

ELECTRICAL DESIGN BASIS

FOR A TYPICAL OIL&GAS ON SHORE PROCESS PLANT POWER DISTRIBUTION SYSTEM AT 33KV WITH STEAM GENERATOR FROM PROCESS STEAM RECEIVING INPUT POWER FROM UPSTREAM 132KV ASWELL AS FROM STG AS PER IEC STANDARD VOLTAGE AND SPECS. THIS CAN EQUALLY BE USED FOR SAFE AREA PROCESS PLANT IF HAZARDOUS PORTION IS TAKEN OUT.

NOTE THIS IS TYPICAL GUIDE TO GENERALISED ELECTRICAL DESIGN BASIS AND HAS TO SUIT YOUR PROJECT KEY SLD AND DESIGN PHILOSOPHY AND TO BE UPDATED ACCORDINGLY

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1.0 INTRODUCTION

1.1 OBJECTIVE

The purpose of this document is to define the basic philosophy to be applied in the design of the electrical network and equipment. The electrical system design and equipment specifications shall be in line with applicable British/IEC Standards or other International Standards, performance standards, subject to local standards/statutory requirements and Order of Precedence in Clause 2.1.

The required plant availability shall be achieved by selection of highly reliable equipment and/or technology and sparing of equipment critical to production and this shall be reflected in the Utility load list. The design of the electrical network shall focus on avoiding total shutdown of the plant due to scheduled or unplanned maintenance.

The objective is to provide suitable electrical infrastructure to enable connecting, starting and running of the project loads and also to cater for process uncertainties in design. Switchgears shall be designed with appropriate spare capacity and spare feeders in order to accommodate process loads without any major modification for electrical infrastructure.

This document shall be read in conjunction with all other referenced and/or relevant philosophies, documents and drawings if included in the package.

1.2 DEFINITIONS

COMPANY	XXX
CONTRACTOR	XXX
SUBCONTRACTOR	The party to the contract with the principal who is responsible for Construction, commissioning and other work under the contract
VENDOR/MANUFACTURER	The party that manufactures or supplies equipment and services to perform the duties specified by the COMPANY or CONTRACTOR.
Shall	The word 'Shall' indicates a requirement.
Should	The word 'should' indicates a recommendation.
May	The word 'may' is to be understood as indicating a possible course of action.

1.3 ABBREVIATIONS

A (kA)	:	Ampere (kilo Ampere)
AC	:	Alternating Current
AVR	:	Automatic Voltage Regulator
AWA	:	Aluminium Wire Armour
BFAS	:	Building Fire Alarm System
BFD	:	Basis For Design

C&A	:	Control & Automation
CCR	:	Central Control Room
CCTV	:	Closed Circuit Television
DB	:	Distribution Board
DC	:	Direct Current
FCS	:	Field Bus Control System
DEW	:	Deep Water Well
DOL	:	Direct On Line
DWD	:	Deep Water Disposal
EDG	:	Emergency Diesel Generator
ELM	:	Code name for All Aluminum Alloy Conductor, with 19 strands & wire diameter of 3.76mm
ENMCS	:	Electrical Network Monitoring & Control System
ESD	:	Emergency Shutdown
EHT	:	Electrical Heat Tracing
FEED	:	Front End Engineering and Design
FAR	:	Field Auxiliary Room
F&G	:	Fire & Gas
FOC	:	Fiber Optic Cable
GCB	:	Generator Circuit Breaker
GIS	:	Gas Insulated Switchgear
GRE	:	Glass Reinforced Epoxy
HMI	:	Human Machine Interface
HV	:	High voltage
HVAC	:	Heating Ventilation and Air Conditioning
HP	:	High Pressure
HSE	:	Health Safety and Environment
ICAO	:	International Civil Aviation Organization
IEC	:	International Electrotechnical Commission
IED	:	Intelligent Electronic Devices
IFB	:	Instrument –Electrical Interface Box
Ik	:	Rated short-time withstand current
IP	:	Ingress Protection
IPS	:	Instrumented Protective system
ISO	:	International Organization of Standardization
MCR	:	Main Control Room
LFL	:	Lower Flammable Limit
LP	:	Low Pressure
LPG	:	Liquefied Petroleum Gas
IPF	:	Instrumented Protective Function
LAN	:	Local Area Network
LED	:	Lighting Emitting Diode
LV	:	Low Voltage
MW	:	Megawatts
MCC	:	Motor Control Center
MOV	:	Motor Operating Valve
MSV	:	Manifold Shutdown Valve

MVUAS	:	Medium Voltage Unit Auxiliary Switchboard
MVUAT	:	Medium Voltage Unit Auxiliary Transformer
N	:	Neutral
NER	:	Neutral Earthing Resistor
NGT	:	Neutral Grounding Transformer
NiCd	:	Nickel Cadmium
OHL	:	Over Head Line
OLTC	:	On Load Tap Changer
OCTC	:	Off Circuit Tap Changer
PAS	:	Production Automation System
PDB	:	Power Distribution Board
PMR	:	Pole Mounted Auto Re-closer
PR	:	Procedure
PS	:	Performance Standards
PRDA	:	Protective Relay And Data Acquisition
PVC	:	Polyvinyl Chloride
QRA	:	Quantitative Risk Assessment
RMS	:	Remote manifold station
RCU	:	Remote Control Unit
RTU	:	Remote Terminal unit
SCADA	:	Supervisory Control And Data Acquisition
SM	:	Synchronous Motor
S/S	:	Substation
STG	:	Steam Turbine Generator.
SWA	:	Steel Wire Armored
I _{THD}	:	Total Harmonic Distortion (Current)
V _{THD}	:	Total Harmonic Distortion (Voltage)
TCP	:	Thyristor Control Panel
TN-S	:	Earthing arrangement where Protective earth and neutral are separate conductors that are connected together only near the power source
TX	:	Transformer
UPS	:	Uninterrupted Power Supply
V (kV)	:	Volt (kilo Volt)
VFD	:	Variable Frequency Drive
VSD	:	Variable Speed Drive
WHCP	:	Wellhead Control Panel
WTP	:	Water Treatment Plant
XLPE	:	Cross-linked Polyethylene

1.4 LANGUAGE AND UNITS OF MEASUREMENT

The English language and the International System (SI) units of measurement shall be used in all documents and drawings. Following table is providing the most used electrical units of measurement. For units not included in the table, general SI units shall be used.

Parameter	Unit	Unit Name
Frequency	Hz	Hertz
frequency, angular	rad/s	
Power, apparent	VA	
Power, active	W	Watt
Power, reactive	VA _r	
Electric Charge/ Quantity of Electricity	C	Coulomb
Electric Current	A	Ampere
Electric Current density	A/m ²	
Electric Potential / Voltage	V	Volt
Electric Field	V/m	
Electrical Energy	Wh	
Luminous Intensity	cd	Candela
Luminous Flux	lm	lumen
Illuminance	lx	lux
Electrical Resistance / impedance / reactance	Ω	Ohm
Electrical Conductance / susceptance	S	Siemens
Electrical Admittance	1/S	
Inductance	H	Henry
Capacitance	F	Farad
Magnetic Flux density	T	Tesla
Magnetic Flux	Wb	Weber
Conductivity	S/m	
Resistivity / Specific Resistance	Ωm	
Reluctance	A/Wb	
Resistance-temperature coefficient	K ⁻¹	
Permeability, absolute	H/m	
Permittivity, absolute	F/m	
Polarization, electric	C/m ²	
Power Factor	-	
Thermal Conductivity	W/m·°C	

2.0 CODES, STANDARDS, REGULATIONS AND REFERENCES (ON PLOT/OFF PLOT FACILITIES)

2.1 ORDER OF PRECEDENCE

In the event of any discrepancies, the order of precedence shall be as follows:

First priority : Local laws, decrees and statutory instruments

- Second priority : Company Policies (PL)
- Third priority: Company Codes of Practice (COP)
- Fourth priority : Project Specific Procedures, Instructions, FEED documentation
- Fifth priority : Company Engineering Specifications (SP)
- Sixth priority : National Standards
- Seventh priority: International Standards

Within the same level of precedence, in the event of any conflict, discrepancy, inconsistency or ambiguity among these documents, the more stringent requirement shall prevail unless otherwise APPROVED.

Applicable edition / revision / version international codes and standard for Vendor / equipment Manufacturer shall be that, available at date of purchase order.

2.2 STANDARDS AND SPECIFICATIONS

The standards and regulations to be applied for the electrical design and installation shall be as per list of standards and regulations as mentioned below.

Any departure from these shall be specifically highlighted together with reasons for such departure and shall be subject to approval by the Company. The design shall also take into account the requirements of any local standards and regulations following the principles and practices described and referred to in the project specifications.

2.3 INTERNATIONAL CODES & STANDARDS

The recommended IEC standards listed below shall generally be followed unless more stringent COMPANY requirements exist. Where IEC standards or COMPANY specifications are not applicable, British Standards shall be used.

Document Number	Description
ASTM G51	Standard Test Method for Measuring pH of soil for use in Corrosion Testing
ASTM G57	Standard Test Method for Field Measurement of Soil Resistivity using Wenner Four Electrode Method
ASTM G187	Standard Test Method for Measurement of Soil Resistivity using Two Electrode Soil Box Method
BS 1990-1	Wood poles for overhead power and telecommunications lines Part 1 - Specification for softwood poles
BS EN 13636	Code of practice for land and marine application
EN 50423-3-4	Overhead lines up to and including AC 45kV
BS EN 62305-1 to 4	Protection against lightning
IEC 60027	Letter Symbols

Document Number	Description
IEC 60028	International Standard of Resistance for Copper
IEC 60034 Series	Rotating Electrical Machines
IEC 60038	IEC Standard Voltages
IEC 61869-2	Instrument Transformers – Part 2 : Additional Requirements for Current Transformers
IEC 61869-3	Instrument Transformers – Part 3 : Additional Requirements for Inductive Voltage Transformers
IEC 60051-1	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 1: Definitions and General Requirements Common to all Parts
IEC 60051-2	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 2: Special Requirements for Ammeters and Voltmeters
IEC 60059	IEC Standard Current Ratings
IEC 60060	High voltage test technique
IEC 60071-1	Insulation Co-Ordination – Part 1: Definitions, Principles and Rules
IEC 60071-2	Insulation Co-Ordination – Part 2: Application Guide
IEC 60072 Series	Dimensions and Output Series for Rotating Electrical Machines
IEC 60073	Basic and Safety Principles for Man-Machine Interface, Marking and Identification – Coding Principles for Indicators and Actuators
IEC 60076 Series	Power Transformers
IEC 60079 Series	Electrical Apparatus for Explosive Gas Atmospheres
IEC 60085	Electrical Insulation – Thermal Evaluation and Designation
IEC 60099-4	Surge Arrestors - Part 4 : Metal Oxide Surge arrestors without gaps for AC systems
IEC 60099-5	Surge Arrestors – Part 5 : Selection and Applications Recommendations
IEC 60099 Series	Surge Arresters
IEC 60104	Aluminium magnesium silicon alloy wire for overhead line conductor
IEC 60129	High Voltage Switchgear and Controlgear – Part 102: Alternating Current Disconnectors and Earthing Switches
IEC 60137	Insulated Bushings for Alternating Voltages above 1000V A.C.
IEC 60146 Series	Semiconductor Converters
IEC 60168	Tests on Indoor and Outdoor Post Insulators of Ceramic Material or Glass Systems with Nominal Voltages Greater than 1000V

Document Number	Description
IEC 60173	Colours of the Cores of Flexible Cables and Cords
IEC 60183	Guide to the Selection of High Voltage Cables
IEC 60204 Series	Safety of Machinery – Electrical Equipment of Machines
IEC 60205	Calculation of the Effective Parameters of Magnetic Piece Parts
IEC 60208	Aluminium alloy stranded conductors (Aluminium magnesium silicon type)
IEC 60214-1	Tap Changers – Part 1: Performance Requirements and Test Methods
IEC 60214-2	Tap Changers – Part 2: Application Guide
IEC 60227	Polyvinyl Chloride Insulated Cables of Rated Voltages up to and Including 450 / 750V
IEC 60228	Conductors of Insulated Cables
IEC 60255 Series	Electrical Relays
IEC 60265-1	High Voltage Switches Part 1: High Voltage Switches for Rated Voltages Above 1kV and Less Than 52kV
IEC 60269	Low Voltage Fuses
IEC 60270	High Voltage Test Techniques – Partial Discharge Measurements
IEC 60273	Characteristics of Indoor and Outdoor Post Insulators for Systems with Nominal Voltages Greater than 1000V
IEC 60282-1	High Voltage Fuses – Part 1: Current-Limiting Fuses
IEC 60287 Series	Electric Cables Calculation of the Current Rating
IEC 60296	Fluids for Electrotechnical Applications – Unused Mineral Insulating Oils for Transformers and Switchgear
IEC 60300 Series	Dependability Management
IEC 60304	Standard Colours for Insulation for Low Frequency Cables and Wires
IEC 60305	Insulators for Overhead Lines with Norm Voltage above 1000V – Part 1: Ceramics or Glass Insulator Units for A.C. Systems – Definitions, Test Methods and Acceptance Criteria
IEC 60309	Plugs, Socket Outlets and Couplers for Industrial Purposes
IEC 60331 Series	Tests for Electric Cables Under Fire Conditions- Circuit Integrity
IEC 60332 Series	Tests on Electric and Optical Fibre Cables Under Fire Conditions
IEC 60364 Series	Low Voltage Electrical Installations
IEC 60375	Conventions Concerning Electric and Magnetic Circuits

Document Number	Description
IEC 60376	Specification for Technical Grade Sulphur Hexafluoride (SF ₆) for use in Electrical Equipment
IEC 60383-1	Insulators for Overhead Lines with a Nominal Voltage above 1000V – Part 1: Ceramic or Glass Insulator Units for A.C. systems – Definitions, Test Methods and Acceptance Criteria
IEC 60383-2	Insulators for Overhead Lines with Nominal Voltage Above 1000V – Part 2: Insulator Strings and Insulator Sets for A.C. Systems – Definitions, Test Methods and Acceptance Criteria
IEC 60398	Industrial Electroheating Equipment – General Test Methods
IEC 60404-1	Magnetic Materials – Part 1: Classification
IEC 60417 DB Snapshot	Graphical Symbols for use on Equipment – Database Snapshots
IEC 60437	Radio Interference Test on High Voltage Insulators
IEC 60439 Series	Low Voltage Switchgear and Control Gear
IEC 60445	Basic and Safety Principles for Man-Machine Interface, Marking and Identification –Identification of Equipment Terminals and Conductor Terminations
IEC 60447	Basic Safety Principles for Man Machine Interface, Marking and Identification. Actuating Principles
IEC 60478 Series	Stabilised Power Supplies, D.C. output
IEC 60480	Guidelines for the Checking and Treatment of Sulphur Hexafluoride (SF ₆) taken from Electrical Equipment and Specification for Re-use
IEC 60502 Series	Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1kV to 30kV
IEC 60507	Artificial Pollution Tests on High Voltage Insulators to be used on A.C. Systems
IEC 62058-21	Electricity metering equipment (AC) - Acceptance Inspection - Part 21 : Particular requirements for electromechanical meters for active energy
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 60575	Thermal-Mechanical Performance Tests and Mechanical Performance Tests on Insulator Units
IEC 60598	Luminaires
IEC 60605 Series	Equipment Reliability Testing
IEC 60616	Terminal and Tapping Markings for Power Transformers
IEC 60617 Snapshot	Graphical Symbols for Diagrams – Database Snapshot
IEC 60644	Specification for High Voltage Fuse Links for Motor Circuit Applications

Document Number	Description
IEC 60652	Loading Tests on Overhead Line Structures
IEC 60664 Series	Insulation Coordination for Equipment within Low Voltage Systems
IEC 60688	Electrical Measuring Transducers for Converting A.C. Electrical Quantities to Analogue or Digital Signals
IEC 60706 Series	Maintainability of Equipment
IEC 60720	Characteristics of Line Post Insulators
IEC 60751	Industrial Platinum Resistance Thermometer Sensors
IEC 60754 Series	Test on Gasses Evolved During Combustion of Electric Cables
IEC 60793 Series	Optical Fibres
IEC 60794 Series	Optical Fibre Cables
IEC 60811 Series	Common Test Methods for Insulating Sheathing Materials of Electric Cables and Optical Cables
IEC 60826	Design Criteria of Overhead Transmission Lines
IEC 60840	Power Cables with Extruded Insulation and their Accessories for Rated Voltage Above 30kV ($U_m = 36kV$) up to 150kV ($U_m = 170kV$)
IEC 60885 Series	Electrical Test Methods for Electric Cables
IEC 60889	Hard Drawn Aluminium Wire for Overhead Line Conductors
IEC 60904 Series	Photovoltaic Devices
IEC 60909 Series	Short Circuit Currents in Three Phase A.C. Systems
IEC 60947 Series	Low Voltage Switchgear and Controlgear
IEC 60949	Calculation of Thermally Permissible Short Circuit Currents, Taking into Account Non-Adiabatic Heating Effects
IEC 61000 Series	Electromagnetic Compatibility
IEC 61034 Series	Measurement of Smoke Density of Cables Burning Under Defined Conditions
IEC 61070	Compliance Test Procedures for Test Plans for Steady State Availability
IEC 61082-1	Preparation of Documents Used in Electrotechnology Part 1: Rules
IEC 61084 Series	Cable Trunking and Ducting Systems for Electrical Installations
IEC 61089	Round Wire Concentric Lay Overhead Electrical Stranded Conductors
IEC 61099	Specifications for Unused Synthetic Organic Esters for Electrical Purposes
IEC 61109	Insulators for Overhead Lines – Composite Suspension and Tension Insulators for A.C. Overhead Lines with a Nominal Voltage Greater than 1000V

Document Number	Description
IEC 61123	Reliability Testing; Compliance Test Plans for Success Ratio
IEC 61124	Reliability Testing-Compliance Tests for Constant Failure Rate and Constant Failure Intensity
IEC 61131 Series	Programmable Controllers
IEC 61140	Protection against Electric Shock
IEC 61158 Series	Digital Data Communications for Measurement and Control
IEC 61194	Characteristic Parameters of Stand-Alone Photovoltaic (PV) Systems
IEC 61204 Series	Low Voltage Power Supply Devices, D.C. Output
IEC 61215	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules – Design, Qualification and Type Approval
IEC 61241	Electrical apparatus for use in the presence of combustible dust
IEC 61284	Overhead Lines-Requirements and Tests for Fittings
IEC 61395	Overhead Electrical Conductors – Creep Test Procedures for Stranded Conductors
IEC 61427	Secondary Cells and Batteries for Photovoltaic Energy Systems
IEC 61439 Series	Low Voltage Switchgear and Control Assemblies
IEC 61459	Low Voltage Fuses – Coordination Between Fuses and Contactors / Motor Starters – Application Guide
IEC 61467	Insulators for Overhead Lines – Insulator Strings and Sets for Lines with a Nominal Voltage Greater Than 1000V
IEC 61511	Functional Safety – Safety Instrumented Systems
IEC 61537	Cable Management – Cable Tray Systems and Cable Ladder Systems
IEC 61558 Series	Safety of Power Transformers, Power Supplies, Reactors and Similar Products
IEC 61641	Enclosed Low Voltage Switchgear and Control Gear Assemblies – Guide for Testing Under Conditions of Arcing due to an Internal Fault
IEC 61660 Series	Short Circuit Currents in D.C. Auxiliary Installations in Power Plants and Substations
IEC 61683	Photovoltaic Systems – Power Conditioners – Procedure for Measuring Efficiency
IEC 61724	Photovoltaic System Performance Monitoring – Guidelines for Measurement, Data Exchange and Analysis
IEC 61730 Series	Photovoltaic (PV) Module Safety Qualification
IEC 61773	Overhead Lines – Testing of Foundations for Structures

Document Number	Description
IEC 61850 Series	Communication Networks and Systems in Substations
IEC 61854	Overhead Lines – Testing of Foundations for Structures
IEC 61865	Overhead Lines – Calculation of the Electrical Component of Distance between Live Parts and Obstacles – Method of Calculation
IEC 61897	Overhead Lines-Requirements and Tests for Stockbridge Type Aeolian Vibration Dampers
IEC 61970 Series	Energy Management System Application Program Interface
IEC 62026	Low Voltage Switchgear and Controlgear Controller-Device Interfaces
IEC 62040	Uninterruptible Power Supplies (UPS)
IEC 62058 Series	Electricity Metering Equipment (A.C.) – Acceptance Inspection
IEC 62124	Photovoltaic (PV) Stand-Alone Systems Design Verification
IEC 62151	Safety of Equipment Electrically Connected to a Telecommunications Network
IEC 62155	Hollow pressurised and unpressurised ceramic and glass insulated for use in Electrical equipment with rated voltages greater than 1000V
IEC 62219	Overhead Electrical Conductors – Formed Wire Concentric Lay, stranded Conductors
IEC 62259	Secondary Cells and Batteries Containing Alkaline or other Non-Acid Electrolytes – Nickel Cadmium Prismatic Secondary Single Cells with Partial Recombination
IEC 62271 Series	High Voltage Switchgear and Control Gear
IEC 60270	High Voltage Test Techniques - Partial Discharge Measurements
IEC TR 60575	Thermal-Mechanical Performance Test and Mechanical Performance Tests on String Insulator Units
IEC TR 61200-53	Electrical Installation Guide Part 53: Selection and Erection of Electrical Equipment – Switchgear and Controlgear
IEC TR 61328	Live Working - Guidelines for the Installation of Transmission Line Conductors and Earth wires-Stringing Equipment and Accessory Items
IEC TR 61346 Series	Industrial Systems, Installations and Equipment and Industrial Products – Structuring Principles and Reference Designations
IEC TR 61459	Low Voltage Fuses – Coordination between Fuses and Contactors / Motor Starters – Application Guide

Document Number	Description
IEC TR 61641	Enclosed Low Voltage Switchgear and Controlgear Assemblies - Guide for Testing Under Conditions of Arcing Due to an Internal Fault
IEC TR 61646	Thin-Film Terrestrial Photovoltaic (PV) Modules – Design, Qualification and Type Approval
IEC TS 60815 Series	Selection and Dimensioning of High Voltage Insulators Intended for use in Polluted Conditions
IEC TS 61200 Series	Electrical Installation Guide
IEC TS 61394	Overhead Lines - Characteristics of Greases for Aluminium, Aluminium Alloy and Steel Bare Conductors
IEC TS 61438	Possible Safety and Health Hazards in the use of Alkaline Secondary Cells and Batteries – Guide to Equipment MANUFACTURERS and Users
IEC TS 61467 Ed. 1.0 b	Insulators for Overhead Lines with a Nominal Voltage above 1000V-A.C. Power Arc Tests on Insulator Sets
IEC TS 62351 Series	Power Systems Management and Associated Information Exchange – Data and Communication Security
IEEE Std. 32	Standard Requirements, Terminology and Test Procedure for Neutral Grounding Devices
IEEE Std. 80	Guide for Safety in A.C. Substation Grounding
IEEE Std. 115	Guide: Test Procedures for Synchronous Machines
IEEE Std. 142	Recommended Practice for Grounding of Industrial and Commercial Power Systems
IEEE Std. 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE Std. 1100	Recommended Practice for Powering and Grounding Electronic Equipment
IEEE Std. 1115	Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications
IEEE 1144	Recommended Practice for Sizing Nickel-Cadmium Batteries for Photovoltaic (PV) Systems
IEEE C62.41 Series	Recommended Practice on Surge Voltages in Low Voltage A.C. Power Circuits
ISO 1680-2	Acoustics - Test Code for the Measurement of Airborne Noise Emitted by Rotating Electrical Machines
ISO 8501 Series	Preparation of Steel Substrates Before Application of Paints and Related Products - Visual Assessment of Surface Cleanliness
ISO 9001	Quality Management Systems Requirements
NACE SP 0169	Control of external corrosion on Underground or submerged metallic piping systems

Document Number	Description
NACE SP 0177	Mitigation of AC & Lightning effects on metallic structures and corrosion control systems
NACE SP 0286	Standard recommended practice – Electrical isolation of cathodically protected pipelines
NACE RP 0285	Corrosion Control of Underground Storage Tank Systems by Cathodic Protection - Item No. 21030
NACE SP 0572	Design, Installation, Operation and Maintenance of Deep Ground Beds
NACE SP 0169	Control of external corrosion on Underground or submerged metallic piping system
ICAO Annex 14	International Civil Aviation Organization
NEMA VE-1 and VE-2	Cable tray & ladder manufacturing and installation

2.4 HEALTH, SAFETY & ENVIRONMENTAL REGULATIONS

All equipment, services and installations applied to the project shall meet all applicable regulations relating to health, safety and environmental requirements.

2.5 QUALITY ASSURANCE AND CONTROL

VENDORS and Sub-VENDORS shall comply quality systems satisfying the applicable requirements as defined in the relevant requisitions and other related project Specifications.

3.0 SERVICE CONDITIONS (TYPICAL FOR MIDDLE EAST DESERT. CHANGE AS APPLICABLE TO YOU)

3.1 ENVIRONMENTAL CONDITIONS

All electrical installations shall be suitable for operation at continuous maximum rating under the extremes of environmental specific conditions for each installation location.

The design environmental conditions are as given below:-

Maximum black bulb temperature	: 82°C
Peak shade temperature, two hours	: 60°C
Continuous ambient temperature	55°C
Minimum average ambient temperature	: 5°C
Maximum daily variation in temperature	: 25°C
Maximum relative humidity	: 98%
Maximum ground temperature at various below-grade-levels	
	: 35°C @ 800 mm
	: 38°C @ 650 mm
	: 40°C @ 500 mm
Minimum ground temperature	: 20°C @ 1000 mm below grade
Soil Thermal Resistivity @ 1m depth	: 237 to 319°C cm/W (As per civil geotechnical report)
Maximum infrequent heavy rainfall	: 25 mm/hour

Seismic Zone	: Zone 2A
Elevation not greater than	: 120 m A.S.L.
Maximum Isokeraunic level	: 10 days per annum
Maximum 3 second gust wind speed	: 122 km/hour
Solar radiation	: 120 mW/cm ²

All outdoor equipment's shall be designed to achieve its rated capacity with continuous ambient temperature unless specified otherwise in equipment DEP's, SP's, project specifications. All Outdoor equipment's shall be suitable to withstand ambient temperature of 60 °C, but not necessarily at rated their capacity.

INDOOR CONDITIONS

Indoor conditions exist inside control rooms, switch rooms, substations, battery rooms etc. and such rooms are considered to be air-conditioned (redundant system). Inside temperature is maximum 25°C with all units operating.

Equipment installed in such rooms shall be specified for a continuous operating temperature of 40°C, and at 50°C for two hours in one day.

GIS switchgear contains SF6 gas as an insulating medium. SF6 gas is non-toxic in normal situations, however after a fault clearance the by-products of SF6 gas decomposition are very toxic and special precautions must be taken when servicing the interruption chambers of these circuit breakers Safety procedures as set out in company SPs will be followed when handling SF6 gas and in the event of gas leakage.

Stationary batteries contain electrolyte which is hazardous for operation and maintenance personnel. Proper instruction for handling and storing shall be provided for each battery room. NiCd batteries contain cadmium while Lead-Acid batteries contain lead; both are toxic elements and require special care during battery disposal. Company rules shall apply for handling and disposal of battery chemicals.

Transformers contain oil, which will be retained in a catchment bund in case of leakage.

3.2 INGRESS PROTECTION

Ingress protection of enclosures for electrical equipment shall be in accordance with the requirements of IEC 60529. Minimum ingress protection shall be as follows:

Outdoor equipment's :

- | | |
|--|------|
| • Transformer cable boxes | IP55 |
| • Busduct | IP65 |
| • Motor | IP55 |
| • Distribution Boards (EHT DB, MOV DB) | IP54 |
| • All outdoor equipment (Other than listed above) | IP54 |

For equipment's installed within combustible dust areas:

- | | |
|-----------------------|------|
| • For Zone 20 and 21, | IP65 |
| • For Zone 22 | IP55 |

Indoor Equipment:

•	HV and LV switchgear	IP41
•	ENMCS	IP41
•	DC and AC UPS	IP41
•	Heater control panel (TCP)	IP41
•	VFD panel	IP41
•	Distribution Boards (Lighting MDB, Sub DB)	IP41
•	All other equipments (such as lighting fixtures JB's , Sockets etc.)	IP41
•	Motor	IP55

Specific requirements are defined in relevant equipment specifications.

4.0 AREA CLASSIFICATION(YOU CAN TAKE OUT FOR SAFE AREA PROCESS PLANT)

4.1 GENERAL

Hazardous areas will be identified in accordance with Part 15 of the IP Model Code of Safe Practice, Area Classification drawing and HSE project specific documents.

Equipment for use in hazardous areas shall comply with IEC 60079.

Area classification and the selection of apparatus for use in areas where there is a combustible dust hazard shall be in accordance with IEC 61241.

Lighting fixtures and its auxiliary equipment, Power and convenience outlets shall also comply with above guidelines.

Notwithstanding the Hazardous Area Classification requirements, all electrical equipment located within process unit boundaries shall be (minimum requirement) suitable for Zone 2, IIB, T3 hazardous area use. The term process unit boundaries applies to all areas handling flammable process fluids or where sulphur dust clouds could form

For battery rooms, all electrical/instrument equipment (extraction fans, switches, lighting, smoke/gas detectors, etc.) shall be certified for hazardous Zone 1 area, gas group IIC. Exhaust fan motors shall have type of protection Ex'e' or Ex'd' or Exde gas group IIC, exhausting to the outside of the battery room. The luminaires and convenience outlets shall be suitable for Zone 1, gas group IIC.

With reference to specific equipment for use in hazardous area location (Zone 1 or Zone 2 & Non-hazardous area), selection as a minimum, shall be based on the following table. For specific requirements relevant Specification/Datasheet shall be referred.

ITEM	HAZARDOUS AREA		NON HAZARDOUS PROCESS PLANT AREA	REMARK
	ZONE 1	ZONE 2	NON HAZARDOUS AREAS	

ITEM	HAZARDOUS AREA		NON HAZARDOUS PROCESS PLANT AREA	REMARK
	ZONE 1	ZONE 2	NON HAZARDOUS AREAS	
LV Motor	Ex-de/Ex-e	Ex-de/Ex-nA	Ex-nA	
HV Motor	Ex-d/Ex-p	1. Ex-de/Ex-p, IIB, T3 2. Ex-nA (Refer remark 1.)	Ex-nA	1.HV Motors with type of protection 'n' or 'e' shall not be installed where :- a. Motor voltage exceeds 6.6kV b. Motor drives centrifugal / screw hydrocarbon gas compressor.
RCU	Ex-de	Ex-de	Ex-de	
Junction Box	Ex-de	Ex-e	Ex-e /Ex n	JB's inside Battery room, shall be suitable for Zone-1, IIC, T3
Welding / convenience receptacles	Ex-de	Ex-de	Ex -de	Industrial type sockets shall be provided in transformer bay for oil filtration.
Lighting fixtures outdoor	Ex-de / Ex-e	Ex-de / Ex-e	Ex-de / Ex-e	Fence lighting shall be industrial type.
Distribution Boards / Local Control Panels	Ex-de	Ex-de	Ex-de	
Glands	dual certified Ex-d / Ex-e	dual certified Ex-d / Ex-e	dual certified Ex-d / Ex-e	
Exhaust fan motors and lighting in battery room	Ex-de/Ex-e, IIC.	NA	NA	
Electrical Heater	Ex-de	Ex-e	Ex-e	

NOTES :-

- Equipment's installed in non-hazardous areas outside process plant and buildings for e.g. Offices, gatehouses shall be of normal industrial type.

4.2 CERTIFICATES, DECLARATIONS AND TEST REPORTS

For all electrical equipment located in hazardous areas, certificates outlined below, shall be provided.

For electrical equipment in Zone 0, Zone 1 and Zone 2:

- A certificate of assurance or
- A certificate of conformity or
- A declaration of compliance for Ex (n) equipment, in case none of the other certificates is available.

The declaration of compliance shall cover both main and auxiliary equipment and shall at least contain the following minimum information:

- To which standard (national or international) the equipment conforms.
- MANUFACTURER's name.
- MANUFACTURER's type identification.
- Apparatus description.
- Markings and any other information required by the relevant IEC standard.
- Assurance by the MANUFACTURER that the equipment complies with the requisition and specifications.
- Additional conditions (if any) which apply to safe installation and operation of the equipment.
- MANUFACTURER's calculations and tests which confirm compliance with maximum temperature limits.

5.0 ELECTROMAGNETIC COMPATIBILITY (EMC)

Control measures shall be incorporated in the design to ensure co-located equipment and systems operate satisfactorily without malfunction, in the presence of electromagnetic disturbance. Design should also ensure that equipment have adequate immunity to disturbance and should not adversely add electromagnetic energy to the environment above the level that would permit interference-free radio communication and reception.

6.0 DESIGN PROCEDURES, STUDIES & CALCULATIONS

The following software shall be used for carrying out the various calculations (Shall be as per Contract or project specific) :

SOFTWARE	PURPOSE
DigSilent Power Factory/ Equivalent (Version 15.2.5)	Performing power system study requirements such as Load flow, Short circuit, Motor starting, Harmonic study and Relay coordination

CYME CYMCAP (Version 5.3)	Performing ampacity and temperature rise calculations for power cable installation requirements .
PSL CADD (Version 13), SAG 10 or CATenary	OHL design
Manufacturer's standard (Agi32)	Illumination calculation
AVEVA Cable router	Modelling of cable trays
AVEVA Clash Manager	Clash check

6.1 ELECTRICAL LOADS SCHEDULE

An "Electrical load list" showing equipment ratings, absorbed power, efficiency, power factor and diversity shall be produced. Electrical loads shall be classified as performing a service, which is 'vital', 'essential', or 'non-essential', as defined

Electricity supplies of enhanced reliability and having duplicate energy sources shall be provided to supply loads forming part of vital services.

The load list shall determine Peak loads and maximum running plant load with diversity factors as used below:

- Maximum Normal Running Plant Load = 100% continuous load + 30% intermittent load.
- Peak Load = 100% continuous load + 30% intermittent load + 10% standby load.

6.2 SYSTEM STUDIES

Electrical equipment's ratings and Electrical system design shall be finalized based on System Study Reports.

The following studies shall be carried out as a minimum :

- Load flow studies
- Fault level studies , according to IEC 60909
- Motor starting
- Restarting & Reacceleration studies
- Harmonic distortion studies
- Relay protection and coordination studies
- Load shedding studies
- Insulation Coordination Studies
- EMC Studies

Electrical System studies shall be carried out for single ended condition (With One of two transformer feeding the switchgear is off) and double ended condition (With both transformer feeding switchboard are on) as a minimum.

For each type of study, worst case conditions with regards to Fault level and impedance / length tolerances shall be considered. For example Minimum grid fault level & positive tolerances for impedances shall be considered for motor starting study.

For Maximum short circuit levels at HV switchgear, bus coupler of switchgear shall be considered as closed with both incomers on. For Maximum short circuit levels at LV switchgear, bus coupler of switchgear shall be considered as open with both incomers on.

Harmonic distortion level shall be determined at each bus and mitigation measures such as filters shall be recommended in power system study report. Harmonic distortion values shall be limited to values as mentioned in IEEE519.

Relay coordination shall be carried out for entire electrical network. Relay coordination shall be carried out taking into consideration various factors such as minimum fault level, equipment short circuit withstand rating, single ended operation, relay operating times etc.

Electrical system studies shall also consider STG with associated electrical equipment's.

6.3 CALCULATIONS

6.3.1 Cable Sizing

The following factors shall be taken into account:

- Continuous current rating
- Short circuit withstand capability of cable
- Voltage drop limits
- Earth loop impedance for small power cables

6.3.1.1 Continuous Current Ratings

Continuous current rating shall be determined based on following factors :

- Max. Continuous conductor operating temperature as per cable Manufacturers data
- Cable installation methods as described in section 7.8.
- Site environmental conditions as per clause 3.0 of this document.

6.3.1.2 Short-Circuit Withstand Capacity

Short circuit withstand current ratings of cable shall be determined based on following factors :-

- Limiting conductor temperature during short circuit.
- Short circuit levels at various switchboard
- Following short circuit withstand time may be considered depending on type of feeder for cable sizing calculation

Sr. no.	Type of feeder	With stand time (seconds)
1.	33kV/6.6kV breaker controlled feeders	1

2.	6.6kV/11kV Breaker controlled motors	0.5
3.	6.6kV fuse-contactor controlled motor feeder	0.01sec
4.	415V circuit breaker controlled transformer incomers	1
5.	415V Circuit breaker controlled feeder to other switchboard or DB	0.6
6.	415V fuse-contactor / MCCB (Current limiting type) controlled feeders	0.01sec

The copper tape screen or / and armour of HV cables shall be sized based on following fault rating for breaker controlled feeder :-

Sr. no.	Voltage level of Cable	Fault current and withstand time
1.	33Kv	7.5 kA for 0.5 sec
2.	11kV (for STG)	1 kA for 1 sec
3.	11kV (for unit transformer)	1 kA for 1 sec
4.	6.6kV cable	1 kA for 1 sec
5.	6.6kV Cable from unit transformer to motor.	1 kA for 1 sec

6.3.1.3 Voltage Drop Limits

Cable voltage drops, as a percentage of nominal voltage, at rated load shall be limited to the following values:

AC Circuits:

Description	Voltage Drop
Power feeders from switchboards (excluding distribution board feeders)	5%
Motor feeders – running	5% at motor terminals
Motor – starting (dynamic)	20% at motor terminals (Refer Note 1) 15% at switchboard
Road, Plant & interior lighting (from switchboard to the farthest light fitting)	5%
Process heaters	5%
Small power socket outlet circuits (At Socket Terminal) Welding outlets, switchgear to outlet	5%
UPS distribution, AC supply circuits	5% at end user (Refer Note 3)
UPS distribution, DC supply circuits	5% at end user (Refer Note 3)
Battery rack to charger	1%

Notes :-

- 1) The voltage available at the motor terminals during starting shall be adequate for developing the required torque for the application intended and should not result in overheating the motor and any other connected equipment
- 2) In specific cases (motors connected thru unit transformers), higher voltage drop at motor terminals may be considered provided confirmation is obtained from the motor VENDOR for delivering the required torque.
- 3) The voltage drop in DC UPS and AC UPS cables shall be consistent with the minimum system voltage at the distribution board and the minimum equipment operating voltage, but should not exceed 5 % in any case.

6.3.1.4 Minimum and Maximum Cable Sizes

Minimum and maximum cable sizes shall be as mentioned below :

- Minimum Cross sectional area for LV power cable & control cable / indication cables shall be 2.5 mm²
- Maximum Cross sectional area for multicore power LV (415V) cable shall be:
 - i. 185 mm² for motor cables
 - ii. 240 mm² for distribution feeder
- Minimum Cross sectional area for HV (6.6kV, 11kV and 33kV) multicore power cable shall be 25 mm².
- Maximum Cross sectional area for HV (6.6kV, 11kV and 33kV) multicore power cable shall be 240 mm².
- Maximum Cross sectional area for HV (6.6kV, 11kV and 33kV) single core cables shall be 630 mm².

6.3.2 Earthing & Lightning Protection System Calculations

Earthing system calculations shall be carried out in compliance with IEEE-80 for substation grounding.

The lightning protection system for the entire plant shall be designed as per BS EN 62305- Parts 1-4. Lightning System design shall be reviewed and approved by the COMPANY.

Calculations and studies for area shall include but not necessarily be limited to:

- Calculation of minimum earthing conductor cross sections required to withstand prospective earth fault current levels for the maximum short time duration as indicated by fault clearance time derived from the Protection Studies.

Duration of fault current shall be considered as 1 second for earth conductor sizing.

6.3.3 Current Transformer Sizing :-

All current transformers (CTs) for protection, metering and indication shall comply with the respective, relevant clauses of IEC 60044. The CT shall have appropriate VA rating

and accuracy limiting factor (ALF) that will ensure proper working of protective devices for all short circuit currents up to the rated value of switchgear.

Current transformers shall have a thermal rating at least equal to circuit requirements with margin as specified in 8.1.2 and a short time (through-fault) rating at least equal to that of the associated switchgear.

Current transformers shall have an output rating adequate to cater for the burden (CT leads, relay, etc.) connected to them.

The Accuracy Limit Factor (ALF) shall be selected with consideration to the maximum value of primary current up to which maintenance of accuracy is required.

For Class PX/Class X CT's knee point voltage calculation shall be carried out as per relay manufacturers catalogue.

In case of metering class CTs, the VA burden shall be matched closely to the connected VA, as it would affect the instrument security otherwise.

7.0 ELECTRICAL SYSTEM DESIGN(TYPICAL FOR A HV PROCESS PLANT. CHANGE AS PER YOUR PROJECT)

7.1 GENERAL

All designed electrical equipment shall be suitable for design lifespan of 25 years.

The transformers shall be designed as 2 x 100% capacity supplying the HV switchgear which in turn feeds the auxiliary transformers supplying the 415V switchgears for LV auxiliary loads.

All the loads will be categorized to be fed at various voltage levels as per clause 7.2. The voltage levels shall be: 33kV, 11kV, 6.6kV and 415V. The power supply to various AC/DC UPS units will be derived from the 415V LV Switchboards with back-up from an independent supply.

33kV Switchboards will be GIS type with 3 Incomers and one bus section. 2 Incomers shall be connected from 132/33 Kv Transformers and 3rd from STG Transformer. The bus section shall be normally closed. An interlock shall be provided in upstream 132 kV(say) buscoupler circuit breaker and downstream 33kV buscoupler circuit breaker to ensure the bus-section circuit breaker can only be closed if the upstream 132kV bus-section breaker is in the closed condition.

The 6.6kV switchboards each shall have two sections with the bus section circuit breaker in close position under normal operating conditions. All HV switchboards shall be provided with load shedding scheme.

6.6 kV Emergency switchboard Switchboard will have two main incomer (I/C-1, I/C-2), one standby incomer (I/C-3) and one buscoupler (B/C). Incomer -3 of 6.6kV emergency switchboard shall be fed from existing/new emergency source.

In normal operation, two main incomers & buscoupler shall be normally closed (NC) & standby incomer shall be normally open. The auto transfer scheme (ATS) shall be provided in I/C-3. The auto transfer scheme shall operate in the event of power failure from both main incomers. ATS shall trip both main incomer breakers & close standby incomer. On resuming the main power supply, restoring back to normal positions of

CB's shall be done through 25CH and selector switch relay with momentary paralleling in manual mode.

415V LV Switchboards each shall have two sections with the bus section circuit breaker in open position under normal operating conditions. Auto change-over scheme shall be implemented for these switchgears with two out of three interlock. Restoration of supply after changeover shall be either manual or automatic. Both the options shall be available. Momentary paralleling shall be allowed for manual/auto supply transfer without interruption.

UPS system shall be provided for vital loads and shall be designed in such a way to ensure the safe shutdown of the plant in worst scenario.

The LV substation auxiliary loads will be fed from dedicated sub-DBs whereas all process loads will be fed from LV main switchboards. Redundancy of supply shall be based on type of loads.

All protection, metering and control for HV switchboards and LV switchboards incomers and bus-coupler shall be supplied from 110VDC UPS source while instrumentation and process control system will be fed through 415/240V AC UPS power supply.

For LV outgoing motor drives, control voltage shall be derived from each feeder.

HSE requirements (if any) such as tripping power outlet feeders etc.) in case gas leakages / other emergencies shall be considered in switchgear control schemes.

Loads of Future plan shall be considered for designing of upstream electrical system.

7.2 STANDARD VOLTAGES & FREQUENCY

The applicable design system voltages and frequency shall comply with Company specification if any. In absence of same< following may be used as per IEC guideline.

System voltages, frequency and neutral earthing (Typical)

Frequency:	: 50Hz
High voltage:	: 132kV, 3 phase, solidly earthed : 33kV, 3 phase, resistance earthed :11kV, 3 phase, resistance earthed : 6.6kV, 3 phase, resistance earthed
Low voltage:	: 415/240V, 3 phase & neutral solidly earthed
UPS:	: AC solidly earthed, DC unearthed

Supply Variations

Steady state Voltage	± 10% at a voltage of 132kV and ± 5% at voltages below 132kV
Steady State Frequency	± 2%

Dynamic Voltage	± 15% at common buses
DC Supply variation	± 10% (For Switchgear control & indications, ENMCS and Telecom equipment's).

Fault Levels

Design short circuit levels for switchboards at various voltage levels shall be as follows :

132kV system	: Rated Short Time Current of 31.5kA for 3 seconds
33kV system	: Rated Short Time Current of 40 kA for 3 seconds
6.6kV system	: Rated Short Time Current of 40 kA for 1 seconds
0.415kV system	: Rated Short Time Current of 65 kA for 1 seconds (for main switchboards connected to 2.5 MVA transformer) : Rated Short Time Current of 50 kA for 1 seconds (for main switchboards connected to 1.6 MVA transformer)

Equipment ratings

Equipment shall be suitable for operation at the following voltages:-

Motors above 2200kW	: By unit transformer from 33kV or 132kV
Motors 185kW-2200kW	: 6.6 kV
Motors up to 160kW	: 415V
Lighting supply	: 415V 3 phase & neutral
Lighting systems	: 240V, phase & neutral
Instruments (non-vital)	: 240V, phase & neutral
Instruments (vital)	: 240V, phase & neutral (Through UPS except S/S-4)
Instruments (vital)	: 24V DC floating
Switchgear closing	: 110V DC floating
Switchgear tripping	: 110V DC floating
Welding outlets	: 415V, 3 phase & neutral
Convenience outlets	: 240V, phase & neutral

The following electrical supply shall be provided for FCS instrumentation system equipment:-

Control System Cabinets:	240VAC+10%, -15%; 50Hz±2%, (Redundant UPS supply)
Auxiliary power supply for Control Cabinets:	240 VAC ± 10%; 50Hz ± 2% (Non-UPS supply)

Electrical to provide following feeders to instrumentation at AC UPS and LV switchboard for each auxiliary room, STG building. Further distribution to individual cabinets, consoles shall be in instrumentation vendor's scope :-

1. 240V AC UPS – 1 hour backup (Redundant Feeders, Total 2 numbers)
2. 240V AC UPS – 4 Hours backup (Redundant Feeders, Total 2 numbers)
3. 240V AC Non UPS feeder – 1 number (non redundant)

The following electrical supply shall be provided for ENMCS/PRDA/SCADA system equipment:-

Workstations and printers:	240 VAC $\pm$ 10%; 50Hz $\pm$ 2% (One Normal and One UPS supply)
ENMCS/PRDA/SCADA Cabinets:	240 VAC + 10%, -15%, 50Hz $\pm$ 2%, (Redundant UPS supply)
Auxiliary power supply for ENMCS/PRDA/SCADA Cabinets:	240 VAC $\pm$ 10%; 50 Hz $\pm$ 2% (Non-UPS supply)

For DC UPS in STG control building, the voltage rating will be of 110 V.

7.3 PROTECTION, CONTROL AND MONITORING

All the substations shall be designed for unmanned operation. Under normal operation the electrical network system can be operated from local control panels or remotely monitored and controlled from Plant Control Room / ENMCS Room or from SCADA as applicable.

The electrical system shall be equipped with automatic protection, which shall provide safeguards in the event of electrical equipment failures or system mal-operation. Protection and Control shall be designed in accordance with the applicable standard drawings, codes and standard practices wherever mentioned: -

The referenced standard drawings if mentioned shall indicate the bare minimum requirement. For design which does not fully fit into any typical drawing, the local and international standards shall apply to ensure all equipment is adequately protected.

It is recommended to have same Vendor for all IEDs/protection relays within the same project in order to achieve easy interfacing and programming as well as easy operation and maintenance during the entire life span.

The protection scheme shall consist of a graded discriminatory system selected to enable all parts of the installation to operate safely, reliably and under control. In the event of a fault, the system design shall isolate only those circuits that are directly affected by fault.

All motors above 2.2MW shall be fed from respective motor unit transformers. Electrical and process safeguard trip matrix .

The LV motor safety switches are applicable for the process cooler with the platform. If there is no platform for process cooler / motors, no safety switches are envisaged.

All process trips shall be wired to instantly trip the circuit breaker as per trip matrix.

A start Permissive signal from Remote Plant CCR shall be required to start the motors above 5MW rating and this shall be achieved through SCADA (Refer process plant automation shared earlier).

For motors (synchronous or Induction) connected to 33kV switchboard with unit transformer and motor cable length exceeding 500m, separate differential protection relay for unit transformer (87T) and motor (87M) shall be provided. In this arrangement the motor differential protection shall be of low impedance type.

7.3.1.1 Instrument Transformers

Current transformers (CT's) and voltage transformers (VT's) shall be specified with characteristics, ratio, rated output and accuracy class that are suitable for their intended application with protection, control or monitoring devices.

The minimum accuracy classes for CT's shall be:

- Protection CT's = 5P
- Differential protection CT's = Class PX/Class 5P/Class X
- Metering CT's = Class 1.0

The minimum rated output of VT's shall be equal to the connected burden of the protection, control or monitoring devices, including lead burden, plus 25% spare capacity rounded up to the next standard rating.

The minimum accuracy classes for VT's shall be:

- Protection VT's = Class 3P
- Metering VT's = Class 1

7.3.2 Electrical Network Monitoring and Control System (ENMCS), PRDA & SCADA System

A substation Automation System integrating all the substations shall be provided. Substation Automation (ENMCS) shall enable to remotely monitor, control and coordinate the distribution components installed in the substations.

High-speed microprocessor based interface control units (ICUs) or Intelligent Electronic Devices (IEDs) or numerical relays shall be used for substation automation and protection system. All relays shall be numerical / digital with suitable interface port for fiber optic connection. The relays shall comply with IEC 61850 communication requirements. No ENMCS shall be installed in S/S-4.

The 33kV, 6.6kV Switchboards and Incomer and Bus section of 415V LV switchboards shall be provided with intelligent relays (IEC 61850) for communication of IO's with ENMCS. These relays shall be connected to Ethernet Switches provided in each Substation. All the Ethernet switches in each substation will be connected in a ring topology for reliable communication through Fiber Optic cable.

S/S will be provided each with one engineering work station, Ethernet switches & ENMCS controllers and also will have the main servers, SNTP server, one operator station HMI, one engineering station console, printer and GPS, each of which will be connected to Ethernet switch provided in the same building., will also have RTU with marshalling and isolation panel for communication with SCADA RTU at 132kV substation in power plant area if provided. In addition to above, AC and DC UPS, Exciter panels, partial discharge system of steam turbine generator and export gas compressor shall also be connected to ENMCS system.

HMI enables the operator to monitor, control and operate the switching elements (switchboards, transformers etc.) in the substation through Graphical User Interface (GUI) at substation level. Electrical equipment shall be represented in form of mimic diagram indicating all the protection, monitoring and control devices with their status and measuring parameters. The control shall be designed as per following guidelines :-

- a) 33kV Switchboard – All Motor feeders shall be controlled from plant FCS/IPS through IFB. The Incomers, Bus section, Transformer feeders and 33kV

distribution feeders shall be controlled locally (at switchboard) or through ENMCS operator station or through SCADA. However, all monitoring facilities shall be available for the whole switchboard from ENMCS.

- b) 6.6kV Switchboard - All motor feeders either with breaker or fused contactor shall be controlled from plant FCS/IPS through IFB. The Incomers, Bus-coupler and transformer feeders shall be controlled locally (at switchboard) or through ENMCS operator station. However, all monitoring facilities shall be available for the whole switchboard from ENMCS.
- c) 415V LV Switchboard - For all motor feeders ,Conventional hardwired control and safeguarding shall be provided from plant FCS & IPS through IFB. All required interfacing relays shall be installed in IFB. The Incomers and Bus-coupler shall be controlled locally (at switchboard) or through ENMCS operator station.

However Circuit breaker control signal (Close, open) shall be considered in I/O schedule and ENMCS engineering. Activation of this control signal shall be decided later.

Start permissive shall be sent from Remote CCR through ENMCS for start-up of motors above 5MW.This signal shall be considered in motor breaker closing logic.

Interface with FCS

ENMCS shall be hooked up with FCS Indications/alarms/control signals to be interfaced between ‘ “ENMCS and FCS’ shall be as per IO schedule .

Interface with SCADA

Signals to be interfaced with SCADA shall be hardwired from 33kV switchgear or transmitted on soft link from ENMCS to RTU . This RTU shall communicate with master RTU at 132kV substation if provided. All alarms, indication & control signals are to be interfaced with SCADA.

Similarly Signals from panels at STG substation shall be interfaced with SCADA RTU at STG substation. SCADA RTU at STG substation shall be interfaced with master RTU at 132 kV substation. All STG alarms, indication & control signals are to be interfaced with Yibal SCADA..

PRDA/ENMCS System at STG Unit

PRDA (Protective Relay and data acquisition) system for, STG control panel ,415V switchgear and AC/DC UPS etc. shall be provided in STG control building. Interconnection and IO's shall be as per architecture diagram and I/O list for STG. Protocol for communication between shall be IEC 61850.

PRDA/ENMCS system at STG substation shall be connected to ENMCS system .

Fiber Optic Network

Fibre optic network provided by Telecom group shall be used for interconnections of substations for purpose of ENMCS and pilot wire differential protection. Patch panels shall be provided by Telecom at each substation and STG control building for termination of fiber optic cables. Fiber optic cable between substations shall be terminated at these patch panels by telecom. Electrical shall route and terminate fiber optic cables inside substation for ENMCS & pilot wire differential protection.

7.4 OPERATION PHILOSOPHY

Switchgear buildings shall be designed for unmanned operation. Under normal operating conditions, the STG, 132/34.5kV power transformers along with 33kV GIS incomers and bus coupler will be controlled and monitored from SCADA control room. .

33kV System and below will be controlled and monitored from main process control location. In addition, each substation building shall be provided with ENMCS (Electrical Network Monitoring and Control System) workstation for programming of the relays, monitoring and control of electrical equipment.

7.5 EARTHING SYSTEM DESIGN

7.5.1 General

The objective of the earthing and bonding applied throughout the facility is to eliminate danger to personnel and to minimize disturbance and damage to plant arising from: -

- Direct or indirect contact with live conductors
- Static electricity

The plant earthing system shall be interconnected with power plant earthing system by two properly rated links. Details of interconnection points shall be provided as a part of earthing design system In earthing layout drawing.

An earthing system shall meet the following requirements; it shall:

- Be designed to achieve a high standard of reliability by, incorporating sufficient redundancy.
- Achieve and maintain a resistance to earth, which shall be less than, or equal to, the specified value over the expected life of the installation.
- Be corrosion resistant.
- Be mechanically robust and/or protected against mechanical damage.
- Be capable of carrying, without deterioration, the maximum earth fault current that is likely to occur during the expected life of the installation.
- Keep step, mesh and touch voltages below safe limits for outdoor and gas insulated substation.
- Incorporate facilities for periodic checking of the resistance-to-earth of the earth electrodes.

The star point of transformers shall be earthed as per dual neutral earthing . Depending on the voltage level, earthing shall be via either resistor or solid earth. The system earthing at low voltage shall be TN-S in accordance with IEC 60364-3. Two numbers of separate earth pit shall be considered for transformer.

The 33kV system shall be resistance earthed through the NER (2000A) of the 132/34.5kV Transformer secondary.

The 33/6.9kV transformer neutral shall be earthed via 400A rated neutral earthing resistor. 33/11.5kV and 33/6.9kV Unit transformers shall be earthed via 20A neutral earthing resistor.

High voltage winding of STG step up transformer shall be resistance earthed through resistor (2000A) of 11/34.5 kV Transformer.

The neutral point of the low voltage AC system will be solidly earthed. There will be separate neutral and protective (earth) conductors throughout the system i.e., the TN-S system.

Transformer neutral shall be directly connected to two independent earth pits, which shall be connected to main earth grid.

The neutral earth cable shall be of the same size and voltage rating as the phase cable.

The connection of the neutral earth cable to the earth rods shall comply with standard drawings. At no time shall the neutral be disconnected from the earth mass, causing the neutral potential to "float".

48V DC supply system shall be unearthed.

110V DC supply system shall be unearthed.

415V/240V AC supply system shall be solidly earthed.

Earth fault detection equipment will be provided with the rectifier/charger units for 415V/240V AC UPS (3 phase) system and with the DC distribution board for the 110V DC UPS system.

Instrument Earth and Electrical Safety Earth systems will be kept separate but bonded at the lowest common point to prevent any events causing one earth system potential to rise in relation to the other. The earthing system and requirement shall also take into consideration the instrument's vendor's recommendation.

Separate telecommunications clean earth shall be provided as per DEP 32.71.00.10-Gen. This clean earth shall not be connected to other clean earth systems such as the instrument clean earth. The telecommunications earth busbar should be connected to the electrical safety earth at one point only and by the most direct route using copper cable of at least 70 mm².

Earth pit/grid shall be provided for telecom towers .

If a telecommunications tower is located nearby, the earth electrodes provided for lightning protection should be used for the telecommunications earth otherwise separate earth electrodes should be buried near the equipment room.

The metallic enclosures of electrical equipment shall be bonded to the plant earth grid. All structural elements of storage tank shall be bonded to form a single conductive structure which is to be connected to the plant earth grid .

The earth grid shall comprise stranded copper earthing cables with green/yellow PVC sheathing and shall extend through the plant in the form of a closed ring.

Plant earthing grid shall be connected to power plant earthing grid at least at two points.

Earth grid shall be laid underground at depth of 600mm. As a general rule, equipment's, metallic structures, metallic skids, Mechanical equipment's shall be connected to earth grid using two separately routed earth conductors. Earth conductors shall be connected at diametrically opposite points.

Size of earth conductor shall be decided based on the fault current conductor is likely to carry and the clearance time of protective devices. Minimum sizes of earthing conductor shall be as defined in company SP.

Solid copper rod of 15mm dia as minm. shall be used as vertical electrodes in earth pit.

Lightning protection shall be provided for as per BS EN 62305.

Earth resistance shall be limited to values as specified in IEC.

Clean earth resistance value as mentioned in the C&A doc. 'shall be considered for instrumentation.

Telecom Clean earth resistance value shall be as mentioned in Telecom doc.

7.6 LIGHTING SYSTEM DESIGN

7.6.1 General

Lighting fixtures shall be of LED type taking into consideration in reducing the carbon footprint.

LED lighting luminaires shall be fabricated in compliance with IEC 60598-1, IEC 62722 2-1: Luminaire performance – Part 2 – 1: Particular requirement for LED and IEC 62504 terms and definitions for LEDs and LED modules in general lighting.

Dynamic lighting shall be provided for main control room. The system works by changing the color temperature and intensity of light automatically throughout the day.

Dimmer control system shall be provided for the Control room, Training room, Conference room / Meeting room.

Lighting design shall take into consideration appropriate lighting for the following:

a) Normal Lighting

i) Indoor Lighting

The indoor lighting fixtures shall be fed from lighting distribution board.

ii) Outdoor Lighting

All The outdoor lighting fixtures including shelter lighting shall be fed from area lighting distribution board, shall be photo-electric relay controlled and provided with a maintenance override switch and timer.

Perimeter security fence and Street lighting (except escape routes) shall be fed from normal lighting distribution board.

b) Emergency Lighting

The emergency lighting fixtures shall be fed from emergency distribution boards. Back-up power supply for emergency distribution boards shall be fed from independent AC power source through step-down transformers). This supply shall be provided for all emergency lighting panels except in Sulphur Blocking Area where, emergency light fittings will have built-in batteries and inverter.

The number of emergency luminaires in relation to the total number of fittings shall be typically as follows:

1. Utility area - 20%
2. Process area - 10%
3. Administrative area - 5%
4. Control room and auxiliary rooms - 50%
5. Substations, field auxiliary rooms, compressor and generator buildings - 30%

c) Emergency Exit Lighting (Escape)

Emergency exit light fittings shall be provided in all escape routes which shall be fed from emergency distribution board and also have integral batteries rated to maintain the lighting for at least 60 min. Back-up power supply from independent power source shall be provided for all emergency lighting panels .

As specified in BS 5266, for escape routes up to 2m in width, the horizontal illuminance on the floor along the center line of an escape route shall not be less than 1 lux and the central band consisting of not less than half of the width of the route shall be illuminated to a minimum of 50% of that value. Wider routes will illuminate as open area or 2m bands.

7.7 SMALL POWER SYSTEM DESIGN

Power supplies shall be derived from Normal 415V, 3 Phase, 4 wire, Distribution boards. The number and location of outlets should be based on the maintenance activity expected in the area.

7.7.1 Convenience Socket Outlets

Convenience socket outlets to be provided for process plant area. Such outlets to be installed away from hazard, in safe area as far as possible.

16A, 240V AC Single phase and neutral convenience outlets to supply portable tools and hand lamps shall be provided within the plant area.

16A, 240V AC single phase sockets shall be reachable using extension cable 30 meters length in plant area.

Convenience socket outlets inside control rooms, telecom room, switch rooms and domestic areas shall be to BS1363 (British style, 13Amps, square three pin plugs). Convenience sockets inside building shall be located with 5 meter spacing between two sockets.

16A single phase, 240V socket outlet of the IEC 60309 standard shall be installed in the transformer compound at 20 meter intervals.

All the convenience socket outlets socket outlets feeders shall be fitted with RCD with sensitivity as required .

Not more than 8 socket outlets shall be served from a single circuit derived from a distribution board in the substation.

7.7.2 Welding Socket Outlets

415V, 63A 3P+N+E Welding socket outlets shall be provided for the process plant area. Such outlets to be installed away from hazard, in safe area as far as possible.

63A socket outlet shall be reachable using extension cable of 20meter in plant area

At each substation Transformer yard shall be provided with heavy duty, weatherproof, three phases and neutral, interlocked switched socket outlets, rated 125A, 415V, and complying with IEC 60309 standard.

All power outlets installed on the process area shall be suitable for Zone 1 gas group IIB use, outdoor installation (certification shall be provided).

All Welding socket outlets shall be protected with an RCD with sensitivity as per DEP 33.64.10.10-Gen.

Not more than 4 socket outlets shall be served from a single feeder derived from a LV switchgear in the substation.

7.7.3 Aircraft Warning Lights

Aviation warning lights shall comply with ICAO (International Civil Aviation Organization) requirements country Civil Aviation Authorities. Aviation warning lights shall be designed and installed for the tall structures such as Flare stack, communication tower, **fired heater, and tall structures whose height more than equal to 45 meters**. The luminaires shall consist of a double lamp unit with automatic changeover to stand-by lamp upon failure of the operating lamp.

The aviation warning lights shall be suitable for high temperature and radiation. Aviation lighting shall be designed to withstand all foreseeable environment. The bulb used shall be designed for long life, rough service and vibration service type. Aviation warning light shall be provided with complete automatic control panel. Power supply shall be from UPS. LED type lamps shall be considered for aviation lights.

Aviation lights for telecom tower will be provided by Telecom tower Vendor.

. Cabling shall be fire resistant as per IEC 60331.

7.7.4 Illumination levels

Lighting system shall be designed to achieve the illumination levels indicated in Appendix-1.

A fouling factor of **0.85** for indoor and 0.8 for outdoor as per DEP 33.64.10.10-Gen shall be considered for arriving at the required illumination levels indicated in the above table.

For indoor lighting type of mounting for luminaire shall be decided based whether building has false ceiling or no false ceiling. For building with false ceiling recess/Flush mounted luminaires can be used. For buildings without false ceiling surface mounted luminaires can be used.

LED luminaire shall be provided for EXIT lights installed above the doors. Exit lighting shall be white text on green background.

LED flood light/high bay luminaries may be used at height in locations such as warehouses.

All high bay luminaries used in equipment houses/shelters shall be controlled (on/off) by local switches.

The lighting installations for areas that require surveillance by CCTV, the level of illumination and the type of luminaries shall be agreed with CCTV system Vendor.

Circuits in areas will be mixed across phases (normal and emergency) to ensure adequate level of illumination in the event of one circuit failure.

Light fitting shall be of LED type. Outdoor type flood lighting luminaires material shall be die cast aluminum alloy, high corrosion resistance and weather resistance. It shall be provided with toughen glasses to withstand the extreme climatic condition. Indoor type luminaire housing material shall be mild steel/GI with powder coating.

7.8 CABLING SYSTEM DESIGN

All cables, in general, shall be laid underground/buried in accordance with company standard drawings. Routing and general arrangement of all cables (i.e. power, instrumentation & control and communication cables) shall be planned concurrently with main pipe runs, structural steel work, civil works etc. to provide direct routes wherever possible. Segregation shall be provided between power cables and instrumentation/communication cables to avoid interference. Intrinsically and non-intrinsically safe circuits shall be segregated.

Generally HV & LV cables shall follow different routes however if it is unavoidable, then HV & LV cables shall be laid in same trench separated by vertical tiles. Cables on normal and emergency services and cables to duplicated equipment shall generally follow separate routes/trenches, taking due regard to minimizing the hazards associated with mechanical, heat, oil, chemical, and fire damage. HV cables shall be earthed at both ends. Telecom and Instrument cables shall not be laid in the same trench with electrical power and lighting cables. Cable tie requirements on cable ladders, trunking requirements etc shall be as per company standard drawings.

Cables crossing the roads and cable trenches in concrete paved areas shall follow company standard drawings.

The space between cables (electrical and other services) and pipelines shall be in accordance with company standard drawings and IEC guidelines. Single core cables shall be laid in trefoil formation and be braced by non-magnetic clamps at intervals of 1 meter. All multicore cables installed on cable trays or supports shall be secured with stainless steel cable ties only.

Cables for safety critical equipment which may require power during a fire emergency event (e.g. F&G detection, emergency lighting) shall be fire resistant as per IEC 60331. Cables shall be run physically separated from each other and other cables via shortest practical route within the building along the walls with mechanical protection provided for entire route. Cable trenches must be sufficiently wide with no sharp bends to allow for proper segregation of cables.

Galvanized Iron (GI) Cable Trays shall be provided for the routing of the interpanel cables. The cable entry for substation building shall be from bottom & only mechanical supporting arrangement shall be provided for large cables to avoid stress on gland plate. Cable trays shall be protected through cover for horizontal runs (if exposed to direct sunlight) and for all vertical runs.

All cables shall be laid in single lengths without any joints unless exception is approved by COMPANY.

It shall be ensured by cable manufacturer that cable supplied shall have round outer shape.

Cable support system shall comprise of hot dip galvanized trays/ladders, suitable for the environment as per ISO 1461. Prefabricated galvanized steel with increased zinc thickness (preferably 80µm) shall be provided for all electrical erection materials used as cable supports. Protection with zinc paint shall be provided on site after cutting or drilling the pregalvanised structures. Multi-cable penetrations shall be used for wall/bulkhead penetrations. Where penetration is through a fire resistant wall, measures shall be taken to ensure that the fire rating is not impaired at this point. Completed cable transits shall have a fire rating equal to that of the wall where it is installed. All cable penetrations shall be sealed.

The Cable racks and trays shall be closed by removable top covers, allowing adequate ventilation, in situations where:

- a) mechanical damage of the cables is likely to occur during plant maintenance activities,
- b) oil or chemical spillages on the trays can be expected,
- c) shielding is required against direct solar radiation.

MCT block shall be used for the electrical cable entering the control room/auxiliary room /instrumentation room.

Each end of cable tray /rack shall be connected to the main earthing network. When cable tray /rack system is broken (if not electrically continuous), cable tray on either side of the break must be bonded together. Cable tray /rack shall be connected to main earth grid at every 25 meters interval.

Underground cables (direct buried) shall be installed as per company standard drawings. Cable route and cable joint markers shall be installed visibly at ground surface level in accordance with the Standard Electrical drawings.

Cable number shall be embossed on a SS anodised plate and installed in accordance with the Standard Electrical Drawings.

Cables shall be identified with their full cable numbers, as detailed on the cable schedule, at both termination points, at every change in direction. Cable tag shall be provided at 5 meter intervals along route length for buried cable and at 25 meter for above ground cable.

Cables shall also be numbered where they branch off from a main route and at both sides of a road crossing.

7.9 ELECTRICAL HEAT TRACING

Electrical trace heating systems shall comply with relevant IEC standards. All trace heating tapes shall be of the parallel circuit self-regulating type. The tapes shall have over-braiding with a low smoke, flame retardant outer sheath. All material and components shall be suitable for Zone 1 service. All circuits shall have earth leakage

protection. All JB's for trace heating shall be of adequate size to prevent cable congestions. The terminals shall be of screw type, spring-loaded terminals shall not be used.

Separate outdoor DB's shall be provided for trace heating circuits.

Heat Tracing DB MCB's shall be provided with "Tripped on Fault" alarm contacts, all contacts being wired in series to outgoing terminals to provide a common alarm signal from each DB.

7.10 CATHODIC PROTECTION

The cathodic protection system shall be designed in accordance with the relevant CP standard NACE specification . For impressed current method the CP current shall be supplied from LV switchboard using a TR unit with a rated output no greater than 48V.

7.11 HVAC MCC

HVAC drives shall be fed from dedicated 415V LV HVAC MCC . The power supply for HVAC MCC in various buildings will be fed from the LV switchgear in the respective building.

7.12 Electrical Isolation

All electrical isolations shall be designed in accordance with below electrical procedures to ensure High voltage and Low Voltages equipments are proved dead ,earthed and safe to work. In addition all interlocks including earth switches shall be designed to address requirement as per company procedures/standards. Note all equipments connected from electrical supply shall be treated live as long as electrical isolation not undertaken as per Permit to work system. Electrical isolation/de-isolation shall be carried out by Authorised/Competent Electrical Person to ensure third party such as mechanical crew etc have acknowledged that the equipment is electrical isolated/locked accordingly. All such matters will abide by company safety standard procedures.

8.0 ELECTRICAL EQUIPMENT & MATERIALS

8.1 GENERAL

The electrical power system shall be designed taking into account of the requirements for an unmanned facility. The design and Equipment selection shall be based on minimum maintenance and minimum intervention requirements. The design shall be such that routine inspections can be carried out without shut down of Equipment. All abnormalities shall be displayed on the respective panels without a need to open the panel.

The design shall take full account of the operation and maintenance of all electrical installations in term of requirements necessary to facilitate access for operation, inspection, maintenance, repair and replacement. The selection of electrical equipment shall take into consideration Equipment efficiency.

Paint shade for electrical equipment installed outdoor and indoor shall be RAL 7035.

The selection of the equipment shall be based on minimum life cycle cost.

8.1.1 Design Margins for Equipment's

Following Margins as a minimum to be considered over actual calculated load requirement, for sizing / rating of various equipment's:-

Sr. No.	Equipment	Margins	Remarks
1.	HV/LV switchgear		
1.1	Fault current Rating (For HV switchboard)	10%	over Calculated Short circuit level.
1.2	Busbar continuous Current rating	--	Current rating shall be equal to Connected transformer full load current. Hence no design margin / Spare Margin is envisaged.
1.3	LV Switchboards busbar continuous current rating	15% 15%	For future Capacity. Design margin (For switchboards Not connected to transformer)
1.4	Outgoing motor feeders (HV/LV) current rating	As per motor kW rating	
1.5	Outgoing bulk power feeder (HV/LV) continuous current rating	20%	For future Capacity
2.	Transformer KVA rating.		
2.1		10%	For future Capacity
2.2		10% (for HV loads) 10% for LV Loads	Margin for Process load uncertainties These margins to be considered for sizing of transformer for initial phase. These Margins shall be revised as the process loads get finalized.
2.3		5%	Design Margin (Transformer loading as per DEP)
3	AC/DC UPS kVA	15%	For future Capacity

	Rating	5%	For Design margin
5.	ENMCS/PRDA/SCADA I/Os	20% 5%	For future Capacity For Design Margin

8.1.2 Sparing Philosophy

Spares as mentioned in the table below shall be considered as a minimum:-

Sr. No.	Equipment		
A	Switchgear	Equipped Spare Feeders	Non - Equipped Spare Feeders
1.	HV Switch board feeder (6.6kV & 33kV)	As Per respective Single line diagram.	
2.	LV switchgear/MCC outgoing feeders	20% of each Size. (Subject to minimum 1 for each size)	20% of each Size. (Subject to minimum 1 for each size)
3.	LV Distribution Board outgoing feeders	25% (Subject to Minimum 2 from each size)	
4.	AC/DC UPS distribution boards outgoing feeders	20% of each Size. (Subject to minimum 1 for each size)	
B	Cables	Number of spare cores	
1.	Control Cable Cores	10% spare cores with minimum one core.	
C	Cable Tray / Trench	Space for future cables	
1	Space for future cables	25% space for future cables for each route. 25% spare sleeves in underground trench crossing the road.	

8.2 STANDARDISATION

Equipment and Manufacturer standardisation shall be addressed to the maximum extent to reduce the spare parts, training, support etc.

8.3 ELECTRICAL SUBSTATIONS

Switchgears, distribution boards and other equipment's shall be placed in substation as per the clearances mentioned in section 8.4.

Substation Switchgear rooms shall be equipped with normal & emergency lighting, convenience outlets, air conditioning, telephone sets, display board, manual rack / cupboard and other standard accessories as outlined in Company standard drawings and international guidelines.:

HVAC shall be provided for each substation. Separate Battery room shall be provided for each substation. Battery room shall be provided with Hydrogen detectors. HVAC equipment's shall be installed over the substation roof.

The transformer yard shall be located adjacent to the switchgear building to accommodate the transformers. The transformer yard shall be fenced with gate. The transformers compound shall have separate road access.

The cable entry for substation building shall be from bottom. All cable entry holes in the substation floor or walls shall be suitably sealed. Where such cable entry openings are required to be gas tight and/or, multi-cable transits blocks shall be installed, or silicone foam, weak-mix concrete (in floors only) or a chemical compound with subliming heat resistant and fire retardant properties may be used.

8.4 EQUIPMENT LAYOUT

Minimum clearance values for equipment's to be installed in substation shall be as follows :

Description	Minimum Clearance
HV Switchgear Front	2500mm
LV Switchgear Front	1500mm
Between HV and LV Switchgear	2500mm
Between LV Switchgear and second row of LV Switchgear	1500mm
Rear side of HV Switchgear	1000 mm
Rear side of LV Switchgear and VFD (with no rear access)	100mm
Rear side of UPS	1000mm*
Left/Right hand side of HV and LV Switchgear	Min. 1000mm and space for two extra panels (one each on either side)
Above Switchgear	1000mm
Clearance around battery racks	1200mm*

Description	Minimum Clearance
Clearance around transformers	1000mm **
Clearance around EDG	1000mm

*The clearances shall be revised based on Manufacturers's recommendations.

8.5 ****CLEARANCE REQUIREMENTS BETWEEN TRANSFORMERS / WALLS SHALL BE AS PER IEC 61936. HIGH VOLTAGE SWITCHGEAR**

High Voltage switchgears shall comply with the requirements of project relevant drawings, this specification and IEC 62271. The arrangement of components on and within switchboards shall be standardised as much as possible.

The HV switchgears shall be internal arc classified according to IAC A FLR, reference to IEC 62271-200 with an arc duration of 1sec. Type test reports regarding internal arc withstand performance shall be available in the quotation stage.

The continuous current rating of the 33kV GIS (SF6)/6.6kV switchboard shall be determined from the full load rating of feeding transformers that supplies the switchboard. The gas insulated switchgear shall be sealed for life.

The 33kV switchgears will operate normally with bus section in closed position therefore no change-over scheme is required.

The 6.6kV AIS switchgear shall be constructed as metal-clad, arc-proof, air-insulated, modular and fully withdrawable type. Type of feeders (contactor+fuse combination or Circuit breaker fed) shall be as indicated in single line diagram. **When motor rating exceeds rating 1500kW,a circuit breaker shall be used.**

The 6.6kV Switchboards shall consist of two sections and one bus-Coupler as shown on the Key single line diagrams. The supply to each section shall be from separate station auxiliary transformer. In normal operation each section is supplied from individual transformer and bus section circuit breaker shall remain Close.

For HV Switchboard equipped with vacuum contactor fuse switch units, the inrush current of unit transformers, motors or VFDs shall be considered for contactor selection and protection scheme arrangement.

Protection and metering shall be as specified in relevant Single line diagrams. Meters used in 33kV and 6.6kV switchgear shall have harmonic THD measurement capability. Meters shall have facility for measurement of THD up to the 50th harmonic level.

8.6 **LOW VOLTAGE SWITCHGEARS, BUSDUCTS AND DISTRIBUTION BOARDS**

General:-

The 415V AC switchgears shall comply with the requirements of this specification and IEC 61439. The arrangement of components on and within switchboards shall be standardised as much as possible. Circuit breakers shall comply with and be type tested to IEC 60947. Meters used in 415V switchgear shall have harmonic THD measurement capability. Meters shall have facility for measurement of THD up to the 50th harmonic level.

8.6.1 LV Switchgears/MCC's

The 415V switchgears shall comply with the requirements of this specification and IEC 61439 and project specification.

The switchboards shall be modular type, Form 4B for Incomer & Bus sections and Form 3B for all outgoing modules as a minimum, double front type tested and of the fully withdrawable type. For STG, single front arrangement, type tested and fully withdrawable switchboards shall be provided.

With regard to safety of personnel, assemblies shall be tested with respect to their ability to withstand internal arcing. The MANUFACTURER shall confirm the successful assessment in accordance with IEC TR 61641, Criteria 1 to 7. Test reports shall be made available in the quotation stage.

The continuous current rating of all switchboards, including incoming cables and incoming circuit breaker, shall be determined from the full load rating of the transformer that supplies the switchboard. Short circuit withstand rating shall be as per System study report fault level plus the margin (minimum) as specified in section 8.1.2.

415V Switchboards shall consist of two sections and one bus-section as shown on the Key single line diagrams. The supply to each section shall be from separate transformer. In normal operation each section is supplied from individual transformer and bus section circuit breaker shall remain open. A source changeover system is required to ensure continued power supply to Bus A and Bus B in the event of loss of respective incoming supply. Restoration of power supply after auto changeover shall be possible with manually or Automatic. **Both restoration options (Auto and manual) options shall be available at switchgear.** The arrangement of change-over scheme shall be as per project relevant SLD drawings and as per specification. Control supply is tapped from phase and neutral with or without control transformer as per company policy

LV switchgear incomer shall be suitable for busduct (Top entry) or cables (Bottom entry) as indicated in single line diagrams of respective boards. Cable entry for outgoing feeder shall be from bottom. The use of busduct shall not affect the pressure relief mechanism of the LV switchgear (if provided).

In order to reduce the fault level of LV sub-distribution systems, fuses or MCCBs equipped with current limiting protection device (I^2t) can be used for LV feeders supplying those DB's. However, while using MCCB, the limiting current factors shall be clearly defined.

Fully equipped and non-equipped spare compartments shall be provided in each switchboard. Refer Section 8.1.3, for number of spares to be provided.

Interface with ENMCS shall be as defined in Electrical and Instrument Interface I/O schedule.

8.6.2 LV Busducts

The LV busduct shall be supplied by using high reliable, robust, metal enclosed, encapsulated and sandwich type (Non segregated) arrangement. Busduct current rating shall be atleast equal to connected switchgear busbar rating. The incoming feeders from feeding transformers shall be busduct type for transformers with rating $\geq 2000\text{kVA}$. All other LV switchgears connected to transformer 1600kVA and below shall be connected using cables. Canopy shall be provided for busduct installed outdoor to prevent from direct sunlight.

8.6.3 LV Distribution boards

Distribution boards shall be of 1kV AC, 1.2 kV DC, rating and conform to IEC 61439. All outdoor distribution boards shall be of Form 2B minimum, the weatherproof enclosure type and shall be arranged so that the door or cover can be locked in the closed position.

For distribution boards with rating less than 63A, Short circuit rating for distribution boards shall be 20kA for 1 second.

For distribution boards with rating equal to 63A up to 160A, Short circuit rating for distribution boards shall be 25kA for 1 second.

For distribution boards with rating above 160A upto 630A, Short circuit rating for distribution boards shall be 35kA for 1 second.

All distribution boards shall provide satisfactory cable entry for all cables which could be required for the number of circuit facilities provided and shall have the neutral bar drilled for the full number of single phase feeders. Each distribution board shall have removable bottom gland plates.

Arrangement regarding number of incomers, requirement of bus sections shall be as indicated in respective single line diagrams.

Refer Section 8.1.3, for number of spares to be provided for each distribution board. Spars shall be equipped with required switchgear and protection and wired up to terminal block.

Each distribution and control board incoming circuit shall be provided with a main load-break isolating switch. The rated current of the load-break isolating switch shall be not less than the maximum design capacity of the distribution board.

Outgoing circuits from LV and DC distribution and control boards shall be equipped with MCCBs, MCB's or fuses. Adequate earth fault protection shall be provided for all outgoing feeders. Outgoing circuits feeding ventilation fans and external lighting systems shall be further equipped with control contactors in the distribution boards. 20% spare terminals (Shorted) shall be provided in each distribution board. All breakers, switches shall have padlocking facility.

Interface with ENMCS shall be as defined in Electrical and Instrument Interface I/O schedule. Signals as per ENMCS I/O list shall be provided from each DB to ENMCS hardwire interface panel.

8.7 POWER & DISTRIBUTION TRANSFORMERS

The power transformers along with incoming and outgoing plant feeders shall be sized in accordance with the design plant peak loads and future expansion loads as per the Load List. Refer section 8.1.2, for margins to be considered for sizing of transformer.

Each transformer NER will be directly connected to two independent earth pits, which will be further connected to the main earth grid to ensure proper earthing of the system.

The 33/11.5kV (or 6.9kV) Unit transformers shall be adequately rated and the neutral shall be earthed through NER protection requirements and project specifications. The Motor Vendor shall size the NER as per motor design requirements; the actual value to

which the earth fault current shall be limited but sufficient to ensure reliable operation of the associated earth fault protection shall consider the followings:

- The earth fault should be restricted to be higher by 3 times the network capacitive current
- The earth fault level shall not cause damage along its path i.e. Cable shield and machine stator, steel plating
- The earth fault protection shall be able to detect the fault current without any sensitivity issues.

The 33/6.9kV Power transformers shall be adequately rated and the neutral shall be earthed through NER to limit the earth fault current to 400A.

The 6.6/0.415kV transformers neutral shall be directly earthed.

Oil-immersed transformers rated 3150 kVA and below shall be hermetically sealed.

The transformers shall be capable of withstanding infrequent re-starting loads of up to 1.8 times the transformer rated current. Five such restart may take place in succession at 5 second intervals.

Motor unit transformer shall withstand 3 successive motor starts and further 2 successive start after 0.5 hour cooling period. The motor unit transformers shall be designed for natural cooling (ONAN).

The unit transformers for large motors shall be provided with OFF-Circuit Tap Changer (OCTC) for a range of +/- 5% in steps of 2.5%.

The transformers rating shall be selected with respect to THD harmonics on the load and local ambient conditions. De-rating factor shall be employed while selecting the transformers.

Impedance, Tap range (OLTC and OCTC) and Optimum tap setting of transformer shall be decided based on power system study reports.

Connections between transformers LV secondary terminal boxes and switchgears shall be made using busduct/cables as mentioned in project specification. Where single core cables are used, cable boxes shall be provided with non-magnetic gland plates.

8.8 ELECTRIC MOTORS

8.8.1 General

VSDs with harmonic filters shall be used with motors specific process application. All other motors should be designed for direct on line (DOL) starting.

Synchronous motor to be used for all motors above 5 MW or as decided by purchaser.

The auxiliary drive motors shall be connected to a section of the switchboard which is fed from the same supply source and supply circuit as the main motor unit in order to obtain optimum availability of the total system.

Vibration requirements for motors to be considered as per SP2030 for low energy centrifugal pump.

8.8.2 HV Motor

High voltage motor protection arrangement shall be in line with project protection SLDs.

Rotor of copper material is preferred for HV Motor. Vendor can propose alternative material as per manufacturers standard design, meeting motor performance requirement.

For motor control and monitoring schematics shall follow the company Standard Drawings.

The control voltage for all HV switchgears shall be 110VDC therefore the system isn't sensitive to the network voltage dips. Instead, under-voltage protection for each motor feeder shall be implemented.

The starting current shall not exceed 6.5 times (including tolerance as per IEC) the rated current of the machine, subject to meeting minimum voltage for starting the compressor/pumps. However for regeneration compressor motor connected 6.6kV Switchboard, starting current shall be limited to 5.5 times (including tolerance as per IEC) of full load current.

All HV machines shall be provided with duplex RTD's, 3 or 4 wire type winding temperature detectors at least six numbers, two per stator phase.

All HV Motors shall be provided with duplex RTD's, 3 or 4 wire type, minimum one each for driving and non-driving bearings for temperature detection.

All HV Motors shall be provided with vibration monitoring probes for on line monitoring.

Motors above 6.6 kV shall be provided with partial discharge (PD) monitoring system on the machine.

The Power supply for the Exciter panel of Export gas compressor Synchronous motor, to be supplied from the UPS system.

8.8.3 LV Motor

All control schemes shall be based as per Company Standard Drawing.

Protection requirements for LV motors are specified in project protection & metering SLDs. Motors rated 30kW and above shall have separate Earth fault protection.

All motors rated 75kW and above shall be designed complete with anti-condensation space heaters for use when motors are out of service. The anti-condensation heaters shall be engaged automatically when the motors are stopped / tripped and shall be cut-off when the motors are running. In case of ESD trip, the anti-condensation heater power supply shall also be isolated.

Restart facility following a transient voltage trip shall be provided.

The locked rotor apparent power shall comply with IEC 60034-12. However, for machines with a rated output in excess of 55kW the starting current shall not exceed 7.0 times the rated current of the machine including positive tolerance.

For motors rated 37kW and below, sealed-for life type grease lubricated rolling element (anti-friction) bearings shall be used with rated L10 lifetime in excess of 50,000 hours under the extreme operating conditions.

VFD fed motors shall be provided with winding temperature detectors (2 per phase) and the non-driving end bearing housing shall be insulated.

Motors greater than or equal to 75kW rating shall be provided with simplex RTD, 3 or 4 wire type winding temperature detectors at least six numbers, two per stator phase.

Motors greater than or equal to 75kW rating shall be provided with one simplex RTD, temperature detector for each bearing.

Motors greater than or equal to 75kW rating shall be provided with vibration monitoring probes for on line monitoring.

Motors less than 75kW rating shall have flat surfaces or threaded area for stud mounting to carry out portable condition monitoring.

8.9 VARIABLE FREQUENCY DRIVE (VFD)

The VFD with all its associated equipment shall comply with IEC Standard spec.

8.10 THE VFD UNITS SHALL BE DESIGNED IN ORDER TO MINIMIZE THE AMOUNT OF HARMONICS SEEN BY THE ELECTRICAL SYSTEM. VFDS' HARMONIC DISTORTION SHALL BE WITHIN LIMITS AS LAID DOWN IN IEEE STANDARD 519. LV VFD'S SHALL BE MINIMUM SIX PULSE TYPE AND SHALL INCLUDE REACTOR ON THE INPUT AND/OR FILTERS ON OUTPUT SIDE AS REQUIRED. VFD'S SHALL BE LOCATED IN SUBSTATION. BYPASS IS NOT REQUIRED FOR VFD.HV VFD'S SHALL BE MINIMUM 12 PULSE TYPE AND SHALL INCLUDE REACTOR/FILTER AS REQUIRED. VFD'S SHALL BE LOCATED IN SUBSTATION.ELECTRIC HEATER

Electrical heaters used in process shall comply with the DEP 33.68.30.33, relevant IEC standards and the interference level (N) shall comply with VDE-875.

8.11 STEAM TURBINE GENERATOR

If Steam is generated from waste heat recovered in process , then this steam is utilized to generate electrical power using a back- pressure steam turbine generator. This power generated from steam turbine generator shall be step-up by generator transformer which shall be connected to 33 kV GIS with 33 kV XLPE cables.

The LV unit auxiliaries shall be fed from STG unit auxiliary board. This board shall be connected to 11/0.433 kV STG auxiliary transformer and 6.6/0.433 transformer connected to emergency switchboard .

The STG shall be with all auxiliary system & accessories. Generator shall be in compliance with the requirements of IEC-60034 and the specific requirements set out in the Steam Turbine Generator Specification.

The generator star point shall be earthed through the primary winding of an earthing transformer with an unbreakable grid type resistor connected across its secondary winding. Means of disconnecting and isolating the generator star point shall be provided.

The generating unit shall be equipped with the following min. equipment's:

- a) Auto/Manual Voltage Regulation
- b) Brushless Excitation control system
- c) Online partial discharge monitoring
- d) Instrumentation for Vibration monitoring system
- e) Generator control and synchronizing panel
- f) Generator protection panel with all protections as per SP-1107
- g) Neutral grounding transformer and resistor

STG Control Philosophy :-

Generator Control panel (GCP) shall be provided for monitoring, synchronization and excitation. It shall include minimum Manual synchronizing equipment and local/remote synchronizing facility. Auto synchronizing equipment shall be provided in the Mark-VI Unit control panel.

Synchronization shall be carried out from GCP, SCADA & TCS/FCS and following are the Synchronizing mode as envisaged.

Automatic synchronizing (inside UCP panel MKVI)

When the GCP is in Auto and MKVI is in Auto and synchronization permissive is available, MKVI will adjust itself the speed and will send the command to GCP for raise/lower voltage and breaker closure when unit is synchronized.

Manual synchronizing :-

When Auto/Man selector on GCP is in Manual position, the synchronization will be made locally from GCP. The panel will send the speed raise/lower (SR/SL) signals to MKVI and Voltage Raise/Lower signals to excitation panel (GEP) for the voltage regulation. These signals are generated by Operator acting on switches on the GCP panel front. When the speed and voltage are matching, the synchrocheck relay 25C on GCP panel will give a permissive to close the breaker, and then the operator will close the breaker from GCP panel front.

Dead Bus Breaker closing

The dead bus closing is done from GCP panel front only, using a selector switch. The operator shall select Dead Bus on selector switch. If all permissive for Dead Bus on GCP are enabled and a permissive to close the breaker is given, operator can close manually the breaker by using selector switch .

Turbine Control System :-

The Turbine Control system will perform Control sequence logic for Startup, shutdown, sequence control, monitoring, and safeguarding of the steam turbine & generator.

Turbine Control System shall be provided with an Operation HMI / Engineering Work Station HMI in STG Unit Electrical & Control Building”.

Operator / Engineering workstation HMI shall contain all necessary graphics for monitoring & control functionality including but not limited to startup, shutdown, synchronization, speed/load control, mode selection, Generator Voltage and MVAR control, Alarm, Event and Trip log display, CMS sensor display, control system diagnostic display etc.

8.12 UNINTERRUPTIBLE POWER SUPPLY SYSTEMS (UPS)

8.12.1 General

Electricity supplies of enhanced reliability and having duplicate energy sources shall be provided to energize loads forming part of vital services.

The size of the UPS system, including batteries, shall be rated with design margin as specified in section 8.1.2.

Robust and reliable UPS supply units and distribution system shall be used to supply safety critical system.

UPS system shall be designed in such a way to ensure the safe shutdown of the plant in worst scenario.

8.12.2 AC UPS Systems

AC UPS systems shall be utilised to supply C & A loads, ENMCS and shall be in line with the relevant IEC standard for Static AC Uninterruptible Power Supply Unit.

415V/240V AC UPS system shall be duplicated static type shall consist of 2 x 100% charger/inverter with static and maintenance bypass, 2 x 100% batteries, and AC distribution boards (AC UPS DBs) for supplying the FCS, IPS, FGS and other critical C&A loads.

The battery voltage and capacity shall be such as to fulfill the inverter input power requirements when the inverter is delivering its rated kVA output at 0.8 power factor lagging, for the specified autonomy time of the UPS while maintaining an output voltage within permissible limits.

8.12.3 DC UPS Systems

The design of DC uninterruptible power supply systems shall be in line with the relevant IEC standard for Static DC Uninterruptible Power Supply Unit.

DC UPS systems shall be utilised to supply switchgear operation and control and ENMCS

110V DC UPS system shall have 2 x 100 % batteries, 2 x 100 % redundant chargers and associated distribution board (DCDB).

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8.12.4 Battery

Battery banks shall be high performance nickel cadmium type (NiCd) and located in a separate air conditioned battery room.

For battery sizing, minimum ageing factor of 10%, temperature correction factor for 5 °C and the cell end of-discharge voltage of 1.14V for DC UPS and 1.05V for AC UPS shall be considered.

The battery voltage and capacity shall be such as to fulfill the load requirements for autonomy time as specified while maintaining an output voltage within the permissible tolerances

General :-

The UPS autonomy time shall be as follows: -

- Electrical DC loads - 8 hours
- FCS, IPS - 1 hour
- Fire & Gas - 4 hours
- CCTV system - 4 hours (Subject to Telecom inputs)
- Telecom system - 4 hours
- ENMCS - 1 hour

8.13 CABLES, WIRES & ACCESSORIES

8.13.1 General

Cables, wires and accessories shall comply with the requirements of relevant IEC STANDARD.

132kV cables shall be single core, cross linked polyethylene (XLPE) insulated, stranded annealed copper conductor-

The overall sheath for 132kV cables shall be high density polyethylene (HDPE) coated with Graphite outside, black in colour with treated outer sheath suitable for laying in buried trench.

33kV cables shall be single core, Stranded annealed copper conductor, Extruded semi-conducting conductor screen, XLPE insulated, Extruded semi-conducting insulation screen, Metallic layer (Copper Tape or Wire), Extruded PVC innersheath, Aluminium wire armour, Extruded Flame retardant PVC outer sheathed power cable in accordance with IEC.

6.6kV/11kV single core cables shall be Stranded annealed copper conductor, Extruded semi-conducting conductor screen, XLPE insulated, Extruded semi-conducting insulation screen, Metallic layer (Copper Tape or Wire), Extruded PVC innersheath, Aluminium wire armour, Extruded Flame retardant PVC outer sheathed power cable in accordance with IEC

6.6kV/11kV multicore cable shall be Stranded annealed copper conductor, Extruded semi-conducting conductor screen, XLPE insulated, Extruded semi-conducting insulation screen, metallic layer (Copper Tape or Wire), Non-Hygroscopic Fillers, Extruded PVC innersheath, Galvanized steel-wire armour, Extruded Flame retardant PVC outer sheathed power cable in accordance with IEC.

LV single core power cables shall be Stranded copper conductor, XLPE insulated, Extruded PVC inner sheath, Aluminum wire armour, Extruded Flame retardant PVC outer sheathed power cable in accordance with IEC. The outer sheath shall also be UV resistant.

LV multicore power cables, control cable, lighting cables shall be Stranded copper conductor, XLPE insulated, Non-Hygroscopic Fillers, Extruded PVC inner sheath, Galvanized steel-wire armour, Extruded Flame retardant PVC outer sheathed in accordance with IEC. The outer sheath shall also be UV resistant.

Applications where multicore fire resistant cable is to be used it shall be, Stranded copper conductor, Mica Tape +XLPE insulated, Non-Hygroscopic Fillers, Extruded LSLH (15 to 17% halogen) PVC inner sheath, Galvanised steel wire armour, Extruded FRLS PVC outer sheath in accordance with IEC. The outer sheath shall also be UV resistant.

Depending on the cable construction and voltage level, a copper screen may be installed over each insulated conductor.

Cables and wiring for indoor building services, panel wiring applications shall be Flame retardant, halogen free.

The outer sheath of 132kV Cables shall be black, for 33/11/6.6kV cables shall be red. For LV cables shall be black.

8.13.2 Earthing Cables

Earthing cables shall be PVC sheathed, coloured yellow/green and shall have stranded copper conductors. Instrument earth cables shall be green coloured.

8.13.3 Cable Accessories

For cables up to 33kV rating, heat shrink terminations or cold shrinkable terminations shall be used throughout.

For GIS SWGR, plug-in type termination shall be provided as per GIS switchgear Vendor recommendation.

Cable glands shall be double compression type for all armoured cables. Type of material for cables gland shall be nickel plated brass.

8.13.4 Colour Codes for Cable Cores:

The colour codes for Cable Cores & Busbars shall be as per IEC Code.

For DC circuit two core cables, Red colour shall be used for positive circuit core and Blue color shall be used for Negative circuit core.

9.0 LAYOUT

Due consideration shall be given to vehicle movement and maintenance access for mobile equipment, including mobile cranes of sufficient capacity for electrical equipment installation and maintenance.

Adequate access for maintenance for all equipment in plant shall be provided. No plant equipment shall be located closer than 3m from the edge of any road.

All outdoor motors shall be provided with suitable sun sheds.

All substations shall be designed without un-necessary cross-beams which render restriction to cable installations. Adequate fire protection/sealing shall be provided for all cable penetrations. Each substation building shall be raised 1.5m clear from ground level.

Specifically for Control Building and FAR Room; all cables shall access the Control building/ FAR room only from side walls without penetrating the bottom concrete base slab. This is essential to satisfy sealing requirement of Control building and FAR Room from Toxic gas ingress.

All switchboards shall have a minimum of 400mm wide cable alleys where applicable. Separate room for VFD panels shall be designed for housing them due to high noise level and heat dissipation. The switchgear buildings shall include a separate battery room to house the battery banks for the UPS Systems.

The arrangement of building HVAC shall include Normal and Emergency systems with consideration for equipment location and equipment power dissipation.

.Separate rooms for ENMCS and Telecom systems shall be provided in substation -1

The locations in the switch rooms where the switchgear is to be installed (floor-standing type) shall have no cross-beams to obstruct the cable entries. Dummy panels shall be used to clear the floor beams.

Primary and emergency power source, location of cabling , power feeds, distribution boards, UPS shall be such that no common failure or hazardous event (fire/explosion) can result in loss of both primary and secondary sources of supply.

Appropriate routings and adequate space for underground and/or aboveground cable installations shall be made.

10.0 ELECTRICAL INSTRUMENT INTERFACE

The interface between the electrical and instrument equipment shall be provided by a dedicated Interface panel Box (IFB) in each Electrical Switchgear room for interface with C & A for control and safeguarding system requirements.

Control, monitoring and safeguarding arrangement shall comply with the requirements of Control and Automation Philosophy and Instrument-Electrical & Telecom interface drawing .

Whenever used, Ethernet or Serial links shall be of redundant configuration for connection of FCS to ENMCS . Equipment shall be wired with FCS shall be as per Instrument-Electrical & Telecom interface drawings and ENMCS architecture diagrams.

APPENDIX-1- ILLUMINATION LEVELS

The following illumination levels, measured at the working plane or 1 m above the floor level in a horizontal plane, shall apply as per the below table:

These values are mean values and the uniformity ratio (E_{min}/E_{mean}) is $\frac{1}{4}$ for normal installations.

AREA	TYPE OF LIGHT FITTING	Average Lux Level Mean
Control room	Linear type LED	500 (Note-1)
SCADA & Telecom cabinet room	Linear type LED	300
HV Switchgear room	Linear type LED	300
LV Switchgear room	Linear type LED	300
VSD Room	Linear type LED	300
Auxiliary room	Linear type LED	300
Engineering room	Linear type LED	400
Battery room	Linear type LED	250
Offices	Linear type LED	400
Stores	Linear type LED	150
Permit area/Reception	Linear type LED	250
Prayer room	Linear type LED	100
Pantry	Linear type LED	100
Toilets	Linear type LED	100
Passages and corridors	Linear type LED	100
Outside, near entrance	Flood light – LED type / Linear type LED	150
Switchyard/Transformer bays	Linear type LED	25
Road tanker parking area	Flood light – LED type / Linear type LED	25
Car park area	Flood light – LED type / Linear type LED	1
Operating area requiring regular operator intervention: pumps, compressors, generators, drivers, valves, manifolds, loading arms etc.	Flood light / Linear type LED/high/medium/low bay LED type	150
Access ways: walkways, platforms, stairways, ladders	Linear type LED	25
Local control and monitoring points: indicating instruments, guages and control devices	Flood light and Linear type LED	75
Non-operational areas with limited attendance: tank farms without equipment requiring regular operator intervention	Flood light and Linear type LED	0.5

AREA	TYPE OF LIGHT FITTING	Average Lux Level Mean
Outdoor Non Operational areas infrequent used	Flood light LED type	0.5
Security fence lighting (lighting will be provided on the CCTV poles)	Fence Light LED type and Roadway LED type	7 (Refer note 5)
Emergency Escape route to the central room/temp. refuge	Street light LED type/Linear type LED/Flood light	1
Areas under CCTV surveillance	Flood light and Roadway LED type	5
Windsocks	Flood light/ Linear type LED	5
Street lighting	Street light LED type/Linear type LED	5
Main gate Entrance near Guard house	Flood light – LED type / Linear type LED	25
Muster points	Flood light – LED type	25

NOTES:

1. Control of the illumination level down to 100 lux should be possible by use of electronic dimmers for control room, meeting room, conference room.
2. In rooms where display units are permanently installed, the lighting shall be designed to avoid reflections and glare from the screens.
3. Minimum lux level requirement (if any) on safety sign boards as provided by HSE group shall be achieved.
4. Requirements for Lux level, Type of lamp of Local Security Agencies shall be taken into account for lighting system design.