country of Origin				
	4	Delivery from (location)				
	5	Type & Designation				
	6	Type tested at Name of Laboratory				
		Address of laboratory				
	7	Installation				
	8	Standards applicable				
	9	No. of Phases				
	10	Single or Three Phase design				
	11	Configuration				
	i)	Number of Feeder bays				
	ii)	Number of transformer bays				
	iii)	Number of Bus coupler bay				
	iv)	GIS to transformer connection				
	v)	GIS to Feeder connection				
	vi)	Number of VT				
	vii)	Number of SA				
		Future extension possibility				
	12	Service conditions				
	i)	Ambient Air Temp. in Deg. C				
	ii)	Max Temp. in Deg. C				
	iii)	Min Temp. in Deg. C				
	iv)	Daily Average Temp. in Deg. C				
	v)	Solar Radiation W/sq mtr				
	vi)	Altitude above MSL, in mtr				
	vii)	Pollution class				
	viii)	Creepage distance, in mm/kV				
	ix)	Relative humidity				
	x)	Condensation				
	xi)	Vibration level				
	xii)	Noise level				
	xiii)	Induced Electromagnetic Disturbance, in kv				
	xiv)	Seismic conditions				
	a	Vertical				
	b	Horizontal				
	13	Enclosure				
	i)	Code of pressure vessel				
	ii)	Type of manufacturing				
	iii)	Design temperature in Deg.C				
	iv)	Material				
	v)	Material grade & applicable standard				
	vi)	Outside diameter in mm				
	vii)	Minimum Wall Thickness, in mm				
	viii)	Painting Shade & Thickness				
	a	External				
	b	Internal				
	ix)	Degree of Protection				

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
	x)	Inductance in H/mt				
	xi)	Capacitance in pF/mt				
	xii)	Resistance in Ohm/mt				
	xiii)	Expansion Bellow				
	a	Material				
	b	Min allowable adjustable displacement				
		Longitudinal				
		Transverse				
	xiv)	xiv Sealing system				
	a	Type				
	xv)	Estimated life in years				
	xvi)	Barrier				
	a	Material				
	b	Dielectric strength				
	14	Support Structure				
		Material				
		Minimum thickness of galvanizing				
		Foundation channels /Anchor bolts				
	15	Grounding				
	i)	Grounding Material				
	ii)	Grounding of complete GIS				
	iii)	Grounding of individual compartment				
	iv)	Grounding at flange joints				
	16	System Parameters				
	i)	Highest System voltage in kV				
	ii)	Rated voltage of System in kV				
	iii)	Rated voltage of Equipment in kV				
	iv)	Rated Insulation level Phase to Earth and between Phases				
	a	One Min Power Frequency withstand voltage kVrms				
	b	Switching impulse withstand voltage, kVp				
		Phase to Earth				
		Between Phases				
	c	Lightning Impulse withstand voltage, kVp				
	v)	Rated Frequency				
	vi)	Rated current in Amp				
	vii)	Rated current at 50 °C (equipment) in Amp				
	viii)	Rated current at 50 °C (bus bar) in Amp				
	ix)	Rated short circuit withstand current kArms				
	a	Duration in sec				
	b	Peak kAp				
	x)	Enclosure withstand time for an internal fault in sec.				
	xi)	Estimated total energy loss at				

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
		100 % of rated capacity				
		75 % of rated capacity				
		50 % of rated capacity				
		25 % of rated capacity				
	xii)	Measures taken to minimize Over Voltage				
	xiii)	Phase labeling				
	xiv)	Auxiliary supply (AC Voltage, Frequency; DC voltage)				
		- Operation				
		- Control				
		- Illumination & heater				
	17	Delivery condition				
	i)	Bays fully assembled at works				
	ii)	Dimensions of longest section for transportation				
	iii)	Weight of heaviest package				
	iv)	Pressure of SF6 gas during transportation				
	v)	SF6 gas monitoring system provided during transportation				
	18	Bus Bar				
	i)	Configuration (Single / Double)				
	ii)	Nos of Phases				
	iii)	Material				
	iv)	Size				
	v)	Rating				
	vi)	Current density adopted				
	vii)	Current density as per type test report				
	viii)	Short time current withstand rating in kA				
	ix)	Duration				
	x)	Resistance per phase				
	xi)	Surge impedance				
	xii)	SF6 immersed insulator				
	a	Material				
	b	Dielectric strength				
	xiii)	Maximum Partial Discharges measured at HSV				
	19	SF6 Gas				
	i)	Applicable standard				
	ii)	Quantity of SF6 Gas of complete GIS at filling pressure, in kg				
	iii)	Quantity of SF6 Gas of largest compartment GIS at filling pressure, in kg				
	iv)	No's of Gas compartments				
	v)	Quantity of SF6 Gas of individual compartment GIS at filling pressure, in kg				
	vi)	Maximum permissible dew point, in Deg.C				
	vii)	Composition of Gas				
	a	SF6 > 99.90 % by weight				
	b	Air < 500 ppm by weight (0.25 vol.-%)				
	c	CF4 < 500 ppm by weight (0.1 vol.-%)				

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR				MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page		
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue		
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1	
	d	H2O < 15 ppm by weight (0.012 Vol-%)					
	e	Mineral oil < 10 ppm by weight					
	f	Acidity, in terms of HF < 0.3 ppm by weight					
	g	Hydrolysable fluorides, in terms of HF< 1 ppm by weight					
	vii)	PRESSURE in MPa in kG/sqcm					
	viii)	Design pressure					
	a	Circuit breaker					
	b	Other compartments					
	ix)	Rated filling pressure					
	a	Circuit breaker					
		Other compartments					
	x)	Type tested pressure.					
	a	Circuit breaker					
	b	Other compartments					
	xi)	Routine test pressure					
	a	Circuit breaker					
	b	Other compartments					
	xii)	operating pressure of PRD					
	a	Circuit breaker					
	b	Other compartments					

				DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page		
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue		
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1	
	xiii)	Alarm Pressure					
	a	Circuit breaker					
	b	Other compartments					
	c	CB lock out Pressure					
	d	Over pressure signaling					
	xiv)	Maximum SF6 Gas leakage rate, in % per year					
	xv)	Density Monitor to be provided for each Individual gas compartment.					
	20	Circuit Breaker					
	i)	Applicable standard					
	ii)	Type					
	iii)	Designation					
	iv)	Operating Mechanism type					
	v)	Nos. of phases					
	vi)	Rated current in Amp					
	vii)	Mechanical Endurance class					
	viii)	Electrical Endurance class					
	ix)	Re-strike probability class					
	x)	Rated SC breaking current					
	xi)	Rated Sc breaking current - single phase test					
	xii)	Rated Line charging breaking current					
	xiii)	Rated cable charging breaking current					
	xiv)	Capacitor bank switching capability,					
	xv)	Inductive current					
	xvi)	Reactive current					
	xvii)	Out of phase making & breaking current					
	xviii)	Rated short line fault current					
	xix)	TRV characteristic					
	xx)	First Pole to Clear factor					
	xxi)	Nos. of interrupters per phase					
	xxii)	Type of arc control device provided, if any					
	xxiii)	Type of arcing contacts					
	xxiv)	Material of main contact					
	xxv)	Material of Arcing contacts					
	xxvi)	Filter material					
	xxvii)	Timings of operations					
	a	Opening at nominal control voltage					
		Opening at minimum control voltage					
	b	Closing time at nominal control voltage					
	xxviii)	Maximum pole discrepancy time					
		Tripping					
		Closing					
	xxix)	Rated operating duty cycle					
	xxx)	Tripping Coils					
	-	No of coils					
	-	Rated Voltage					
	-	Rated Current					
	-	Rated Watts					
	-	Resistance					
	xxxi)	Closing Coil					

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR				MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page		
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue		
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1	
	-	Rated Voltage					
	-	Rated Current					
	-	Rated Watts					
	-	Resistance					
	xxxii)	Spring Charging Motor					
	-	Rated Voltage					
	-	Rated Current					
	-	Rated Watts					

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
	xxxiii)	Spring charging time at rated Aux supply				
	xxxiv)	Spring charging time at min Aux supply				
	xxxv)	Maintenance required after nos. of operation at				
	a	No load				
	b	Rated current				
	c	25% of rated SC current				
	d	50% rated SC current				
	e	Rated SC current				
	f	Provision of anti pumping				
	g	No of operations after switching off of motor				
		Aux. supply				
	xxxvi)	Provision of Manual trip				
	xxxvii)	Electrical interlocking				
	xxxviii)	Padlocking				
	xxxix)	Type of Operation counter provided				
	21	DISCONNECTORS				
	i)	Applicable standards				
	ii)	Type				
	iii)	Rated current in Amp for				
	-	Bus disconnecter				
	-	Line disconnecter				
	-	Transformer disconnecter				
	-	PT disconnecter				
	iv)	Maximum Current that can be safely				
		Interrupted by the Isolator (Amp).				
	-	Inductive				
	-	Capacitive				
	v)	Rate Short time withstand Current in kA, for 3 sec				
	vi)	Rated peak short time Current, kAp				
	vii)	Rated bus charging current, in Amp				
	viii)	Type of contacts				
	ix)	Material of contacts				
	x)	Current Density at minimum cross section				
	xi)	Rated lightning impulse withstand voltage across the open gap, kVp				
	xii)	Rated Power Freq withstand voltage across the open gap, kVrms				
	xiii)	Mechanical Endurance class				
	xiv)	Type of Operating Mechanism				
	xv)	Operating Motor details				
	-	Type				
	-	Rated Voltage				
	-	Rated Current				
	-	Rated Watts				
	xvi)	Operating Time				
	-	Closing				
	-	Opening				
	xvii)	Mechanical indication on drive shaft				
	22	Maintenance Grounding Switch				
	i)	Applicable standards				
	ii)	Type				

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR				<u>MCDERMOTT</u>	
Rev	Project Name		MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client		INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location		PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
	iii)	Rate Short time withstand Current in kA, for 3 sec					
	iv)	Rated peak short time Current, kAp					
	v)	Rated lightning impulse withstand voltage across the open gap, kVp					
	vi)	Rated Power Freq withstand voltage across the open gap, kVrms					

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
	vii)	Type of Operating Mechanism				
	viii)	Operating Motor details				
	-	Type				
	-	Rated Voltage				
	-	Rated Current				
	-	Rated Watts				
	ix)	Operating Time				
	x)	Mechanical indication on drive shaft				
	23	Fast Acting Grounding Switch				
	i)	Applicable standards				
	ii)	Type				
	iii)	Rate Short time withstand Current in kA, for 3 sec				
	iv)	Rated peak short time Current, kAp				
	v)	Rated induced current switching capability				
	vi)	Rated capacitive current switching capability				
	vii)	Rated lightning impulse withstand voltage across the open gap, kVp				
	viii)	Rated Power Freq withstand voltage across the open gap, kVrms				
	ix)	Electrical Endurance class				
	x)	Type of Operating Mechanism				
	xi)	Operating Motor details				
	-	Type				
	-	Rated Voltage				
	-	Rated Current				
	-	Rated Watts				
	xii)	Operating Time				
	-	Closing				
	-	Opening				
	xiii)	Mechanical indication on drive shaft				
	24	Current transformers				
	i)	Type				
	ii)	Material				
	iii)	Position of current Transformer				
	iv)	Reference Standard				
	v)	Rated Continuous thermal current				
	vi)	Rated Short Time current				
	vii)	Duration				
	a	Incomer Bay CT				
	i)	Metering Core				
	-	Ratio				
	-	Output Burden				
	-	Accuracy Class				
	-	ISF				
	ii)	Protection Core -1				
	-	Ratio				
	-	Output Burden				
	-	Accuracy Class				
	-	ALF				
	iii)	Protection Core -2				

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
	-	Ratio				
	-	Output Burden				
	-	Accuracy Class				
	-	ALF				
	b	Transformer Bay CT				
	i)	Metering Core				
	-	Ratio				
	-	Output Burden				
	-	Accuracy Class				
	-	ISF				
	ii)	Protection Core -1				
	-	Ratio				
	-	Output Burden				
	-	Accuracy Class				
	-	ALF				
	iii)	Protection Core -2				
	-	Ratio				
	-	Accuracy Class				
	-	Minimum Knee Point Voltage at highest ratio				
	-	Maximum Excitation Current at Vk				
	-	Maximum Resistance at highest ratio				
	iv)	Protection Core -3				
	-	Ratio				
	-	Accuracy Class				
	-	Minimum Knee Point Voltage at highest ratio				
	-	Maximum Excitation Current at Vk				
	-	Maximum Resistance at highest ratio				
	c	Bus Coupler Bay CT				
	i)	Metering Core				
	-	Ratio				
	-	Output Burden				
	-	Accuracy Class				
	-	ISF				
	ii)	Protection Core -1				
	-	Ratio				
	-	Burden				
	-	Accuracy Class				
	-	ALF				
	iii)	Protection Core -2				
	-	Ratio				
	-	Burden				
	-	Accuracy Class				
	-	ALF				
	d	Sectionalizer Bay CT				
	i)	Metering Core				
	-	Ratio				
	-	Output Burden				
	-	Accuracy Class				
	-	ISF				
	ii)	Protection Core -1				
	-	Ratio				

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR				MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page		
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue		
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1	
	-	Burden					
	-	Accuracy Class					
	-	ALF					
	iii)	Protection Core -2					
	-	Ratio					
	-	Burden					
	-	Accuracy Class					
	-	ALF					
	e	Feeder Bay CT					
	i)	Metering Core					
	-	Ratio					
	-	Output Burden					
	-	Accuracy Class					
	-	ISF					
	ii)	Protection Core -1					
	-	Ratio					
	-	Burden					
	-	Accuracy Class					
	-	ALF					
	iii)	Protection Core -2					
	-	Ratio					
	-	Burden					
	-	Accuracy Class					
	-	ALF					
	25	Voltage Transformer					
		Type					
		Position of Voltage Transformer					
		Reference Standard					
		Rated Over Voltage Factor -Continuous					
		Short Time Over Voltage Factor					
		Duration					
		Partial Discharge Level					
		Thermal Rating of Primary Winding					
	26	Line & Bus VT					
	i)	Metering Core					
	-	Ratio					
	-	Output Burden					
	-	Accuracy Class					
	ii)	Protection Core -1					
	-	Ratio					
	-	Ratio					
	-	Output Burden					
	-	Accuracy Class					
	27	Enclosed Surge Arrester					
	i)	Name of Manufacturer					
	ii)	Arrester Class & Type (with mfr type designation)					
	iii)	Applicable Standard					
	iv)	Rated system voltage (kV)					
	v)	Rated Arrester Voltage (kV)					
	vi)	Max continuous operating voltage (MCOV) –(kV)					

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR			MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page	
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue	
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1
	vii)	Nominal Discharge Current (KA) with 8/20 Micro-second wave				
	viii)	Max resistive component of cont. current at MCOV-mA crest				
	ix)	Max capacitive component of cont current at MCOV - mA crest				
	x)	Long Duration Discharge Class				
	xi)	Min. Energy Discharge Capability (KJ/KV rating)				
	xii)	Max. switching current impulse residual voltage (KVP)				
	-	1000 Amps				
	-	250 Amps				
	xiii)	Pressure Relief Class KA (rms)				
	xiv)	High Current short duration impulse withstand level with 4/10 micro- second wave (KA) peak				
	xv)	Over –voltage withstand capability –KV				
	A	100 Seconds				
	B	10 Second				
	C	1.0 Second				
	D	0.1 Second				
	E	Reference Voltage (KV)				
	F	Reference Current (KA)				
	xvi)	xv Surge counter				
	xvii)	xvi Leakage monitor				
	28	Local Control Cubical				
	27	Name of Manufacturer (OEM of GIS)				
	i)	Location in GIS				
	ii)	Material				
	iii)	Sheet Thickness				
	iv)	Degree of Protection				
	v)	Padlocking arrangement				
	vii)	Major components of LCC				
	-	Bay control mimic diagram				
	-	Control Switches				
	-	Indicating lamps				
	-	Position indicators				
	-	Annunciation scheme				
	-	Auxiliary relays				
	-	Contact multiplication relays				
	-	System parameters display				
	-	Heater with thermostat				
	-	Interface terminal blocks for relaying & protection				
	29	Line to GIS connection				
	i)	Nos of XLPE cable can be terminated				
	ii)	Type of cable termination required				
	30	GIS to Transformer connection				
	i)	Nos of XLPE cable can be terminated				
	ii)	Type of cable termination required				
	31	Maintenance				
	i)	Maximum down time for replacement or removal of any part				

		DATASHEET FOR EHV GAS INSULATED SWITCHGEAR				MCDERMOTT	
Rev	Project Name	MALEIC ANHYDRIDE PROJECT	Project No.	359755	Page		
	Client	INDIAN OIL CORPORATION LIMITED	Requisition No.		Issue		
	Location	PANIPAT, INDIA	Document No.	359755-MDR-000-ELE-DAS-0001	Revision	1	
	ii)	Maximum down time for degassing and refilling the biggest compartment					
	iii)	Time between two refilling of SF6 gas.					
	iv)	Recommended period for overhauling					
	v)	Operation and Maintenance manual attached					
	vi)	Nearest local service centre					
	vii)	Minimum time of availability of local service					
	viii)	Availability of spares at local service centre					
	ix)	List of recommended spares attached?					
	x)	List of recommended special tools, etc. attached?					
	xi)	List of commission spares attached?					
	xii)	List of maintenance spares attached?					