

ELECTRICAL DESIGN BASIS

0	06.12.2007			
REV.	DATE	PREPARED BY	CHECKED BY	PREPARED BY



Onshore Engineering Services
New Delhi

PROJ: Assam Renewal Project
Job No.: OESG-AA-07-001

ELECTRICAL
DESIGN
BASIS

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ELECTRICAL DESIGN BASIS

1.0 Electrical Design Philosophy: Salient Features

The Electrical design basis broadly outlines the minimum requirements for the design, selection, sizing and installation of the electrical equipments and associated systems of the installation.

The electrical system shall be designed to ensure:

- Safety to personnel and equipments.
- Reliability of service.
- Minimum fire risk.
- Ease of maintenance and convenience of operation.
- Adequate provision for future expansion and modification.
- Maximum interchangeability of equipments.
- Automatic protection of all electrical equipments through selective relaying system.
- Fail safe features.
- Hook-up provisions with existing facilities, wherever required.
- Adequate provision for future expansion and modification.

1.1 Site Conditions

All electrical equipments and accessories / materials are to be suitable for installation and operation under dusty, humid, corrosive and hostile environment with special degree of hazards. Min / Max ambient temperatures, RH, Height from MSL and other related environmental parameters for site are mentioned elsewhere in bid package.

1.2 General Safety

The electrical system should incorporate safety margins to ensure that the installation is safe under all operating conditions, including those associated with the start up and shut down of equipment and throughout intervening shut down periods. The emphasis in equipment specification shall be on operability, prevention of accident / fault and functionality for the intended design life. All insulating materials specified for the equipment should be non-toxic.

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1.3 Fire Integrity

All cable penetrations through firewalls, switchgear room walls, control room walls, and between safe and hazardous area (from close to open or open to close) have to be sealed using multi cable transits to maintain fire integrity and prevent gas migration.

2.0 Codes and Standards

The specification of design documents, material and system performance is based upon the requirements of the latest versions of all applicable national / international standards, codes, regulations and code of practices being followed by the industries. Some of them are listed below:

IS	-	Indian Standards: Specifications and code of practices of Bureau of Indian Standards
IEC	-	International Electro Technical Council
IEEE	-	Institution of Electrical and Electronics Engineers
ASTM	-	American Society for Testing of Materials
BS	-	British Standard Institute
API	-	American Petroleum Institute
NEC	-	National Electric Code (USA)
OISD (Elect. Std.)	-	Oil Industry Safety Directorate
OMR	-	Oil Mines Regulations

The applicable specifications as drawn by the above organizations / institutions are also mentioned in the corresponding equipment standard specifications.

In the event of conflict between codes and standards being used, the most stringent one has to be followed. Where Indian standards do not exist or equipment is supplied by foreign manufacturer, relevant international standards shall be applicable.

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3.0 Degree of Protection

The degree of protection against dust and water ingress, necessary for individual electrical items is determined by the equipment duty, its environment, its location, and the hazardous area classification. The equipment located outside or subject to deluge from fire water system / rains are to be of specified weather proof construction and protected against the most adverse conditions that are anticipated. These enclosures are to be classified to IP – 55 as a minimum degree of protection, increased as necessary where the location / situation demands. Indoor equipment will be a minimum of IP – 52 protection and accessible equipment within enclosures will be a minimum of IP – 22 degree of protection. Ingress protection of IP – 42 will be considered for only indoor equipments with specific ventilation requirements.

4.0 Hazardous Area Requirements

The hazardous area classification drawings form the basis for selection of electrical equipment for various locations.

Classification of hazardous area shall be as per following (as applicable):

Oil Mines Regulations (DGMS Guidelines)

OISD	-	113
API-RP	-	500
IS	-	5572 / 5571

Incase of any conflict amongst the above, the more stringent shall be followed.

The following factors shall be considered for proper selection of equipments for use in hazardous area:

- Area classification i.e. Zone-0, 1 or 2.
- Gas group classification: The characteristics of the gas or vapor involved in relation to the ignition current or minimum ignition energy and safe gap data.
- Temperature classification: The ignition temperature of gas or vapor involved or the lowest value of ignition temperature if more than one combustible material is present.
- Environmental conditions in which equipments are to be installed: The selected

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electrical equipments shall be suitably protected against corrosive and solvent agents, water & moisture ingress, thermal and mechanical stresses as determined by the environmental conditions.

The types of protections generally used for electrical equipments in hazardous areas are as follows :

- Zone 0 - Intrinsically Safe, Type of Protection “i”.
- Zone 1 - Intrinsically Safe, Type of Protection “i”.
 - Flameproof equipment, Type of protection “d”.
 - Pressurized enclosure, Type of protection “p”
 - Sand filled equipment, Type of protection “q”.
 - Other electrical apparatus specifically designed for zone 1, “s”.
- Zone 2 - Protection as suitable for Zone-0 and 1.
 - Increased Safety protection “e”.

Electrical equipments to be used in hazardous area shall possess type test certificates from one of the following recognized testing and certifying authorities:

CMRI	:	Central Mining Research Institute.
CCE	:	Chief Controller of Explosives (Indian).
UL	:	Underwriters Laboratories Inc. (USA).
FM	:	Factory Mutual Research Corporation (USA).
BASEEFA	:	British Approvals Service for Electrical Equipment in Flameproof Atmospheres.
PTB	:	Physikalisch Technische Bundesanstalt (Germany).
RIIS	:	Research Institute of Industrial Safety (JAPAN).

All equipments falling in the hazardous area shall be intrinsically safe (type “i”), or flameproof / explosion proof (type “d”). Only in case for any application, when equipments of such protection classification are not available, other types of protections can be considered as indicated in the table below:

Zone	Type of Protection
1	p, q, s
2	p, q, s, e

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The temperature of exposed surface of any equipment (including electrical) installed in hazardous area shall not exceed the minimum ignition temperature of the gases involved, subject to a maximum of 200⁰C (Temp. Class – T3).

In addition to above, the equipments to be used in classified areas must have type test certificates from CMRI or any other testing agency as above and must also be approved by DGMS. Any other statutory approval, if required in view of Clause 5.0 of this document, will also be the responsibility of the contractor.

Besides all indigenous equipments to be used in classified areas shall have valid BIS license as required by statutory authorities. The copies of the BIS certificates with the DGMS approval certificates shall be furnished during documentation review. It is the contractor's responsibility to obtain all statutory approvals including the DGMS approval for the plant.

- NOTE:
- 1.0 Electrical equipment installation in Zone-0 area shall be avoided.
 - 2.0 Switchgear room, the outdoor switchyard, housing for emergency power generator set shall be located in safe area.
 - 3.0 Overhead power lines passing through hazardous area shall be avoided.
 - 4.0 Equipments / items installed in battery room shall be suitable for Zone – 1, Gas group – II C.

5.0 Statutory Requirements and Approvals

The designed electrical system shall conform to all statutory and government regulations. As a minimum, contractor need to meet and fulfill the requirements of following statutory Acts / regulations and obtain all statutory approvals / certificates, as required, from concerned authorities:

- Indian Electricity Act.
- Indian Electricity Rules.
- The Factory Act.
- The Mines Act (DGMS) / Oil Mines Regulations.
- Fire Insurance Regulations.
- The Petroleum Rules.

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- State Electricity Rules / Regulations laid down by Chief Electrical Inspector of State.
- Any other applicable rules / regulations of central / state / local statutory body.

Note: Special attention is to be paid to chapter X of IE rules, while designing electrical system in oil mines.

6.0 Equipment Protection

Protection system for electrical equipment shall be selected and coordinated for the protection of equipment and operating personnel against internal/external fault, over loading of equipment and other abnormal conditions such as lightning, surges etc., and to ensure continuity of operation of those parts not affected by the fault.

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 co-ordination between the electrical equipment and the protective devices shall be done in line with IS: 2165 and IS: 3716.

All protective devices, including relays and current transformers (CT's) etc. are to be adequately rated to withstand the prospective short circuit current which can flow or be induced. Wherever applicable, the relay protection devices are such that a clear indication is given of fault, which caused a trip. Circuit breakers are not able to re-close without first resetting the appropriate master trip relay.

Further the electrical system and equipment shall conform to the following amendment to Rule 116, sub rule (1) of Indian Electricity Rules:

“In the interest of safety, appropriate equipment shall be suitably placed in the mines for automatically disconnecting supply in any part of the system, where a fault, including earth fault occurs. Fault current shall not be more than 750 milli-amperes in 550V/1100V system for underground / oil fields and 50A in 3.3kV /6.6kV system in open cast mines. The magnitude of the earth fault shall be limited to those specified values by employing suitably designed, restricted neutral system of power supply.”

The following relay protections shall be provided as minimum for electrical installation.

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6.1 Transformers, Motors and Feeders Protection

RELAY (REF:- ANSI / IEEE / IEC 37.2)	TRANSFORMER		MOTOR	OUTGOING FEEDER		INCOMER	
	POWER	DISTR.	HV (650 V < HV ≤ 33 kV)	HV (650 V < HV ≤ 33 kV)	MV PMCC (250 V < MV ≤ 650 V)	HV (650 V < HV ≤ 33 kV)	MV PMCC (250 V < MV ≤ 650 V)
IDMTL O/C (51)	YES	YES	-	YES	YES (4)	YES	YES (4)
IDMTL E/F (51N)	YES (7)	NO	-	YES	YES (4, 8)	YES	YES (4,9)
BACK UP E/F (51N) (SECONDARY SIDE NEUTRAL)	YES	YES	-	NO	NO	NO	NO
MOTOR PROTECTION RELAY WITH LOCKED ROTOR FEATURE (50, 51, 50N, 46, 49, 50L/R)	NO	NO	YES	NO	NO	NO	NO
INSTANT. REST.E/F SECONDARY SIDE (50N)	YES	NO	-	NO	NO	NO	NO
INST.O.C (50)	YES	YES	-	NO	NO	NO	NO
INSTANT.EF. (R) (50N)	YES (6)	YES	-	NO	NO	NO	NO
DIFF. PROT.(87)	YES (1)	NO	YES (2)	YES (3)	NO	NO	NO
TRIPPING RELAY (86)	YES	YES	YES	YES	YES (4)	YES	YES
TRIP CKT SUPERVISION (95)	YES	YES	YES	YES	NO	YES	NO
TFMR AUX. RELAY (63TX)	YES	YES	-	NO	NO	NO	NO
UNDERVOLTAGE WITH TIMER (27,2)	-	-	YES	-	-	YES (5)	YES (5)

Note:

- (1) For transformers rated 5 MVA and above.
- (2) For motors rated 1500 KW and above.
- (3) For critical / long feeders.
- (4) These relay functions can be substituted by inherent releases.
- (5) Wherever Auto-transfer feature is provided.
- (6) Provide INST E/F 50N for transformers with primary delta.
- (7) Provide IDMTL E/F 51N for transformer with primary star.
- (8) MV outgoing feeders and motor starters shall be provided with sensitive earth leakage protection. ELCB shall be used for all feeders up to 63A rating and motor starters up to 7.5KW rating. For rating higher than these CBCT and Earth leakage relay and timer along with indication lamps shall be provided.
- (9) MV incomers shall be provided with CBCT operated sensitive earth fault protection with time delay.
- (10) CBCT ratio shall be selected to suit earth leakage relay setting range. CBCT and relay setting shall be suitably selected to achieve required sensitivity as per OISD norms.
- (11) Sensitive earth fault relay with built-in adjustable timer with suitable settings to achieve required sensitivity shall be provided in transformer secondary neutral circuit.
- (12) Suitable neutral displacement relays along with necessary PTs (with open delta windings) also be provided to sense earth fault in the system and give alarm / indications.
- (13) Contactors units used as MV (up to 650 volt) motor starters incorporate the following protective devices:
 - MCCB for short circuit.
 - Earth fault protection as per scheme for feeder protection as per note-8 above.
 - Over load relay with built-in single phase preventor.
- (14) Motors rated 75 kW and above shall be provided with motor protection relay.

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6.2 Generator Protection

The protections generally used for generators are as under. However the actual protective requirements shall vary from case to case, depending on the rating, excitation system, operation, type of prime mover etc.

- 87 G- Differential protection (For ≥ 1500 kW)
- 51 N- Stator earth fault
- Rotor earth fault
- 51V- Voltage controlled over current
- 32- Reverse power (For parallel operation)
- 40- Field failure
- 46- Unbalanced loading protection (Negative sequence)
- 49 T- Stator winding temperature protection (For ≥ 500 kW)
- 81- Under/over frequency protection
- Over / under voltage protection
- 86 Lock out relay

When generator with unit transformer is employed besides individual equipment protection, the following additional protections are required:

- i) Transformer over-fluxing protection.
 - ii) Overall generator unit transformer differential protection.
- In installations where generator is operating in parallel with grid, special protection such as out of step relay shall be required.

6.3 Capacitor banks Protection

The protective requirements of HV capacitors provided for power factor correction are as follows.

- IDMTL over current for protection against short circuits.
- Instantaneous earth fault.
- Neutral phase displacement.
- Under / Over voltage.
- Fuses for individual capacitor units (internal element fuses and external expulsion type fuses).

The capacitor bank feeders shall generally be tripped on bus under / over voltage

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conditions and necessary interlock shall be provided for re-switching to take care of capacitor residual voltage.

MV capacitors of smaller ratings shall be protected with MCCBs. Capacitor banks above 125 kVAR shall be protected by ACB. Feeder to capacitor panel at PMCC shall have protections like IDMTL O/C, IDMTL E/F, & Trip Relay.

The continuous current rating of fuses and switching devices for capacitors should be 30 % higher than the normal full load current.

6.4 DC Feeders (110V DC, 24V DC) Protection

MCCBs / MCBs used for DC incomer feeders and DC distribution feeders are to be provided with short circuit and overload protection as a minimum.

7.0 Earthing & Lightning Protection

Earthing system shall cover the following:

- Equipment earthing.
- System neutral earthing.
- Static electricity protection.
- Lightning protection.

7.1 An earthing system as per IS 3043 shall be installed in each plant area for system neutrals, all electrical equipments and steel frame buildings. Each earthing system shall consist of G.I. pipe electrodes, G.I. earthing flats of sizes as required in a common loop to interconnect all earth rods. All major structural steel, stacks, vessels and process equipment likely to become charged with static electricity shall be solidly connected to the earthing system. The overall resistance of earth grid shall be less than 1.0 ohm. Soil resistivity survey shall be carried out by the contractor for design of earth grid. The earth network conductor shall be sized to carry maximum earth fault current without undue rise in temperature. All electrical equipments shall have two separate & distinct connections to earth grid.

7.2 Lightning protection system shall be provided for equipment, structures, Tankages (Existing & New) and buildings as per OISD std.180 and IS 2309 with independent earthing system of earth resistance less than 5 ohms.

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Lightning protection with independent earthing system shall be provided for oil storage tanks and separator vessels by use of lightning protection masts around such storage tanks and separator vessels as per OISD 180.

The lightning protection network shall be bonded with the main earthing network below ground, minimum at two points.

7.3 For HV system each lightning arrestor shall be connected to a separate copper plate earthing located as close as possible to it and within the fenced area of each set of arrestors. The three numbers of earthings for each set of arrester shall be spaced about 5 meters apart so that they are all within the enclosing fence. Each of these earthings shall be interconnected.

7.4 An earthing schedule giving the type / sizes of earthing conductors for different equipments is given below. Required sizes for earthing conductors shall have to be established by design calculations. The sizes given below are indicative and minimum only.

TYPE OF EQUIPMENT	BARE GI WIRE/GI WIRE ROPE OR GI STRIP
MOTORS UPTO 3.7KW	6mm DIA. WIRE ROPE
MOTORE 5.5KW TO 30KW & WELDING RECEPTACLES	10mm (3/8") DIA , WIRE ROPE
MOTORS ABOVE 37KW INCLUDING HT MOTORS	16mm (5/8") DIA, WIRE ROPE
BUILDING COLUMNS	40mm X 5mm STRIP
STORAGE TANK (VERTICAL & HORIZONTAL)	40mm X 5mm STRIP
LOADING RACKS	40mm X5mm STRIP
PIPE RACKS VESSELS & HEAT EXCHANGER	10mm (3/8") DIA, WIRE ROPE
SMALL EQUIPMENTS & INSTRUMENTS	NUMBER 8 SWG SOLID
LIGHTING POWER & INSTRUMENT PANELS	10mm (3/8") DIA, WIRE ROPE
MAIN EARTH BUS / LT & HT SWITCHGEAR INTERCONNECTIONS/ POWER TRANSFORMER	AS CALCULATED
EHV & HV SUBSTATION	AS CALCULATED
PUSH BUTTON STATIONS	NUMBER 8 SWG SOLID
STREET LIGHT POLES / HIGH MAST LIGHT TOWER	10mm (3/8") DIA , WIRE ROPE

LIGHTING TRANSFORMERS	16mm (5/8") DIA, WIRE ROPE
LIGHTNING PROTECTION DOWN CONDUCTOR	40mm X 5mm G.I. Strip

8.0 Electrical Loads

Load Classification:

Electrical loads are classified as Normal, Emergency and Critical.

- Normal - Loads in service for full production application.
- Emergency - Loads required for utility services (including UPS, DC supply system), complete lighting, critical loads for process, plant and personnel safety in case of failure of grid / SEB supply.
- Critical - Critical Lighting and instrument / control power requirement in case of failure of emergency generator set.

Utilization Category:

Electrical loads are divided into following three classes according to use:

- Continuous Load - Which draws power at continuous rate.
- Intermittent Load - Which draws power as per duty cycle for short duration.
- Stand-by Load - Which is connected with power supply and ready to act as and when required.

Load Assessment:

All electrical loads are to be developed by the contractor based on estimated load identified in the equipment list. The data sheet should specify maximum power requirement. In evaluating load summary, utilization category is applied as following:

Total Load:

- i) Continuously Operating Equipment - 100 % of operating load
- ii) Intermittent Load - 50 % of the total intermittent load or the largest intermittent load whichever is higher.
- iii) Stand-by Equipment - 10 % of total 'stand-by' load or largest stand-by load, whichever is higher.

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- iv) Margin for Future Load Growth - 10 % of estimated load {i.e. sum of i), ii) and iii}).

The total load for sizing of transformers and TGs shall be sum of i), ii), iii) and iv).

9.0 Generation and Utilization Voltage Levels

Power:

Existing power supply to individual installations is availed from 33/11 kV sub stations of CPPs (Captive power plants) located at Lakwa, Geleki and RDS through overhead lines / UG cables. Otherwise for isolated installations power supply is availed from state grid generally at following voltage levels. Under This Bid captive power plants to meet the full power requirement is envisaged without any back up from SEB.

Main TG Voltage : 11 KV Nominal

Frequency : 50 Hz $\pm$ 3%.

Emergency Generator Voltage : 415 V, 3 Φ , 50 Hz.

Utilization / Distribution Voltage Levels:

11/kV	: Large motors in plant and overhead transmission
440 / 415 Volts	: Plant distribution .
240 V, AC (phase to phase)	: Lighting as per DGMS guidelines.
240 V, AC (phase to phase)/110V DC	: Switchgear control supply.
240 V, AC 1 Φ , 50 Hz	: Anti condensation space heaters, convenience outlets.
110 V DC, 2 wire (Battery back-up)	: Critical & Exit lights for 1 hour duration, Generator, Breaker Controls / Instrument supply etc.
24 V DC, 2 wire (Battery back-up)	: Instrument supply, Fire and Gas detection system etc.
240 V AC, UPS	: Communication, Instrument control, Process control, Distributed Control

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System etc.

: SCADA / As Applicable.

The short circuit levels for all voltage levels shall be calculated and systems shall be accordingly designed.

10.0 Electrical Equipment / Product / Material Selection Philosophy

All components of electrical system shall be sized to operate under maximum load at the most severe operating conditions with additional safety margin. All electrical equipment / product / material (viz. motors, transformers, switchgears, distribution systems, cables etc.) offered by the vendor shall be as per relevant standards, specifications, new and unused, of current manufacture and the highest grade and quality available for the required service and free of defects. The equipment is to be protected from construction damage and damage in transportation, storage and damage due to sandblasting and painting.

The selection of electrical equipment / product / material is generally based on the following factors:

- Electrical Design Basis / Criteria and Standard Specifications in respect of each individual equipment.
- Applicable Standards, Codes & Recommended Practice.
- Reliable and trouble free performance for designed life of the installation.
- Safety
- General Operating / Site Conditions.
- Hazardous area classification.
- Statutory Regulations.
- Suitability for the specified requirement for use in outdoor and indoor locations.
- Suitability for the corrosive effects of the saline and humid and extremely dusty atmosphere.
- All electrical equipments shall be suitable for installation in hot and humid

tropical environment (50°C temperature and maximum 90% RH for design).

Note: Equipment / Switchgear rating indicated anywhere in the bid specification shall be considered as minimum. Exact rating shall be decided by contractor based on actual design calculations plus 10% spare capacity (if spare capacity is not specifically mentioned).

11.0 Specific requirements for Equipments & Associated Components

11.1 Outdoor Switchyard

- Isolators : Pole mounted, 3 Φ , Gang operated, horizontal/ Double break type; Manual Operation.
- Earth switch : Gang operated vertical break, manual operation.
- Lightning Arrestors : Non-linear, Gapless Metal Oxide; Vertical, pedestal mounting with insulating base, Line discharge class 3.
- Insulators : Post insulator, solid core, type 'A'.
- Current transformer } : Pole mounted outdoor type, duly tested and
Voltage transformer } certified by SEB. The transformers are to be oil -
& Tri-vector meter } immersed type.

11.2 SUB STATION

- HT switchgear : Indoor, 3.3 / 6.6 / 11 / 22 / 33 KV, SF6 / Vacuum Circuit Breaker panel
- Transformer : Delta/Star, 3-phase
(power / distribution) In door, cast resin dry type.
- LT Switchgear : Indoor.
- Incoming C.B. (LT) : ACB (4 – pole).
- System : Complete system to be grounded as per the statutory requirements.
- Transformer : Indoor, 415 V / 240 V; Delta/Star, 3-phase,
(Lighting) Up to 100 kVA - Non-encapsulated winding
(Vacuum resin impregnated dry type)

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Above 100 kVA- Encapsulated winding

(Cast resin dry type)

Natural air-cooled type.

Insulation: F–up to 100 kVA; H–above 100 Kva

Two nos. of lighting transformers are required for each installation. Each lighting transformer shall be sized to take care of the total lighting load of the plant with a provision for 10% extra capacity. Lighting system of the complete installation shall be as per DGMS guidelines as detailed later. Lighting transformers with the MLDB(s) shall be located inside the MV switchgear room.

The substation building shall be sized to take care of all the present and future requirements and to maintain adequate clearances between equipments for ease of maintenance. A margin of at least 25% space shall be kept in switch gear rooms and battery rooms for future expansion. HV/MV switch boards shall have provision for future extension from both ends. The following minimum clearances around various equipments and panels shall be maintained:

- a) Front clearance for switchboard/ panels
 - 2500 mm
(HV Switch Board)
 - 2000 mm
(MV Switch Boards/ others)
- b) Rear clearance for panels requiring maintenance from rear
 - 1500 mm
(HV Switch Board)
 - 1000 mm
(MV Switch Board)
- c) Rear clearance for panels having access from front only
 - 750 mm

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- d) Side clearance between two switchboards
or from nearest obstruction - 1500 mm
- e) Battery rack to rack clearance - 750 mm
- f) Battery rack to wall / clearance - 750 mm
- g) Front clearance for wall mounted equipments - 1000 mm
- h) Front clearance for operator station/
annunciation / control panel - 2500 mm
- i) Head room clearance for overhead
equipments - 2000 mm

Vertical clearance above the top of the highest equipment shall be minimum 1500mm from roof slab. For areas with false ceiling minimum clearance of 750mm shall be provided between top of the equipment and the false ceiling.

11.3 PMCC / MCC / Switchgears

All panels shall be single / double front, fully draw-out type. Compartments shall be capable of withdrawing to a test position. This test position isolates the power cables to allow the live commissioning of control circuit.

The MV switch boards are provided with a minimum 20% fitted spare motor starters and feeder modules (subject to minimum 01 of each rating and type).

Each starter unit have component designed for Type – 2 co-ordination as per IEC / IS – 13947. All load feeders shall be provided with earth leakage protection.

For the PMCC, feeders for more than 400 ampere rating shall be provided with ACB. Feeders up to 400 ampere rating shall be provided with MCCB. All lighting / auxiliary / power panel main incomers will be MCCB. All lighting sub-distribution board incomers up to 63 amperes shall be MCB and beyond 63 amperes MCCB shall be provided. Bus bar and isolating devices are rated at 125% of total design load. Bus bars are generally identified as R, Y & B with phase coloured as red, yellow and blue. All the switchgears are industrial grade equipment installed in freestanding sheet metal cubicles of modular design. All the switchgears are to be installed in a

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closed naturally ventilated room.

All equipment and switchgear ratings are decided based on actual design calculations (actual requirement) and 10% spare capacity (if spare capacity is not particularly mentioned).

Cable entry to all panels of H.T. & L.T. switchgear and control panels shall be from bottom.

Bus coupler switch gear rating shall be higher of the following:

- Largest incoming breaker
- Maximum load on either side of bus section
- Maximum of current rating of bus- bars on either side of coupler.

Switch board components such as breakers, MCCBs, horizontal and vertical bus bars shall be designed to withstand design fault current or maximum fault current at the point of installation, which ever is higher for a minimum period of 1 sec.

11.4 MV Incomers

Incomer feeders shall be withdrawable, four pole, air circuit breakers with charging motor, spring release and close mechanism. Breaker close / trip solenoid are fed through 110 Volt D.C. There shall be three positions for the draw out trolley, “Full-in”, “Test” and “Full-out”.

11.5 Power Factor Control

Switched capacitor banks with automatic power factor correction relay shall be provided in all installations to improve the power factor. Capacitor banks shall be provided at MV (415 V) and / or HV panels, as per requirement and shall be sized in order to arrive at over all power factor up to 1.0 at each installation. The capacitors impregnation shall be non toxic, non PCB (poly chlorinated biphenyl) type and bio degradable.

HV Capacitor banks

The banks of ungrounded star connected capacitors shall be mounted out door at least 2.75 meters above ground. Capacitor banks shall be supplied with series reactor and RVT. Series reactors shall be designed to limit in rush current and to suppress harmonics. The banks shall be switched on by vacuum switches with back

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up protection of VCB. Microprocessor based automatic p.f. correction relay shall also be provided for control.

MV Capacitor banks

415 V, indoor type, delta connected capacitor bank for p.f. control complete with over voltage protection, microprocessor based automatic p.f. correction relay and switching contactors.

Capacitor units shall be dry type, mixed di-electric, low loss, long life with over pressure protection device.

11.6 Motors

All the motors required by mechanical packages shall meet the requirement of relevant National / International standards. The voltage ratings for motors shall be as below:

Rated Voltage in kV (U_N)	Minimum rated output (kW)
415	≤ 160
$3.3 \leq U_N \leq 6.6$	> 160 and < 1000
$6.6 \leq U_N < 11$	≥ 1000

Also all electric motors installed outdoor shall meet the criteria for the hazardous area requirement and the below mentioned criteria in addition to the standard specifications and data sheet for same:

Enclosure : TEFC (totally enclosed fan cooled) with IP-55.

Insulation : Class "F" with temperature rise limited to Class "B".

Starting : Requirement of starters shall depend on SEB regulations. Generally for MV motors Direct on line starters for motors rated below 45 KW & reduced voltage starters for motors rated 45 KW and above shall be required. Starters for HT Motors to be fed from CPP shall be of DOL type.

Space heater : For motors rated 15 KW or above.

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Control : A local / remote selector switch shall be provided to enable field starting of motors from local control station. MCC shall be provided with stay put type of stop button.

Starting torque and minimum torque of the motor shall be compatible with the speed torque curve of driven equipment under specific operating conditions. For DOL start applications, HV motors shall be suitable for starting with 80 % of the rated voltage at the terminals and MV motors with 75 % of the rated voltage at the terminals. For heavy duty drives such as reciprocating compressor, agitator, crusher etc. high starting torque motors (minimum 150 % of rated torque) shall be provided to limit starting current and time.

11.7 UPS & DC Supply

UPS and DC supply shall be provided as per project requirement. Separate battery room is to be provided in all switch gear rooms. Generally, the following shall be required:

11.7.1 UPS (for communication, Instrumentation and Control application)

Input : 415 Volts $\pm$ 10%, 50 Hz $\pm$ 3%.

Output : 240 Volts (AC), 1-phase.

Type : Parallel redundant with bypass.

Back up time : 2 hours for full rating of UPS.

Battery type : Sealed Maintenance Free (SMF), VRLA

Capacity : To be decided during detailed engineering (spare capacity of 50 % is to be provided).

11.7.2 UPS (for SCADA application)

Input : 415 Volts $\pm$ 10%, 50 Hz $\pm$ 3%.

Output : 240 Volts (AC), 1-phase.

Capacity : 5 KVA (Min.)

Type : Parallel redundant with bypass.

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Back up time : 04 hours for full rating of UPS.

Battery type : Sealed Maintenance Free (SMF) VRLA

11.7.3 DC supply

DC supply system shall be provided with charger, SMF batteries, Lead acid and DC distribution board. DC supply shall be sized during detail engineering.

a) Output : 110V DC (1 hour battery back up)

To cater to specialty lighting, i.e. critical and exit lights, breaker controls / instrument supply etc.

b) Out put : 24V DC (2 hour battery back up)

To cater to instrument / control supply, Process and control PLC, Fire and Gas detection system etc.

c) Output : 24 V DC

To cater to the starting requirement of Emergency Gen. sets, Fire water pumps.

11.8 a) Emergency Generator

Emergency generator driven by battery started diesel engine with AMF panel shall be provided in all installations. The electrical loads to be fed by emergency generator shall consist of the following as minimum:

- Complete lighting load.
- All utilities including air compressor, UPS, DC battery and charger system, Potable water, Service water, Bore well water, etc.
- Fire fighting equipment including jockey pump but excluding main fire water pumps
- Diesel fuel handling / transfer system
- Loads critical for process (as defined in basic bid work), plant and personnel safety
- Loads essential for safe shut down of the plant

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- Instrumentation and communication systems.
- Process Loads of installations as mentioned in Power system Philosophy Annexure- II, enclosed elsewhere in the bid package.
- 10 % margin for future expansion shall be considered while sizing the generator set.

b) Gas engine Generator for installations fed by ASEB supply

Gas engine generator shall be sized to meet full power requirement of the installation as follows.

- i) Continuously Operating Equipment - 100 % of operating load
- ii) Intermittent Load - 50 % of the total intermittent load or the largest intermittent load, which ever is higher

The total load for sizing of generator shall be sum of i), ii) and additional 10% margin for future.

12.0 Cables & wires

HT power cables shall be armored, heavy duty, XLPE insulated, with copper conductor, ISI marked & conforming to DGMS requirement.

All LT power cables shall be armored, heavy duty, XLPE insulated with copper conductor, ISI marked & conforming to DGMS requirements.

Control cables shall be of copper conductor, heavy duty, armored, XLPE insulated, ISI marked & conforming to DGMS requirements.

All the above cables are indented to be used in mines and shall accordingly be identified on outer sheath as per IS.

Cable entry:

HT Switchgear : Bottom
 LT Switchgear : Bottom
 Control Panels : Bottom

Voltage Rating:

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The voltage rating of cables shall be as follows –

- High Voltage Cables : 3.3 / 6.6 / 11 / 22 / 33 KV (as required)
- Power and Control Cables : 1100 / 600 V
- DC Cables : 150 V DC

Cable sizing:

During detailed engineering all power and control cables are to be identified and sized according to the requirements of Indian and International standards. The sizing calculation takes into account the following factors:

- System Voltage
- Connected Load
- Current Carrying Capacity
- Voltage Drop
- Short Circuit withstand criteria
- Laying conditions

Wherever possible, power cables and control cables are to be routed separately or with adequate spacing to minimize the effects of de-rating.

De-rating of cables due to ambient air temperature, ground temperature, grouping & proximity of cables, method of laying (air / underground), thermal resistivity of soil etc. shall be taken into account. De-rating factor of 0.6 or less shall be considered for sizing of all cables.

The minimum value of oxygen index for cables shall be 29 at $27 \pm 2^{\circ}$ C. The flame retardance properties shall meet the requirements of IS – 7098 (1994) applicable to C1 category of cables for all power and control cables (up to and including 1100 Volts).

All cables shall be without intermediate joints. The cable sizes selected shall meet the following requirements of voltage drops.

Voltage drop:

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The maximum allowable voltage drop in any feeder under steady state condition at full load is to be maintained as follows –

- Between transformer secondary and HV Switchboard or PCC / PMCC - 1 %
- Between HV Switchboard and HV Motor - 3 %
- Between PCC / PMCC and remote MCC / Auxiliary Switchboard - 2 %
- Between PCC / PMCC and Motors - 5 %
- Between remote MCC and Motors - 3 %
- From lighting transformer to MLDB in Substation - 0.5 %
- Between MLDB and remote lighting panels - 2.5 %
- Between Lighting points and Lighting panels - 2 %
- DC system - 3 %
- The voltage drop at the worst affected pre-loaded bus is not to exceed 15% of nominal voltage during start-up of the largest HV motor and 10% of nominal voltage during start-up of the largest MV motor.
- The voltage available at motor terminals during start-up is to be sufficient to ensure positive starting and acceleration or reacceleration to full speed by the motor (even with motor in fully loaded condition, if required) without causing any damage to the motor. However, under no circumstances, the voltage at motor terminals during starting or reacceleration is allowed to fall below 80% of the nominal voltage for HV motors and 75 % of nominal voltage for MV motors.
- Cables for capacitor banks shall be sized for 143% of the rated capacitor current.

Minimum cross section of cable conductor:

- MV Power Cables : 2.5 mm² (copper)
- MV Control Cables : 2.5 mm² (copper)
- Lighting : 3 x 2.5 mm² (copper)

One core shall be left as spare in control cables having up to 5 cores. From 7 cores upward about 20% or minimum 2 cores shall be left as spare for future use. Control wiring of the panels shall be carried out with flexible, 1.1kV grade, PVC insulated, switchboard wire with stranded copper conductor of 2.5 mm². For connecting relay instruments, 1.5 mm² copper conductors will be acceptable.

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For lighting circuits of non-industrial buildings following sizes of copper conductor, PVC insulated wire shall be used in concealed PVC conduit system with 2-pole MCBs:

- For circuit wiring : Minimum 2.5mm².
- For point wiring : Minimum 1.5mm²(for 5amp. points).

For Air-conditioner machine circuits 4.0mm² (Copper conductor) PVC insulated wire shall be used.

Cable Glands and Multi Cable Transit (MCT) Frames:

Suitable size double compression type glands are supplied for all cables. For entries into Ex(d) enclosures, barrier type (or compound filled) glands are provided. All cable glands and adaptors are made up of nickel plated brass and are fitted with soft sealing nylon washer. Fiber washers are not to be used. Lock nuts are used for entry into sheet steel boxes enclosures.

Industrial cable glands are not used on oil / gas installations. All cable glands are to be type tested and certified by appropriate authorities for use in specified hazardous area.

Cable transit frames are to be fitted where cables pass through outdoor trays / trenches indoor areas or vice-versa.

Such cable transit frames are designed to include 25 % spare capacity for future use. Cable transit frames are to be supplied with test certificates from an accredited independent test authority to confirm adequate fire rating for areas where they are to be installed.

13.0 Cable support system

All the cables in outdoor areas shall be laid in FRP cable trays as stipulated in the specification for cable erection in the bid package. All enclosed / paved/ inside areas shall have RCC lined cable trenches with FRP cable trays. The cabling system shall be reviewed and finalized during detailed engineering. For underground cables the road crossings shall be made by drawing the cable through ERC (RCC Pipes embedded in PCC) as detailed elsewhere in the bid package. The cabling shall include the following:

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- a) Complete cable trays, supports, rack-risers, ducts, trenches and area cabling for all the equipments / loads, termination kits, glands, lugs, markers, tag plates & etc.
- b) The cable trays, racks & trenches shall be sized to allow for 20% future cables.
- c) Special care is to be taken to the routing and separation of cables to minimize the effect of fire on emergency and essential supplies and production operations. Intrinsically safe circuit cables run in separate trays. Instrument and communication cables shall not be laid along with the power cables. Cabling for fire water system shall be as far as possible taken in exclusive route through underground trench.
- d) In addition the minimum distance between power / control wiring and electronic signal wiring on prolonged cable route will be as follows:

<u>Power / Control cable</u>	<u>Minimum distance from electronic / signal cable</u>
Up to 125 V	150 mm
Up to 300 V	150 mm
Up to 1000 V	300 mm
Above 1000 V	450 mm

- e) Cable ladders / trays are to be manufactured from FRP material with UV protection features. They are heavy duty type having loading criteria, fire withstanding capacity and other properties as detailed in standard specification for FRP cable trays.
- f) The overhead cable trays are installed a minimum 2700 mm. (minimum) above grade level. At road crossings overhead trays shall be installed at 7000 mm. (minimum) above grade level.

14.0 Lighting system

The plant lighting system shall be fed by the lighting transformer. The lighting system includes all lighting fixtures, lamps and complete accessories / associated equipment required for lighting of outdoor / covered / indoor areas (e.g. pump houses, dosing

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sheds, storage sheds, laboratory, instrumentation, control room, electrical substation rooms, office complex, gate cabin etc.) of the installation including DC critical lighting in the compressor / pump houses, sub-station, control room etc. and all escape routes as required.

For illumination of the complete outdoor area (e.g. open area, street lighting etc.) coming under each plant area, motorized flood lighting high mast(s) (20 mtrs high approximately) shall be provided. Each high mast shall have minimum 12 nos. of 2 x 400W HPSV fixtures. The number of fixtures in each mast including mast's exact location shall be worked out during detailed engineering.

The dark areas / shadows shall be illuminated with suitable street light / floodlight fixtures.

The type and exact number of fixtures required for different locations shall be worked out during detailed engineering and shall fulfill the minimum illumination level criteria.

The fixture selection (i.e. flameproof / non-flameproof) shall be based on the area classification. Outdoor fittings in safe areas shall be of weather proof (i.e. IP 55) construction. Corrosion resistant fixtures will be provided in places like chemical storeroom and battery room.

A maintenance factor of 0.8 shall be considered for all illumination level calculations.

All ballasts shall be low loss type with copper winding and power factor improvement capacitor.

The lighting fixtures of various circuits shall be suitably interlaced so that failure of one circuit does not result in complete darkness.

Depending upon operational requirements, minimum illumination levels shall be as follows:

Illumination in lux

Roads	20
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Process Areas:

Pump houses, dosing shed etc.	100
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Main platforms for operation and access stairs	60
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Other process areas (pipe racks, injection manifold, filters, tanks, dosing system etc.)	60
Injection Pump Shed	100
Compressor area	200

Non-Process Areas:

Laboratory	400
Control room	400
Electrical switch room, DG room, UPS /	
Charger and battery room	200
Transformer bay, outdoor switchyard	100
Cable cellar	70
Loading-unloading area, Tube-well area	100
Fire water pump house	150
Tank farm area	20
Pipe rack area	60
Flare area	60
Injection header	60
Raw water tank area	60
Lube oil / Grease store	100
Office	300
Stairs / corridors	70
Change rooms, garage etc.	100
Gate cabin & entrance	100

Residential Area:

Living area, Toilets	100
Recreation room	200
Canteen	150

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Under normal operation the above lighting shall be fed by normal power source on 240 V AC supply (SEB or D.G. set supply through lighting transformer). Upon failure of both of above supplies the Critical lighting system will come into function. The minimum illumination level requirements for critical lighting are as below:

i) Near to areas where specific safety operations (visual tasks) are to be carried out (e.g. control room, sub-Stations, D.G. shed, F. W. / crude oil pump house etc.) Spot lighting : to be provided.

ii) Escape Lighting

- a) Escape way (interior) : 10 Lux
- b) Areas at exit door and at points where it is necessary to emphasize the position of potential hazard, if any. : 30 Lux
- c) Other notified general outdoor areas. : 10 Lux

Taller structures shall have aviation obstruction lighting as per statutory regulations (D.G.C.A.).

15.0 DGMS GUIDELINES FOR LIGHTING SYSTEM

The oil and gas installations come under DGMS (OMR) jurisdiction; hence the lighting system shall be as per DGMS (OMR) requirements given below.

Oil Mines Regulations, 1984 state that the lighting systems installed in the mine shall comply with the provisions of the Indian Electricity Rules, 1956. Indian Electricity Rules indicate additional precautions to be adopted in mines and oil fields. Additional precautions for oil mines state that wherever electric lighting is used; the voltage between phases shall not exceed 250 V if the neutral of the system is connected with earth.

Lighting system shall be maximum 250 volts, 3-phase, 3-wire system with lighting equipment connected between phases. It would also be essential to control all lighting through-two-pole switches.

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In order to comply with the above statutory requirements, the lighting system for the installations in oil mines under the jurisdiction of DGMS shall be designed on the following basis:

- a) Phase to phase voltage in the lighting system shall be limited to maximum of 250 V.
- b) Lighting transformers shall be 415 / 240 V, three phase delta-star connected with neutral point of secondary connected to earth and taps of $\pm 5\%$ and $\pm 2.5\%$ on primary.
- c) Further distribution from lighting transformers to MLDB and LDBs shall be at a voltage of 240 V, 3-phase (3-wire system without neutral).
- d) All lighting distribution boards and lighting panels shall have three phase buses rated for 240 V, 3-phase and shall be without neutral bus.
- e) Outgoing circuits from lighting panels shall be controlled by 2 – pole MCBs. Earth leakage protection shall also provide isolation in both poles.
- f) All lighting fixtures and equipments shall be connected between two phases at a voltage 240 V phase to phase.
- g) Incase of lighting of building within the plant premises, double pole switches or 2-pole MCBs shall be used in the lighting circuits instead of conventional single pole switches.
- h) All 240 V, 1-phase sockets in plant area as well as in buildings shall also be connected between phases at a voltage of 240 V phase to phase and controlled by 2-pole MCBs or double pole switches.

16.0 Corrosion / Abrasion

For outdoor locations, corrosion / abrasion resistant materials are considered for electrical equipment. As a minimum material / equipment requirements are as follows:

- Cable ladders and trays are to be of composite fiberglass reinforced plastic and UV protected.
- Associated accessories shall be of SS – 316.

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- Explosion proof junction boxes, light fittings, control stations etc. are to be manufactured from copper free cast aluminum alloy (LM – 6) with an epoxy finish.
- Cable glands should be of nickel plated brass or equivalent.
- All metal surfaces for all equipments and panels shall be painted after proper surface finish

The painting procedure to be followed for all equipments and panels is as described below:

All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any traces of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finished coat. After preparation of the under-surface, the panels shall be spray painted with two coats of epoxy-based final paint or shall be powder-coated. The colour shade of the final paint shall be shade 631 (light grey) as per IS-5. Spray-painted finished panels shall be dried in stoving ovens in a dust-free atmosphere.

- All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust and corrosion. All hardware shall be corrosion resistant. All joints and connections of the panel members shall be made of galvanized, zinc passivated or cadmium plated, high tensile strength steel bolts, nuts and washers, secured against loosening.

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