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**OIL & GAS DEVELOPMENT COMPANY LTD.****KPD-TAY INTEGRATED DEVELOPMENT PROJECT PHASE-II****ELECTRICAL DESIGN BASIS**

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1.0 **INTRODUCTION**

Oil and Gas Development Company Limited (hereinafter called “COMPANY”) intends to undertake Kunnar/ Pasakhi Deep and Tando Allahyar Integrated Development Project (PROJECT). The objective of the PROJECT is to construct a gas processing facility to process raw gas from Kunnar/ Pasakhi and TAY gas fields located in Hyderabad District about 25 km away from Hyderabad city, Sindh Province of Islamic Republic of Pakistan and to supply processed sales gas to Sui Southern Gas Company Limited and to extract LPG as a product. The Gas Processing Plant will be constructed adjacent to COMPANY’S existing LPG plant.

PROJECT comprises of Wellhead facilities, Gas Gathering System and Gas Processing Plant. The gas processing plant shall be capable of handling and treating 250 MMscfd raw gas and the associated Sales Gas, Condensate, LPG and Produced Water etc.

1.1 **Scope**

This section defines the minimum requirements for the design of electrical power generation and distribution system for the Wellhead Facility, Gas Gathering, Gas Processing Plant and Sales Gas Pipeline for the Kunnar / Pasakhi Deep and Tando Allahyar Integrated Development Project named as KPD -TAY Integrated Dev. Project.

1.1.1 **Abbreviations and Definitions**

▪ COMPANY	:	OGDCL
▪ PROJECT	:	KPD-TAY INTEGRATED Dev. Project
▪ GPP	:	GAS PROCESSING PLANT
▪ SOW	:	SCOPE OF WORKS

2.0 **CODES AND STANDARDS**

All codes, standards and regulations mentioned below shall be of the latest revision in force on the date of the contract agreement.

2.1 **Electrical Standards**

The following codes and standards shall apply:

- IEC The International Electro technical Commission.
- IP The Institute of Petroleum.
- IEE The Institution of Electrical Engineers (UK).
- BSI British Standards Institute.
- API American Petroleum Institute.
- NFPA National Fire Protection Association (USA).
- ISO International Organization for Standardization.
- Local Codes & Standards where applicable.

Other codes & standards may also be acceptable subject to approval of the Company.

2.2 **Instrumentation and Control Standards**

For equipment fabrication, I&C designing, installation, and operation the following codes and standards shall be used:

- ISO/IEC International Standard Organization / International Electro Technical Commission.
- ISA Instrumentation, Systems and Automation Society.
- IEEE Institute of Electrical and Electronics Engineers (USA).
- ANSI/TIA/EIA American National Standard Institute / Telecommunication Industry Association / Electronic Industries Alliance (USA)
- CENELEC European Electro technical Standardization Committee.
- EN European Norms.
- ITU-T International Telecommunication Union-Telecommunication
- ITU-R International Telecommunication Union – Radio.
- API American Petroleum Institute.
- BSI British Standards Institute (UK).
- DIN Deutsche (German) Industrial Standards.
- NFPA National Fire Protection Association (USA).
- IP Institute of Petroleum.

Other local Codes & Standards may also be applicable with prior approval of Company.

2.3 **Environmental Standards**

2.3.1 Codes and legislative Requirements.

The following codes and standards shall apply:

- PEPA-1997 Pakistan Environmental Protection Act-1997.
- Guidelines for Operational Safety, Health and Environmental Management (Director General of Petroleum Concessions, December 1996).
- NEQS 2001 National Environmental Quality Standards (Self Monitoring and reporting by industries), Rules, 2001.
- Sectoral Guidelines for Environmental Reports-Oil and Gas Exploration and Production Pakistan Environmental Protection Agency under PEPA, 1997.

3.0 **SITE CONDITIONS**

- Site Elevation : approx. 60 m above sea level.
- Site Conditions : fairly level (cultivated area).

Climate of the area is characterized by four periods, the cold season (Mid-December to March), the hot season (April to June), the monsoon season and the post monsoon (October to Mid-December). The area is marked by dry weather, being generally hot and dry in summer and cold and dry in winter.

3.1 **Environmental Data**

Ambient temperatures	min.: +36 °F (dry bulb) max.: +122°F (dry bulb shade)
Design temperature for equipment	min.: +41 °F max.: +122 °F
Relative humidity	20% - 77% design wet bulb temperature 178.4 °F.
Rainfall	Maximum daily rainfall recorded over 24 hours 251 mm. Maximum monthly rainfall recorded 286 mm.
Wind direction	The prevailing wind directions are either blowing from the North to the North-East, or blowing from the South-West to South-East.
Wind velocity for structural design	45 m/s at 10 m elevation, Exposure factor C - flat open terrain, Importance factor 1.15-essential facility.
Earthquake zone	Zone 2A of Uniform Building Code- UBC-1997.
Airborne dust Particles	Possible effect of airborne dust particles shall be considered when developing the design.
Bearing Capacity at Existing Kunner Plant	0.9 Ton / ft ² (95.0 KN/m ²)

4.0 **GENERAL CRITERIA FOR ELECTRICAL SYSTEM DESIGN**

4.1 **General**

The design criteria shall be governed by the following principles:

- a) Personnel and plant safety.
- b) Environmental conditions of the site.
- c) Reliability of supply.
- d) Redundancy built in electrical system.
- e) Reduction of spaces, weights and cost.
- f) Easiness of management, operation and maintenance.
- g) Adequate flexibility for future installations and interchangeability.
- h) Standardization and availability of components.
- i) No risk of fire.

4.2 Classification of Hazardous Areas and Selection of Equipment

The hazardous area classification will be ascertained in accordance with the requirements of IEC, API & Institute of Petroleum Model Code of Safe Practice, Part 15.

All areas within scope of Project shall be classified as one of the following zones to define the design and installation requirements for electrical equipment and facilities:

Zone 0:

Area where an explosive gas atmosphere is present continuously or is present for long periods.

Zone 1:

Area where an explosive atmosphere is likely to occur in normal operation.

Zone 2:

Area where an explosive gas atmosphere is not likely to occur in normal operation, if it occurs, will exist only for a short period.

Natural Non-hazardous:

A location considered inherently non-hazardous due to its separation from hazardous locations.

The source of hazard in external locations is Class 1, Gas Group IIA gases and vapours with a surface temperature classification not higher than 200°C (Class T3).

The source of hazard in internal locations such as battery rooms housing unsealed lead acid and nickel-cadmium batteries Class 1, Gas Group IIC gases and vapours with a surface temperature classification not higher than 200°C (Class T3).

NOTE: Sealed (valve-regulated) lead-acid batteries will not be segregated from other electrical equipment because:

1. The batteries do not normally release hydrogen.
2. The rooms housing the batteries will have sufficient air changes to maintain the hydrogen concentration below dangerous levels.

4.3 **Equipment Selection**

The selection of equipment and certification requirements necessary will be in accordance with the following Table:

Table 4.3.1 Hazardous Area Equipment Selection

Class	Zone	Permissible Equipment Certification
1	0	Intrinsically safe EEx‘ia’
1	1	Increased safety EEx‘e’ for non-sparking equipment. Flameproof EEx‘d’ for all inherently sparking equipment. EEx‘de’ for all motors
1	2	All equipment Suitable for Zone 1 (as above), as well as non-sparking EEx‘n’
Non-hazardous		Non-certified, industrial design suitable for environmental conditions.

Permissible equipment certification for electrical equipment in terms of Encapsulation (EExm), Purged/Pressurized (EExp) and Special Protection (EExs) may be solicited where applicable.

Electrical apparatus for use in hazardous areas shall be certified by recognized international authority e.g. CENELEC, BASSEFA, FM, UL and/or any authority approved by COMPANY for full compliance with safety requirements in classified areas.

4.4 **Equipment Degrees of Protection**

Equipment will generally comply with the following degrees of protection, in accordance with IEC 60529.

Equipment located in indoor areas such as : IP31
Electrical Control Room, Building Areas, etc.

Equipment located outdoors : IP65
(excluding Low Voltage motors).

Low voltage motor enclosures/terminal boxes : IP55

Electrical enclosures, with door(s) open, : IP20
shrouding of live parts.

4.5 System Voltages and Frequency

Electrical equipment shall be suitable for the following electrical distribution systems as applicable. The system frequency is 50 Hz.

Service	Rated Voltage (V) (User Voltage)	Phase/Wire	Earthing
High voltage distribution	6,600	3/3	Resistance
Low voltage distribution	400/230	3/4	Solid
Motors over 185 kW	6,600	3/3	Resistance
Motors over 0.75 kW ~ up to 185 kW	400	3/3	Solid
Motors up to 0.75 kW *	230/400	1/2, 3/3	Solid
Lighting fixtures	230	1/2+Grounding	Solid
Power (welding)	400/230	3/4+Grounding	Solid
Convenience receptacles	230	1/2+Grounding	Solid
Control circuits			
– 6.6 kV motor starters control	230**	1/2	Solid
– LV motor starters control	230	1/2	Solid
AC UPS for DCS and instrumentation	230	1/2	Solid

Note *: Motors up to 0.75 kW will be single phase 230V for nonhazardous area, and 3 phase 400V for hazardous area.

Note **: 110V DC may also be considered.

Permissible voltage and frequency variations are:

Steady state (long-term) voltage variation
(6.6kV Normal & Emergency) : $\pm 5.0\%$

Steady state (long-term) voltage variation
(Normal LV) : $\pm 10\%$

Steady state (long-term) frequency variation : $\pm 2\%$

Transient voltage variation
(Normal LV power) : $\pm 20\%$

Transient voltage variation
(Emergency LV power) : + 20%, -15%

Note: -15.0% is the lowest level that the UPS systems can handle without reverting to battery backup. All other systems and equipment fed from the Emergency LV power can withstand -20.0% voltage dip.

UPS voltage : $\pm 3\%$

UPS frequency : $\pm 1\%$

4.6 **Allowable Voltage Drop in Cables**

The maximum allowable voltage drops in cables during stable conditions, as a percentage of against system voltage at rated load, shall be as follows:

6.6 kV power distribution	:	2 %
6.6kV motors	:	5.0 %
400/230 volt power distribution	:	2.5 %
400 volt motors	:	5.0 %

4.7 **Supply Capacity**

a) **Power Generation**

Main power at the site will be generated by gas engine driven generators. The number of gas engine driven generators is envisaged to be 4 Nos. duty + 1 No. standby. The exact numbers of generators with ratings shall be confirmed in later stages of detailed engineering. Another diesel engine driven generator shall be provided as emergency/black startup source of power.

b) **Electrical Power Distribution**

In general all distribution shall be sized for the maximum operation loads plus 20 percent spare capacity to be available at Mechanical Completion.

4.8 **Transformer Sizing**

- a) The distribution transformers shall be sized to supply for the maximum demand of load connected to the associated switchgear plus 20% spare capacity for future expansion at ambient temperature. The maximum demand of loads shall be calculated by considering intermittent loads.
- b) The transformer kVA rating shall be chosen as far as possible in accordance with the standard sizes as per IEC 60076 recommendations.

- c) The maximum capacity of 400V transformer shall be limited up to 2000kVA.

4.9 **Cable Sizing**

The cable shall be sized based on the thermal limits in normal service conditions, and the maximum allowable voltage drops in the circuit.

The current carrying capacity (thermal limit) of cables in normal service conditions shall take into account the de-rating due to the laying conditions or grouping.

The current rating of the circuit for cable sizing shall be as follows:

- a) The transformer primary and secondary cables shall be rated based on a current equal to the rated current of the transformer.
- b) The cables to switchgear and/or panel boards without step down transformer shall have a current carrying capacity equal to the maximum demand of loads connected to the switchgear/panel board.
- c) The motor feeder cables shall be sized based on the 100% of motor nameplate rated current.
- d) All the remaining cables not mentioned above shall have a current carrying capacity equal to the maximum current demand of continuous duration.

4.10 **Local Isolator**

Motors shall be equipped with local isolators or equivalent means such as local control stations with padlock facilities in the off position. Where motors are fitted with anti-condensation heaters, a heaters safety switch shall be installed adjacent to the motor remote control unit. Local isolators, if used, shall have padlock facilities in the off mode.

5.0 **POWER GENERATION SYSTEM**

5.1 **Power System at Wellheads**

For supplying power to the instrumentation and telemetry system installed on the wellheads, suitably designed solar power system shall be installed. The system shall comprise of solar cells, inverter panels, battery chargers, battery banks and power distribution panels.

The supply voltage from the solar power system shall be 24VDC. The battery bank shall be suitably sized to sustain an un-interrupted operation of the system for 4 days (considering the prolonged cloudy weather at the wellhead sites).

The system shall be safe, smooth and reliable for the wellheads' instrumentation & control system at all times.

It shall be protected against lightning and static charge. A local earthing pit to be installed for this purpose.

The distribution panels should be installed under a safe shelter to protect them from the site conditions. The shelter should be provided with lights suitable for 24VDC for maintenance work during night at the time of such need.

Note: A similar power supply arrangement as mentioned above shall be made for the Sales Gas Fiscal Metering Skid to be installed at the SSGC Tie-in point.

5.2 **Main Power Generation System at GPP**

The power generation system shall tentatively consist of 4 Nos. operating & 1 No. standby (N+1), 6.6kV gas engine driven generators for the main or normal operation and a diesel engine driven generator for the emergency & black start operation of the Gas Processing Plant. Generator sizes will depend upon finalization of process loads and shall be finalized during detailed engineering.

The power generator sets shall be self contained units complete with reciprocating internal combustion engines, alternator, cooling system, exhaust, etc., mounted on industrial type rails complete with power distribution network. The units shall be equipped for electric-start with batteries as primary means of starting generators. Secondary means of starting the units will also be considered.

The generator sets shall be installed in the canopy in safe area under a shed. The noise limits of the total skid shall not be more than 85dB (A) at 1 meter distance from the edge of the canopy. The canopy shall be sized to have adequate free space for maintenance and shall meet requirements of IP42.

The selection of generator sets shall be influenced by overall capital costs considering system reliability, uniformity and the expected impact on warehoused parts. All gas engine generators shall be identical.

An important element in generator sizing shall be the calculation of the normal operation load and the maximum operation load, calculated using process design data. Multipliers of 10% each will be added for design contingency and future growth allowance.

The number of generators in service shall be large enough to carry the maximum continuous normal and essential power load (including future growth allowance) plus provide the starting current requirement of the single largest motor without exceeding the combined site capacity of the 4 no. of gas generators.

The power system shall operate reliably over the entire life of the plant.

5.3 **Emergency Diesel Generator**

Essential power for the plant shall be provided by 1 No. 6.6kV, 3 Phase, 50 Hz emergency diesel engine-driven generator.

On loss of normal power at the Essential (6.6KV) bus bar for extended time, the emergency diesel generator shall start up manually or automatically. It shall be capable of starting, accelerating to operating speed, and carrying full load within ten to fifteen seconds after actuation of the start signal. When the generator has attained rated volts and speed, the control system will automatically close the incoming feeder and connect the generator onto the emergency bus.

The emergency diesel generator will also be capable of starting under 'black start' conditions, when no utilities or other services are available.

The emergency generator shall be sized to supply the total average demand of all safety, life support, and emergency process and utility loads required for the plant.

The emergency generator shall have its own diesel tank and piping arrangement which shall assure autonomy of 12 hours operation at rated load.

The emergency diesel generator shall be for continuous operation of 110% rated power.

6.0 **POWER DISTRIBUTION SYSTEM**

6.1 **Overview**

All the above mentioned shall be connected to a common 6.6kV busbar, (SWG-001). This bus bar will comprise of multiple sections coupled through intermediate bus couplers. This will allow flexibility of operation in terms of load shedding and section-wise load isolation.

One of the above mentioned bus-bar section will be designed as essential bus and shall be used to connect the emergency diesel genset.

All operation generators shall be synchronized including emergency genset. This synchronization will be achieved in dedicated panels, which will also incorporate automatic generator starting, automatic load transfer and interlock controls for the operation of generator switchgear and bus couplers.

There shall be another 6.6kV bus (SWG-002) which shall be located in Main Electrical Building/Switchgear room. This bus-bar receive 6.6kV supply feeder from SWG-001 and shall also include outgoing 6.6kV switchgear for MV consumers.

This bus-bar shall also be made of multiple sections with bus couplers. Essential bus-bar section shall be fed from dedicated emergency feeder from emergency bus-bar of SWG-001. The bus-bar shall feed the following.

- MV motor loads for both trains and utilities.
- Distribution transformer 6.6/400V.

The above mentioned Distribution transformer shall act as source for 400/230V power supply for all LV consumer on the plant.

For LV distribution, 4 Nos. MCCs are envisaged and shall serve as main LV distribution points for LV motors as well as downstream LV sub-distribution system.

The section of plants connected to each MCC is as follows:

MCC-01	For process Train-1.
MCC-02	For process Train-2.
MCC-03	For common Process of both trains including motors, normal lighting loads, small power loads, UPS, etc.
MCC-04	For Utilities, and all other essential loads including emergency lighting, control system loads, safety related loads, etc.

All down stream, sub-distribution boards (such as lighting DBs, UPS DBs, building sub-station boards, etc) shall be fed from the above mentioned MCCs.

6.2 **General Switchgear Requirements**

All switchboards will have single bus bar, free standing, air-insulated, metal clad design.

Incoming and bus-tie switching devices will be withdraw able. The design of all switchboards will allow equipping of spare modules/cubicles with feeder or starter equipment to be carried out without requiring that the switchboard to be shutdown.

Each MV switchgear (incoming and outgoing), will have a microprocessor-based monitoring and protection relay (or relays, depending on configuration). The protection relays will each have a single communication port, but to give system integrity the relays will be connected daisy chained in a dual-redundant link. Drive status information and control signals will be transmitted between the Electronic Protection relay modules (EPR) and DCS.

6.2.1 6.6 kV Switchgear (SWG-002)

6.6kV feeder panels shall be required to supply power through transformers to LV switchgear & MCC as well as operate the MV motors (>185kW) of TRAIN-1 & TRAIN-2 process area.

Transformer feeder units will be fused vacuum contactor, latched type.

Transformer protection will be provided using proprietary microprocessor based electronic protection relays (EPR) having the required functions of:

- a) Over current.
- b) Earth fault.
- c) Phase current imbalance.
- d) Over-temperature (transformers).

6.2.2 LV Switchgear & MCC

The 400V switchboard bus bar system will be rated for the total average demand of the GAS PROCESSING PLANT, inclusive of a 20% spare capacity for design and operating margins.

The 400V normal switchgear system consists of MCC-001, MCC-002, MCC-003 & MCC004 (for TRAIN-1, TRAIN-2, COMMON PROCESS & UTILITIES respectively) as described previously.

The main incomers, on these MCCs as well as bus-couplers shall be withdrawable air circuit breakers.

Motor starter and feeder units will be fully withdrawable and shall comprise of circuit breaker, air-break contactor, and thermal overload relay as a minimum. Each motor starter and feeder unit will have facility to padlock the unit in the open/isolated position. Facility to reset the thermal overload will be provided on the external face of the unit, negating any requirement to open the unit.

At design inception, a 10% design contingency, and a 10% operating margin will be applied to the initial total average demand, and the resultant figure will be used for the initial sizing of distribution equipment (switchgear, generators and transformers).

It is expected that the 10% design contingency will be depleted through the project design phase, resulting in a 10% operating margin in the delivered switchboards.

The number of equipped spares provided in the MV/LV Switchgear will generally be based on 10% of installed numbers of each motor starter module and feeder size, with a minimum of one of each.

6.2.3 Fault Levels

In assessing the maximum system fault levels, it will be assumed that the following plant will contribute:

- a) All 'duty' drives on the same voltage level as the fault.
- b) In addition, it will be assumed that the bus tie on MV switchboard is closed and all the gas generators are in operation.

The electrical distribution system will be designed to limit fault levels to the maximum calculated values, and switchgear will be selected that has fault ratings equivalent to or in excess of these ratings. The following table shows a preliminary assessment of expected short circuit levels. Actual calculations will be based on actual equipment parameters and shall be updated during detailed design.

Table 6.2.3.1 - Maximum Fault Levels

Voltage Level	Short-time withstand current	Remarks
6.6 kV	31.5 kA / 1 sec.	At the 6.6 kV Switchgear
400 V	80 kA / 1 sec.	At the 400 kV Switchgear

6.3 Lighting and Small Power Distribution Boards

Lighting and Small Power boards will feed all plant lighting fixtures, all single and three phase convenience/power outlets rated 32 Amps or less, and any miscellaneous utility power supplies.

Miniature circuit breakers will provide outgoing circuit isolation and protection facilities.

All small power circuits feeding general purpose (convenience) outlets will have residual current protection.

Power to the lighting chassis section of the distribution board will be switched through a photocell-controlled contactor. An over-ride facility will be provided on the distribution board or elsewhere within the electrical room, to enable manual switching of the lighting.

6.4 **AC UPS System**

Uninterruptible (vital) AC power shall be provided from battery backed UPS.

Dedicated UPS system will be provided for the Control System (DCS, ESD, F&G, CCTV, Unit Control PLCs) and Telecom System.

Each UPS system will consist of 2x100% rated rectifiers and inverters, 2x100% rated static bypass switches, 2x100% rated battery banks, and an isolating transformer/bypass transformer.

The UPS systems will have dual incomers, one side being fed from the 'normal' 400V switchboard system, and the other side and mains bypass transformer, being fed from the 'Essential/Emergency' 400V switchboard bus.

All UPS batteries will be sealed (valve regulated) lead-acid type, housed in enclosed freestanding cabinets.

Each battery bank will have a means of isolation which can be tripped by the ESD or F&G system, and which will also automatically isolate the battery bank at the end of discharge.

Battery banks will be sized for 4hrs backup time for Control System & Telecom System.

400/230V AC UPS distribution board will distribute power to the required loads. The distribution board will either be housed in the UPS system / equipment cabinets, or they will be separate freestanding or wall-mounted distribution panels. Should the latter arrangement be implemented, the distribution boards will be electrically and physically segregated from each other, so as to maximise the UPS system's integrity.

AC UPS system will be located in the electrical room.

6.5 **DC Supply System**

DC supply systems with battery backup will provide power to the 6.6kV Switchboard closing and tripping supplies, protection relays & generators Control Panels. 230V AC from AC-UPS may also be considered for the same.

Rectifiers for the DC supply systems will be sized to supply the standing load whilst recharging the battery banks to 90% capacity in 10 hours.

Battery banks will be sized to provide 4hrs backup power on loss of AC supply.

The DC UPS system will consist of 2x100% rated rectifiers and 1x100% rated battery bank.

The one rectifier will be fed from the 'normal' 400V switchboard system, and the other from the 'Essential/Emergency' 400V switchboard.

All DC UPS batteries shall be sealed (valve regulated) lead-acid type, housed in enclosed freestanding cabinet.

DC UPS system will be located in the Electrical.

Earthing of the DC systems will be as per Vendor's standard.

7.0 **ELECTRICAL ROOM**

The Electrical Room shall house 6.6kV (SWG-002), 400V switchgear, transformers, MCCs for Train-1, Train-2, COMMON PROCESS & Utilities, AC / DC UPS including battery banks, Lighting & HVAC DB etc. and will have reinforced concrete walls, concrete roof and elevated concrete floor. A cable vault is built underneath the switch room and MCCs to allow the underground cable entries.

It will be air-conditioned and pressurised.

In the cable vault underneath the Electrical Room, galvanised steel cable ladders will be installed, as necessary, for all cables to the MV / LV switchgear and for all interconnecting auxiliary cables between switchgear, MCC, panels etc.

Generators, Generators switchgear, 6.6kV (SWG-001), control & synchronizing panels shall be located in Generator house, which may or may not be part of Electrical room.

Equipment will generally have bottom entry for cables.

8.0 **TRANSFORMERS**

Power transformers will be dry type, having cast resin encapsulated windings, 6.6/0.4 kV, 3Phase, 50 Hz, Dyn 11 vector group.

The air-natural (AN) rating of the transformers will be such that one transformer can supply the total average LV power demand of the connected switchboard, inclusive of 10% contingency.

The transformers will have an air-forced (AF) rating equivalent to 125% of their AN rating. If the system load analysis shows that the peak LV power demand of a switchboard exceeds the transformer AN rating, then the transformer may be fitted with cooling fans.

The transformers will have off-load tap change links on the primary (MV) side, allowing $\pm 2.5\%$ and $\pm 5\%$ adjustments.

Transformer MV connections will be via cables. For transformers rated higher than 1.5MVA, the 400V connection can be through bus duct.

If any transformer is required to operate in AF mode, the fan control equipment will be housed in a separate control panel, which will be mounted either on-skid, or in the electrical room.

9.0 **MOTORS**

- Electrical motors shall be outdoor use, industry type, 3 phase squirrel cage induction motors in accordance with 165-4-SPE-010.
- Motors to be installed in hazardous area shall meet the requirements described in Section 4.2.
- Single phase AC motors can be used only for the fractional and non-essential motors of 0.75kW and below. Three phase motors shall be applied for hazardous areas.
- Motors shall be designed to operate for a periods of not less than 5 minutes at a voltage of 25 % below the normal values and at nominal frequency without injurious overheating.
- The starting current at full voltage for LV motors shall not exceed 600% of rated current.
- The starting current at full voltage for MV motors shall not exceed 600% of rated current.
- The motors, when specified, shall be designed to apply re-acceleration due to the voltage dip and re-starting after power restoring.
- Generally the motors shall be 3 phase, asynchronous cage induction type, totally enclosed fan cooled (TEFC), with fan directly mounted on the motor shaft.
- All motors will be continuously rated, and will be suitable for direct-on-line starting.
- When variable frequency drive (VFD) is used for motor control, motors shall be suitable for VFD starting.
- Energy efficient motors are required for any continuous duty application, where available.

- All motors will at minimum have class F insulation, and be rated for operation having a class B temperature rise, adjusted for the site ambient design temperature of 50°C.
- The minimum degree of protection for motor enclosures will be IP55 to IEC60529 including motor terminal boxes.
- Motor certification for operation in hazardous areas will be in accordance with Table 4.2.
- All motors operating directly in the airflow of ventilation systems, or required to operate following a fire and gas shutdown, will be suitable for Zone 1 operation. This applies regardless of whether the location is a hazardous or non-hazardous zone.
- Anti-condensation heaters shall be provided to motors greater than 75kW rating.

10.0 **ALTERNATOR**

Alternator shall be brushless synchronous generator.

Standard	:	IEC
Voltage	:	6,600V, 3-phase, neutral lead out and with earthing transformer
Frequency	:	50 Hz
Insulation class	:	Class F
Temperature rise	:	Class B (based on 45°C ambient temperature)

Diesel engine driven alternator for emergency and start-up GEN SET .

Standard	:	IEC
Voltage	:	6,600V, 3-phase, neutral high resistance earthed.
Frequency	:	50 Hz
Insulation class	:	Class F
Temperature rise	:	Class B (Based on 45°C ambient temperature)

The protection degree of generator and auxiliaries shall be IP31 in case of enclosures are provided, IP54 shall be applied for out-door installation.

11.0 **CABLES AND CABLE INSTALLATION**

11.1 **Cable Material**

Power, control and signalling cables shall be stranded copper conductors, Poly Vinyl Chloride (PVC) insulated, single galvanized steel wire armoured and PVC over sheathed.

All cables for outdoor installation buried or laid on cable trays will have steel wire armour construction.

Cables for indoor installation laid in cable tray can be unarmored.

Cables sheathing insulation will be flame-retardant as per IEC60332-3-24, Category C.

Earthing cables shall be stranded copper conductor, PVC sheathed, coloured yellow/green.

Cable glands shall be suitable for the type of cable. For use in hazardous areas, certified type of glands shall be used.

11.2 **Cable Sizing**

- a) Cable size shall be decided in accordance with the requirements specified in Section 14.1.4 and the requirements below.
- b) Current carrying capacity of cables shall be based on the following conditions:
 - Ambient temperature : 122°F
 - Soil temperature : 111°F
- c) Cable arrangement shall be in general so designed that the de-rating factor due to grouping of cables shall not be less than 0.6 for above ground installation and 0.4 for underground installation.
- d) The minimum conductor sizes shall be follows:
 - Low voltage power cable to load : 2.5 mm²
 - Control cable : 1.5 mm²
 - Lighting cable : 2.5 mm²
 - Lighting cable within building : 1.5 mm²
 - Cable for convenience outlet : 2.5 mm²
 - 6.6kV power cable : 25 mm²

11.3 **Installation Criteria**

In principle, cable shall be installed at underground cable trench for out door installation, unless otherwise specified.

Paved area	:	Brick walled trench with cover
Unpaved area	:	Directly buried with protection tile
Road crossing	:	In duct bank

For above grade cable ways, ladder type cable tray or perforated cable tray cable ways shall be applied.

Power cables shall be run in a continuous length from the power source to the load.

MV and LV single core cables shall be laid in trefoil groups with 150 mm spacing between trefoils. On trays or racks MV cables shall be segregated from the LV cables.

Cables shall be installed underground in trenches in a single layer as far as possible. Power, control, and instrument cables will be buried minimum 600mm below grade and MV cables will be buried minimum 750mm. Instrument, fire and gas, and telecoms cables will have a lateral separation from power cables of 600mm.

Underground cable routes shall be designed to avoid close pipe crossings and adjacent runs with underground pipelines, i.e. a clear distance of at least 300 mm between cable and pipe (including insulation) shall be maintained. Cables should cross underneath buried pipelines except where the depth measured at the top of the pipeline is more than 1 meter.

Appropriate cable route markers shall be used to indicate the underground cable laying. Cable tags shall be used to identify the cables in the trenches or in the cable trays at both ends of the cables. Intermediate tags shall be used at every 30m distance from the electrical room end to the consumer side. The tags shall also be used on either end of the road crossing for underground cabling.

At road crossings and cables emerging from floors or soil rigid PVC conduits shall be used for mechanical protection.

All penetrations of underground cables into the electrical room walls shall be through conduits suitably sealed (silicon foam) to be water tight.

- Cables shall be installed mainly on extra heavy duty execution of hot dipped galvanized steel ladder type trays in accordance with BS. The cable tray as specified NEMA class 20B is minimum requirement. For branches from the cable tray or when cable are small number, cables shall be installed on hot dip galvanized perforated cable tray or steel conduit.

- Cable trays may be installed without removable top covers allowing adequate ventilation except where:
 - Mechanical damage of the cables is likely to occur during plant maintenance.
 - Oil or chemical spillage or dirt accumulation can be expected.
- The trays shall firmly be supported to preclude the sliding.
- Motor feeder cables for normal running motors and stand-by motors shall be laid in alternate fashion across each layers and they may touch each other.
- Cables such as lighting or control cables on trays may be bunched in more layers as long as the thermal de-rating factor is not further affected.
- The cable shall not run close to parallel hot lines or large high temperature surfaces. Whenever practicable, a 300 mm spacing shall be maintained.
- 6.6kV and 400V cables are preferably installed on the separate tray. Where they are installed on the same tray, the metal plates (diverters) shall be fixed between 6kV and 400V cables.
- Duct bank system shall be used for road crossing. Duct bank shall be PVC or non-metallic pipes encased in concrete of at least 50 mm thickness.
- The top of the concrete encasement shall be at least 600 mm below grade where the duct banks cross the road. Burial depth of duct bank may be reduced where duct bank is installed free from the heavy loads.
- Multi-cables may be installed in one pipe provided that the current carrying capacity of cable remains within the allowable limit.
- 6.6kV cables and associated control cables can be installed in same pipe.

12.0 **LIGHTING**

12.1 **Lighting Distribution**

12.1.1 **Normal Lighting**

Normal lighting will be fed from small power distribution board connected to 400V Switchboard.

Normal lighting will be photocell controlled, with manual override facilities.

12.1.2 Emergency Lighting

Distribution boards connected to the 400V emergency switchboard power fed by MCC-004. It will constitute approximately 15-20% of plant's total luminaries.

Emergency lighting will be positioned so as to facilitate ease of escape, and to illuminate Emergency work areas such as equipment control panels, operator stations, and switchgear operating positions.

12.1.3 Essential Lighting

These will also be power fed from the 400V emergency switchboards connected to MCC-004. However each of these luminaries will be fitted with a battery pack that will provide 1hour of power for one tube of the fitting.

Essential lighting will be permanently lit. In the event of total power failure (normal and emergency), the essential lighting luminaries will provide reduced lighting, adequate for personal safety and escape, (minimum two lux) for the minimum backup time of 2hrs.

These luminaries will be positioned to illuminate escape routes and emergency exits.

12.2 Luminaries Types

Luminaries in the more dense areas of the compression plant will generally be twin tube, two pin fluorescent types, having electronic ballasts.

In open and laydown areas, floodlights will be utilised. Floodlights will be high-pressure sodium type. Metal halide may also be considered as an alternate.

In all hazardous areas, whether Zone 1 or Zone 2, fluorescent luminaries will be certified suitable for Zone 1 use, either EExe, or a combination of hazard protection techniques.

All floodlights will be located in non-hazardous or Zone 2 areas, but not in Zone 1 areas. All floodlights will therefore be certified suitable for Zone 2 operation at minimum.

In non-hazardous areas, all luminaries except essential lighting will be non-certified. Essential light fittings will be Zone 1 certified fluorescent luminaries in all areas of the Plant, whether hazardous or non-hazardous.

Fluorescent luminaries will operate at 230VAC. Floodlights will operate at 230VAC voltage, and any requirement to balance loads across the three-phase distribution system.

12.3 **Lighting Circuit Design**

Lighting circuits can be single phase or through phase depending on individual application and mode of distribution.

Luminaries will be through-connected so as to minimise the requirements for lighting junction boxes (JBs). If lighting junction boxes are necessary, they will be EExe certified, IP66, with a minimum of four entries.

Lighting circuit breakers for all the plant lighting will be two-pole type. 20 % spare circuit breakers shall be provided in each lighting distribution board (LDB). The maximum load of the LDB should not generally exceed 80% of its rating capacity.

Lighting circuits for floodlight poles and for street lighting shall be 3 phase and neutral, 400V, having the luminaries balanced on phases.

Lighting circuit breakers for these circuits will be four-pole type.

12.4 **Illumination Levels**

Average illumination levels will be designed in accordance with the values given in table.

The design will allow for a maintenance level of 0.7. Illumination levels are at 1.0 metres above floor level.

Table 12.4.1 - Illumination levels

Area	Lux Level
Process areas, pumps, valve stations, gauge panel.	100
Stairways, walkways, instrument stands.	50
At front of switchboards, local control panels, controller cabinets.	300
General lighting in switch room, instrument equipment room.	200
Electrical Room, Instrumentation Cabinet Room and Central Control Room.	400
Outdoor tank areas.	20

Area	Lux Level
Offices, first aid areas, reading areas.	500
Storerooms, warehouses.	75
Workshops	300
Roadways & Security (boundary wall) Lighting.	20
Essential lighting level - plant escape routes.	2
Emergency lighting level - Electrical Room, Instrumentation Cabinet Room and Central Control Room.	20

Where possible, maximum illumination levels will not be more than three times the minimum illumination level in any area, and sharp changes in illumination level will be avoided.

13.0 **SMALL POWER**

Single and three phase power outlets for general purpose requirements and for welding will be provided throughout the plant.

Single-phase outlets will be fed from the 'normal' small power distribution boards. All outlets in external areas will be fed via two or four pole MCCBs (as appropriate).

Welding outlets (63A) will be fed directly from the 400V switchboard.

The outlets shall be located such that the maximum length of lead required to reach any outlet is not more than 30 meters.

General purpose (convenience socket) outlets in the plant and utility areas will be rated at 16 Amps, 230VAC single phase and shall be power fed from the small power distribution boards (normal as well as emergency supply).

Three phase and welding outlets will be rated at 63Amps, 400V, 3p, N + E, and have five pins.

All general purpose outlets will be protected by residual current devices (RCDs). Welding outlets will have RCD protection having 300mA sensitivity.

Not more than 2 (two) welding outlets shall be fed from one cable feeder.

No more than 4 (four) convenience outlets shall be fed from one cable feeder.

Single and three phase outlets located in the outdoor areas, or in areas subject to splash, spray or washdown, will have an IP66 degree of protection. Outlets located in equipment rooms, switch rooms, etc. will be industrial style, with a degree of protection of at least IP44.

All single and three phase outlets located externally will be certified EExde.

If required for specific applications, outlets may need to be fed from the UPS or Emergency power system (for example, in the Instrument control room). Should these be required, the outlets will be specifically labelled, and will have a unique pin configuration, (round phase and neutral pins, with a flat earth pin), so as to prevent the connection of unauthorised equipment to the UPS supply.

14.0 **EARTHING AND LIGHTING PROTECTION SYSTEM**

14.1 **General**

Earthing and bonding systems will be implemented for the following:

- a) Electrical system earthing.
- b) Protective earthing.
- c) Static or equipotential bonding.

Earthing conductors will be single core, stranded conductors, having green/yellow PVC sheath.

14.2 **Electrical System Earthing**

Earthing and bonding systems will be implemented for the following:

The following earthing systems will be employed:

- a) 400V solidly earthed at transformer and generators' star points (TNS system).
- b) UPS neutral solidly earthed to clean earth.

At least one electrical system earth bar will be provided in each of the following locations:

- a) Electrical Room.
- b) Instrumentation Cabinet Room.
- c) Central Control Room.

In addition, at various locations in the plant, electrical system earth bars will be mounted. A continuous earth ring, looping from earth bar to earth bar, will interconnect all electrical system earth bars.

An earth loop of buried copper conductor, interconnected with multiple earth rods will be installed throughout the plant.

Instrumentation control equipment shall be connected to Clean Earth, which shall be a separate network from Protective Earth network (Dirty Earth), presented above.

14.2.1 MV System Earthing

Neutral transformers shall be used for applying earthing at the MV Gas Generators' switchgear (SWG-001) to minimise the short circuit current and harmonics.

14.2.2 LV System Solid Earthing

LV system earthing will be achieved by means of a solid copper link between the neutral bar and the earth bar.

The star points of the distribution transformers secondaries, generators, will not be directly connected to the earth in the field, but will be earthed through the neutral earth link in the switchboard.

In the switchboard, the bus-tie circuit breaker will be three-pole only, and will not open the neutral. This is done so as to prevent the neutral-earth link being unobtainable if the bus tie is open.

The star points of the distribution transformers secondaries, generators, will not be directly connected to the earth in the field, but will be earthed through the neutral earth link in the switchboard.

In the switchboard, the bus-tie circuit breaker will be three-pole only, and will not open the neutral. This is done so as to prevent the neutral-earth link being unobtainable if the bus tie is open.

14.2.3 UPS System Earthing

The generated neutral on the load side of the UPS inverter will be solidly earthed via a solid copper link between the UPS neutral bar and the UPS earth bar. The UPS earth bar will in turn be connected to the Main Earth Bar in the electrical room.

14.3 **Protective Earthing**

For the purpose of personnel safety, all enclosures housing electrical equipment will be electrically bonded to the structure on which they are mounted, or directly to the nearest electrical system earth bar. This will include all switchboards and distribution panels, motors, local control stations, junction boxes, power outlets and control panels.

The bonding will be done using an appropriately sized earth conductor.

14.4 **Static / Equipotential Bonding**

Equipotential bonding will be carried out for non-electrical equipment such as buildings, pipe work, vessels, equipment skids, and steelwork, etc. to ensure that static charge can not rise to the point of creating a dangerous potential relative to the plant earth.

All non-electrical equipment and structures will be fitted with one or more earth bosses which will be bonded via earth conductor to the nearest electrical system earth bar.

Cable ladders will be bonded across joints and to electrical earthing system at each end.

14.5 **Lightning Protection**

The requirement for and extent of lightning protection will be assessed in accordance with the guidelines given in BS6651–Code of practice for protection of structures against lightning.

14.6 **Earth Resistance Values**

The following shall be the maximum values of resistance to earth:

- | | | |
|--|---|------------|
| a) 400V solidly earthed system | : | 1 ohm |
| b) Electrical equipment bonding | : | 1 ohm |
| c) Non-electrical equipment (static) bonding | : | 1 mega ohm |
| d) Lightning protection (if required) | : | 10 ohms |

14.7 **Electromagnetic compatibility (EMC)**

The Contractor shall prepare, present and implement an EMC management plan, describing the specific EMC requirements during the detail engineering, procurement, construction and commissioning phase of the project.

The EMC plan should also address any interfacing between new and existing facilities.

Lightning shall be included as a possible major source of disturbance. In accordance with IEC 62305, the maximum value of peak lightning current shall be assumed to be 200kA.

15.0 **ELECTRICAL PROTECTION SYSTEM**

15.1 **General**

The electrical relay protection system will be designed to perform the following functions:

- a) Isolate the faulted section quickly.
- b) Minimize damage to the faulted section.
- c) Prevent loss of stability of the generation and distribution system.
- d) Minimize any disturbance to the healthy sections of the plant.
- e) Protect personnel.

15.2 **Generators**

Following protections shall be considered for the gas engine driven & emergency diesel engine driven generators:

- a) Inverse definite minimum time over current.
- b) Inverse definite minimum time earth fault.
- c) Differential phase and earth fault protection.
- d) Winding over-temperature detection.
- e) Reverse power protection.
- f) Under frequency detection.
- g) Over and under voltage protection.

15.3 **Power Transformers**

Following protections shall be considered as minimum:

- a) Fused contactor (incorporating a latched mechanism).
- b) Inverse definite minimum time overcurrent.
- c) Restricted earth fault.
- d) Winding over-temperature detection.
- e) Inter-tripping from downstream LV distribution.

15.4 **LV Motors**

Following protections shall be considered as minimum:

- a) LV Circuit breaker short circuit protection.
- b) Earth fault (motors over 37kW).
- c) Thermal overload protection.
- d) Phase imbalance protection.

Note: Variable speed drive systems (VSDS) where used, shall be equipped with the protection, control, alarm and metering equipment functions as required for their safe & reliable operation.

15.5 **LV Feeders, Power and Convenience Sockets**

Protection will include:

- a) Short circuit protection by circuit breaker.
- b) Earth fault.

16.0 **CATHODIC PROTECTION (CP) SYSTEM**

The design of the cathodic protection system shall be an integral part of the wellheads, total flow lines and GPP design. Pipeline isolation and a suitable pipeline coating system shall be provided for the flow lines and pipeline design.

The impressed current based cathodic protection system shall be designed such that any external corrosion on the wellhead casings, flow lines, pipelines and tank bottoms is eliminated and any adverse stray current effects on the flow lines, pipelines or on foreign structures are avoided.

17.0 **ELECTRICAL TRACE HEATING**

Following types of trace heating, where required, shall be used:

- a) Self-regulating heaters.
- b) Constant wattage parallel heaters.
- c) Mineral insulated heaters (M.I. cable).

18.0 **NON-INDUSTRIAL BUILDINGS**

Non-industrial buildings comprise all buildings outside the process areas, e.g., work-shops, warehouses, administration buildings, fire stations, security gate, chemical stores, etc.

They shall all be classified non-hazardous with the possible exception of chemical stores, depending on the chemicals and the method of their storage and handling.

The design and installation of the power, lighting and earthing systems shall comply with IEC 60364, the relevant parts of this specification, and the local regulations whichever are the most stringent.

Power supply to each building shall be through suitably sized LV feeder.

Emergency lighting shall be installed in the building switch room(s). Escape lighting shall be installed along with all the emergency exit routes from the building by means of luminaries with integral 1 hr battery back-up. The selection of luminaries shall be in accordance with architectural drawings of the buildings.

Socket outlets of the domestic pattern standard to the country of installation shall be used. Industrial pattern convenience outlets and power outlets shall be provided, e.g., in work-shops, as applicable.

Earthing, bonding and lightning protection shall be derived directly from the main switchboard.

Concealed cabling and wiring shall be installed unless stated otherwise.

19.0 **TESTS**

All electrical equipment and systems shall be tested completely and detailed in sub-contractor's workshop. All tests required by the codes and standards as well as all manufactures' tests shall be performed.

The test program for the work shop test shall be submitted at least 8 weeks prior to start of the tests. Detailed test protocols of all tests performed shall be submitted prior to installation. The relevant test protocols have to be submitted.

In addition to above, the following site tests shall also be considered:

- a) Pre-installation testing.
- b) Pre-commissioning.
- c) Commissioning with test on completion.

With the tests the proper and reliable function of the complete scope according to the requirements shall be proven.

Proper record of and documentation of these tests witnessed and duly signed by the authorized personnel of the Client as well as Contractor shall be maintained at all time for future reference.