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Electrical Design Guideline

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GENERAL

1.1 Introduction

This Guideline provides the basis for design and installation of electrical systems and services. The guidelines apply to the following systems within the sites and premises of Residential, Commercial, Institutional, Healthcare, Light Industrial facilities, etc.:

- MV Primary and Secondary Power Distribution Systems
- Low Voltage Power Distribution
- Lighting Systems
- Power System
- Earthing/Grounding System
- Lightning protection System

1.2 Applicability

This guideline applies to the Entity's project including Building types defined in Document Number EPM-KEA-GL-000001: Architectural Design Guidelines.

1.3 Definitions

For a list of general definitions refer to Document Number EPM-KE0-GL-000011: Volume 6, Chapter 2 - Definitions & Reference

This Section contains definitions for acronyms, abbreviations, words, and terms as they are used in this Chapter. For definitions not listed, the latest issue of the following Documents shall apply:

- Saudi Building Code
- International Electrotechnical Commission Glossary
- IEC Electropedia, http://www.electropedia.org
- Comprehensive Dictionary of Measurement and Control, International Society for Measurement and Control.

Definitions Specific to the Subsection:

Definitions	Description
Ambient Temperature	Average temperature of air or another medium in the vicinity of the luminaire. Ambient temperature is expressed in degrees Celsius.
Ampacity	The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.
Backup Power System	A system of circuits and equipment arranged for automatic, delayed, or manual connection to the alternate power source and that serves all of the loads identified as essential for the facility.
Bonded (Bonding)	Connected to establish electrical continuity and conductivity.
Bonding Jumper	A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.
Bonding Jumper, Equipment	The connection between two or more portions of the equipment grounding conductor at the service.
Cabinet	An enclosure that is designed for either surface mounting of flush mounting and is provided with a frame, mat or trim in which a swinging door or doors are or can be hung.
Circuit Breaker	A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

Definitions	Description
CIE Color Group	A grouping system for the color rendering and color appearance of light sources.
Classified Areas	An area where the hazardous classification is defined by three main criteria as follows: The type of hazard (groups), The auto ignition temperature of the hazardous material (temperature or “T” rating), The likelihood of the hazard being present in flammable concentrations (zones).
Color Rendering Index	Quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
Concealed	Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them.
Conduit	Part of a closed wiring system of general circular cross-section for insulated conductors and/or cables in electrical or communication installations, allowing them to be drawn in and/or replaced.
Continuous Load	A load where the maximum current is expected to continue for 3 hours or more.
Coordination (Selective)	Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice of overcurrent protection devices and their ratings or settings.
Critical Branch	A subsystem of the emergency system consisting of feeders and branch circuits supplying energy to task illumination, special power circuits, and selected receptacles serving areas and functions related to patient care and that are connected to alternate power sources by one or more transfer switches during interruption of normal power source.
Data Branch	A subsystem of the emergency system consisting of feeders and branch circuits supplying energy to mainly Low Current System during interruption of normal power source.
DALI	A lighting control protocol that allows the use of digital addressing of lighting components to function and to communicate using 2 way digital communications specified by IEC62386.
Demand or Diversity Factor	The ratio of the maximum demand of a system, or part of a system, to the total connected load of a system for the part of the system under consideration.
Device	A unit of an electrical system that carries or controls electric energy as its principal function.
Disconnecting Means or Isolator	A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.
Distribution Board (DB)	A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front.
Duct	A pipe provided to facilitate the installation of cables and provides protection for the cables.
Duct Bank	A multiple array of ducts.
Emergency Systems	Electrical systems legally required to be installed and that supply loads essential to safety and life.
Enclosed	Surrounded by a case, housing, fence, or wall(s) that prevents persons from accidentally contacting energized parts.
Enclosure	The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage.

Definitions	Description
Equipment	A general term, including material, fittings, devices, appliances, luminaires, apparatus, machinery, and the like used as a part of, or in connection with, an electrical installation.
Equipment System	A system of circuits and equipment arranged for delayed, automatic, or manual connection to the alternate power source and that serves primarily 3phase power equipment.
Feeder (Electrical)	All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device.
Handhole	A small jointing chamber of the joint box category but restricted to footway use only.
Interface Point (IP)	A location established for demarcation of contractual responsibilities.
Interrupting Rating	The highest current at rated voltage that a device is intended to interrupt under standard test conditions.
Isolator	Refer to “Disconnecting Means”.
Joint (splice)	The connection of two or more lengths of wire or cable at a single point.
Joint Box	A jointing chamber the top of which consists of fully removable covers.
Life Safety Branch	A subsystem of the emergency system consisting of feeders and branch circuits intended to provide adequate power needs to ensure safety to building occupants and that are automatically connected to alternate power sources during interruption of the normal power source.
Labelled	Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization and concerned with product evaluation, that maintains periodic inspection of production of labelled equipment or materials, and by who’s labelling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
Luminaire	Apparatus which distributes, filters or transforms the light emitted from one or more lamps and which includes all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply. The words "luminaire" and "lamp system" are often assumed to be synonymous. For the purposes of this standard, the word "luminaire" is restricted to apparatus used for distributing light in general lighting, while "lam p system" implies use of lamps in other than general lighting applications.
Luminaire Efficacy	Quotient of the luminous flux emitted by the power consumed by the Luminaire. The efficacy is expressed in lm /W.
Luminaire Lifetime	Length of time during which 70% of the measured initial luminous flux value are provided, as a function of maximum operating temperature range. The luminaire lifetime of the module is expressed in hours.
Dimmer System	Mainly in Conference and Class rooms
Lumen Maintenance	Value of the luminous flux at a given time in the life of a Luminaire divided by the initial value of the luminous flux of the luminaire and expressed as a percentage “x” of the initial luminous flux value. The lumen maintenance of a Luminaire is the effect of decrease of lumen output which is sometimes referred to as depreciation or lumen loss factor.
Main Distribution Board	Board in the building which fulfils all the functions of a main electrical distribution for the supply building area assigned to it and where the voltage drop is measured for operating the safety services.
Main Incomer	Refer to “Service”.
Neutral Conductor	The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.
Nonlinear Load	A load where the wave shape of the steady-state current does not follow the wave shape of the applied voltage.

Definitions	Description
Operating Temperature Range	Ambient temperature range within which the luminaire with regard to the specification can be operated. The operating temperature range is expressed in degrees Celsius.
Overcurrent	Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.
Panelboard	Refer to “Main Distribution Board”, “Sub Main Distribution Board” and “Distribution Board”.
Residual Current Device	A mechanical switching device or association of devices intended to cause the opening of the contacts when the residual current attains a given value under specified conditions.
Ring Main Unit	A Ring Main Unit includes two load break switches for the connection of the substation to the ring and a transformer protection unit.
Separately Derived System	A premises wiring system whose power is derived from a source of electric energy or equipment other than a service. Such systems have no direct electrical connection, including a solidly connected ground conductor, to supply conductors originating in another system.
Service	The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served. Also referred to as “Supply Intake” or “Main Incomer”.
Short Circuit Current Rating	The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria.
Splice	See Joint.
Standby Systems	Include alternate power systems for such applications where interruption of normal power would cause discomfort to personnel or damage to product.
Sub Main Distribution Board	Any distribution board which is neither a Main Distribution Board nor a Distribution Board
Surround Ratio	The average illuminance just outside the edge of the carriageway in proportion to the average illuminance just inside the edge of carriageway. Acceptable surround ratio values allows drivers to see pedestrians and other road users who may be about to cross the road.
Switchboard	A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets.
Task Lighting	Is lighting directed to a specific surface or area to provide illumination for visual and/or manual tasks.
TN-C System	A system in which neutral and protective functions are combined in a single conductor throughout the system.
TN-S System	A system having separate neutral and protective conductors throughout the system.
Vacuum Interrupter Switch	A current interrupting switch for power distribution systems comprising an outer case and a plurality of vacuum interrupter bottle switches positioned in the case.
Voltage (of a circuit)	The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned.
Voltage, Nominal	A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class. The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

1.4 Abbreviations

For a list of general abbreviation refer to Document Number EPM-KE0-GL-000011: Volume 6, Chapter 2 - Definitions & Reference

The following abbreviations apply to this Subsection:

Abbreviations	Description
A	Amperes
AC	Alternating Current
ACB	Air Circuit Breakers
A/E	Architect/Engineer
AFF	Above Finished Floor
AFFL	Above Finished Floor Level
AGL	Above Ground Level
ANSI	American National Standards Institute
ATF	Active Tracking Filters
ATS	Automatic Transfer Switch
AVG	Average
BAS	Building Automation System
BIL	Basic Impulse Insulation Level
BITS	Bypass Isolation Transfer Switch
BMS	Building Management System
CB	Circuit Breaker
CCT	Correlated Color Temperature
CAD	Computer Aided Design
CEN	European Committee for Standardization (Lighting control protocol)
CIE	Commission Internationale De L'eclairage (International Commission on Illumination)
CR	Critical
CRI	Color Rendering Index
CT	Current Transformer
DALI	Digital Application Lighting Interface
DB	Distribution Board
DP	Distribution Panel
ECG	Electronic Control Gear (Lighting)
EMT	Electrical Metallic Tubing
EPC	Engineering Procurement and Construction
EPR	Ethylene Propylene Rubber
FLA	Full Load Amps
FMC	Flexible Metal Conduit
FNC	Flexible Non-Metallic Conduit
GPCS	Guiding Procurement and Construction Specifications
HCIS	High Commission for Industrial Security
HID	High Intensity Discharge
HVAC	Heating Ventilation and Air Conditioning
HZ	Hertz
IEC	International Electrotechnical Commission
IESNA	Illuminating Engineering Society of North America
IFC	Issued for Construction
IP	Ingress Protection
KA	Kilo-amperes
KW	Kilo-watts
KV	Kilo-volts
KVA	Kilo-volt-amperes
LED	Light Emitting Diode
LFMC	Liquid-tight Flexible Metallic Conduit
LMS	Lighting Management System
LS	Life Safety
LV	Low Voltage
MCB	Miniature Circuit Breaker
MCCB	Molded Case Circuit Breaker
MDB	Main Distribution Board
MIN	Minimum
MIS	Metering Installation Standard

Abbreviations	Description
MIS1	Metering and Interface Standards
MTS	Manual Transfer Switch
MV	Medium Voltage
NA	Not Applicable
NEC	National Electrical Code
NFPA	National Fire Protection Association
OS	Optional Standby
PVC	Polyvinyl Chloride
RCD	Residual Current Device
RMU	Ring Main Unit
RMS	Root Mean Squared
RNC	Rigid Non-metallic Conduit
RSC	Rigid Steel Conduit
SASO	Saudi Arabian Standards Organization or Saudi Standards, Metrology and Quality Organization
SBC	Saudi Building Code
SDS	Saudi Distribution Standards
SDCS	Saudi Electricity Company Distribution Construction Standard
SDMS	Saudi Electricity Company Distribution Materials Specification
SDPS	Saudi Electricity Company Distribution Planning Standard
SEC	Saudi Electricity Company
SMDB	Sub Main Distribution Board
SMSS	Saudi Electricity Company Material Standard Specification
SPD	Surge Protection Device
TCDD	Typical Construction Detail Drawing
UPS	Uninterruptible Power Supply
V	Volts
VIS	Vacuum Interrupter Switch
XLPE	Cross-linked Polyethylene

1.5 General Requirements

1.5.1 All equipment and material shall be selected in consideration of the following:

- Performance
- Ability to withstand the environmental conditions
- Availability and ease of shipment
- Ease of installation
- Maintenance characteristics.

1.5.2 All the electrical equipment and materials shall be as per the specification.

1.5.3 Health, Safety and Environmental Considerations

- All work undertaken in relation to these guidelines shall be completed in full compliance with the respective health and safety requirements established by the following:
- Legislation, Regulation, Standards and Codes
- Entity Construction Specifications
- Entity Typical Construction Detail Drawings (TCDD)

  In the absence of any or all the above, best international industry practices, with reference to health, safety and welfare, shall be employed and utilized throughout.

1.5.4 Electrical systems design using these Guidelines shall consider the following features:

- Safety of personnel, building and plant.
- Design with consideration for energy efficiency and sustainability.

- Electrical system design shall compliance with latest version of Saudi Building Code-SBC 601: Energy Conservation.
- Compliance with standard voltage levels established for the development, as detailed in this Guideline and the latest SEC Standards DPS-02, SDMS-01
- A design arrangement that allows minimum interruption to the system during maintenance that is carried out on a part of the system.
- Allowances for future load growth and system expansion.
- Economy, considering overall building and plant cost as well as electrical system costs.
- Adequate interrupting capacity for circuit interrupting devices.
- Proper coordination of all elements of the system with regards to insulation levels, protective relaying, fusing and mechanical strength.
- Power factor correction to address concerns associated with the electrical distribution network.
- Consideration for minimizing the impacts harmonics associated with non-linear loads.
- Automatic Transfer Switch (ATS) or changeover switch from Normal power source to Essential and vice versa
- Power Co-ordination Studies which includes Balanced load flow analysis, Asymmetric load flow analysis, Harmonics analysis, Short circuit analysis, Arc flash analysis and Power network protection

1.5.5 Environmental Conditions

Electrical Installation must be suitably designed, constructed and maintained to operate safely and carry out their designated function in the expected operating environment in the Kingdom of Saudi Arabia.

1.5.6 Equipment Enclosures

All equipment enclosures shall meet the following Ingress Protection rating as defined by IEC 60529. The object of these standards is to give:

- Definitions for degrees of protection provided by enclosures of electrical equipment as regards:
- Protection of persons against access to hazardous parts inside the enclosure;
- Protection of the equipment inside the enclosure against ingress of solid foreign objects;
- Protection of the equipment inside the enclosure against harmful effects due to the ingress of water.

  Measures to protect both the enclosure and the equipment inside the enclosure against external influences or conditions such as:

- Mechanical impacts
- Corrosion
- Corrosive solvents (for example, cutting liquids)
- Fungus
- Vermin
- Solar radiation
- Icing
- Moisture (for example, produced by condensation)
- Explosive atmospheres
- And the protection against contact with hazardous moving parts external to the enclosure.

1.5.7 IP Ratings shall apply as a minimum requirement for the following equipment

- Low Voltage Switchgear (Indoor) – IP52
- Sub Main Distribution Board (Indoor) – IP52
- Sub Main Distribution Board (Outdoor) – IP65
- Distribution Board (Indoor) – IP52

- Distribution Board (Outdoor) – IP65

For SEC related equipment, follow SEC Standards and Specifications for IP ratings.

1.5.8 All enclosures located outside which are not sheltered or made from stainless steel shall have a white finish to lower the internal temperature

1.5.9 All enclosures with a lens or transparent display cover subject to direct sunlight shall be glass or as a minimum UV resistant.

1.6 Codes

All electrical equipment, material and the installation shall comply with the current requirements of the following authorities:

- Saudi Building Code 401 Electrical
- Occupations Safety and Health Act (OSHA)
- Saudi Building Code 501 Mechanical Requirements
- Saudi Building Code 201 Architectural Requirements
- Saudi Building Code 701 Sanitary Requirements
- Saudi Arabian Distribution Code
- Saudi Building Code 801 Fire Protection Requirements
- Civil Defense Department (CDD)
- Saudi Building Code 601 Energy Conservation

1.7 Standards

1.7.1 All work shall conform to the applicable industry Codes, Standards and Associations.

1.7.2 The latest revision of the referred codes and standards shall be used wherever applicable. In case of conflict, the A/E shall propose equipment conforming to one group of Codes and Standards.

- CIE International Commission on Illumination
- EN Euro-norms published by CEN
- EN 13201 Road lighting
- EN 12464 Workplace Lighting Outdoor Spaces
- EN 12193 Light and Lighting Sports Lighting
- IEC International Electro-Technical Commission
- IEEE Institute of Electrical and Electronics Engineers
- NFPA National Fire Protection Association
- SASO Saudi Arabian Standards Organization
- SDCS Saudi Electricity Company Distribution Construction Standards
- SDMS Saudi Electricity Company Distribution Materials Specification
- SDPS Saudi Electrical Company Distribution Planning Standard
- SDS Saudi Electric Company Distribution Standard

1.7.3 Specific Standards which are referenced in this Section of the guidelines include the following:

- ANSI/**ASHRAE/IES Standard 90.1**-- Energy Standard for Buildings Except Low-Rise Residential Buildings
- BS 7430 Code of practice for protective earthing of electrical installations
- CIE 115 Lighting of Roads for Motor and Pedestrian Traffic.

- IEC 60076 Power transformers
- IEC 60079 Explosive atmospheres
- IEC 60227 Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
- IEC60228 Conductors of insulated cables
- IEC 60332 Tests on electric and optical fiber cables under fire conditions
- IEC 60364 Low-voltage electrical installation - Electrical installations of buildings (including all sub-parts)
- IEC 60427 High-voltage alternating current circuit-breakers
- IEC 60502 Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV)
- IEC 60529 Degrees of protection provided by enclosures (IP code)
- IEC 60644 Specification for high-voltage fuse-links for motor circuit applications
- IEC 60715 Dimensions of low-voltage switchgear and control gear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and control gear installations.
- IEC 60724 Short-circuit temperature limits of electric cables with rated voltages of 1 kV (Um = 1.2 kV) and 3 kV (Um = 3.6 kV)
- IEC 60754 Test on gases evolved during combustion of materials from cables
- IEC 60787 Application guide for the selection of fuse-links of high-voltage fuses for transformer circuit application
- IEC 60898, Circuit breakers for overcurrent protection for household and similar installations.
- IEC 60981 Extra heavy duty rigid steel conduits
- IEC 61000-3-2 Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions
- IEC 61000-3-3 Electromagnetic Compatibility (EMC) – Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations
- IEC 61034 Measurement of smoke density of cables burning under defined conditions
- IEC 61340 Electrostatics
- IEC 61386 Conduit systems for electrical installations
- IEC 61439 Low-voltage switchgear and control gear assemblies
- IEC 61537 Cable management – Cable tray systems and cable ladder systems
- IEC 61643 Low-voltage surge protective devices
- IEC 62031 LED Modules
- IEC 62305 Lightning Protection
- IEC 62384 Performance Requirements for Electrical Control Gear for LED Modules
- IEC 62471 Photobiological Safety of Lamps and Lamps Systems
- IEC62504 General Lighting – LEDs and LED Modules – Terms and Definitions
- IEC 62560 Self-ballast LED Lamps (>50V)
- IEC 62717 LED Modules Performance
- IEC 62722-2-1 LED Luminaires Performance
- IEEE STD 80 Guide for Safety in AC Substation Grounding
- IEEE STD 142 Recommended practice for grounding of industrial and commercial power systems
- IEEE STD 1453 Recommended Practice for Measurements and Limit of Voltage Fluctuations and Associated Light Fluctuations and Associated Light Flicker on AC Power Systems
- IESNA Lighting Handbook
- IESNA LEM-3 Design Considerations for Effective Building Lighting Energy Utilization
- IESNA LM-5 Guide for Photometric Measurements of Area and Sports Lighting Installation
- IESNA RP-1 Practice for Office Lighting
- IESNA RP-7 Practice for Industrial Lighting
- IESNA RP-16 Nomenclature and Definitions for Illuminating Engineering

- IESNA RP-24 Practice for Lighting Offices Containing Computer Visual Display Terminals
- IESNA RR-96 Lighting Ready Reference / Energy Management
- IES/IESNA LM-79-08 Approved Method: Electrical and Photometric Measurement of Solid-State Lighting Products
- IES/IESNA LM-80-08 Approved Method for Measuring Lumen Maintenance of LED Light Sources
- NFPA 70 National Electrical Code (NEC) (Applicable only if guidance is not available in IEC)
- NFPA 72 National Fire Alarm and Signaling Code
- NFPA 99 – Healthcare
- NFPA 101 Life Safety Code
- NFPA 110 Standard for Emergency and Standby Power Systems
- NFPA 111 Standard on Stored Electrical Energy Emergency and Standby Power System
- NFPA 900 Building Energy Code
- AASHTO LTS-2 Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals
- AASHTO GTB-77 Guide for Selecting, Locating, and Designing Traffic Barriers
- SASO 55 PVC-insulated cables with circular copper conductors
- SEC SDCS-02, Distribution Construction Standard – Construction Standard for Underground Distribution Network
- SEC DPS-01, Distribution Planning Standards – Estimation of Customer Load Guideline
- SEC DPS-02, Distribution Planning Standards – Design Guideline of Underground Low Voltage Network to Supply Customers
- SEC DPS-09, Distribution Planning Standards – General Guidelines for Design of Electrical Distribution Networks of Private Plot Plans
- SEC SDMS, Distribution Material Specification
- SEC SDS-5, Metering Installation Standard
- NFPA 780 – Lightning Protection System
- NEMA – National Electrical Manufacturers Association
- ANSI – American National Standard Institute
- NETA ATS – International Electrical Testing Association and Acceptance Testing Specification
- UL Listed – Underwriters Laboratory

2.0 POWER SYSTEMS

2.1 Electrical Characteristics

2.1.1 General

The electrical characteristic shall describe the quality of the power supply and its ability to handle the critical situation during disturbance and variation on load

- The frequency of all alternating current power systems shall be 60 Hz.
- Phase rotation shall be in accordance with latest SEC Standard DPS.
- All systems shall be grounded. Refer to Subsection 9.0 Grounding.

2.1.2 System Voltage Level

- Nominal voltages, standard shall be in accordance with SEC Standard and Saudi Arabia Distribution Code (DPC 2.2)

2.1.3 Voltage Drop

- The electrical system shall be designed to account for voltage drop for the entire electrical distribution system. The electrical components including feeders and branch circuits shall be sized and selected to limit the total voltage drop from source to loads as follows:
    - For network voltage drop design shall be in accordance with the requirements of the latest SEC Distribution Planning Standard DPS-02.
    - For Consumers' (customers) installations voltage drop design shall be in accordance with SBC 401.

2.1.4 Power Factor

The A/E shall consider the utilization power factor for the facility and determine whether power factor correction is required to maintain operation within the required power factor ratio according to the latest SEC Distribution Planning Standard DPS-02.

2.1.5 Fault Levels

Fault levels for facilities with all voltage ratings shall utilize the maximum allowable symmetrical short circuit values from the latest SEC as the available fault level to the facility.

2.2 Site Power Distribution

- Site Development power distribution are developed as per the Entity's requirement in accordance to the latest SEC Standards
- This guideline applies to the Entity's project including Building types defined in Document Number EPM-KEA-GL-000001: Architectural Design Guidelines

2.3 Equipment

2.3.1 Uniformity and Standardization

- Uniformity in the design of electrical system components is important to minimize the number of spare parts required to be stocked for maintenance and repairs.
- The design for the electrical system shall standardize to reduce the number of different types of transformer, switchgear, panelboard, and cable size used.

2.3.2 Insulation Levels

The BIL (Basic Insulation Level) ratings for the equipment's shall be specified and to be in accordance with the latest SEC Standard 01-SDMS-01.

2.3.3 Equipment Grounding and Grounding Conductor

Exposed non–current carrying metal parts of fixed equipment that are likely to become energized shall be connected to an equipment-grounding conductor

2.3.4 Derating Factor – Power cable and the Equipment

2.3.4.1 General

- The high temperatures prevalent in Saudi Arabia shall consider when selecting the appropriate capacities of electrical cables and equipment. When ambient temperatures exceed a certain threshold, the current carrying capacity shall be derated to compensate for the environmental conditions. The standard service conditions for electrical system design are identified in latest SEC Standards DPS-02 and 01-SDMS-01.
- The manufacturers of all specified electrical system components and equipment shall be consulted to ensure that the proper derating factors are applied to the electrical equipment.

2.3.4.2 Derating of Cables

- Temperature Correction Factor:
  - The rate of heat dissipation from cable to surrounding depends upon the temperature difference between them. If the temperature of surrounding is high, then the temperature difference between cable and surrounding will be less resulting in less heat dissipation from cable to surroundings.
  - The cable ampacities are specified at certain ambient temperature. It is required to correct the cable ampacities by applying temperature correction factor depending upon surrounding ambient temperature
  - Ampacity of the cable passing through different temperature zones installation method shall be corrected by applying appropriate temperature correction factor for highest zone temperature through which the cable is passing
  - SBC 401 Tables shall be used as reference.
- Group Derating Factor
  - Where a number of circuits are installed in close proximity to one another, consideration must be given to the mutual heating effect.
    - Cables installed on the outside of the group will be able to dissipate heat outwards, but will be restricted in dissipation towards other warm cables.
    - Cables installed between others near the center of the group may be challenged to dissipate heat at all and will rise further in temperature.
  - The cables in the group shall be derated by applying appropriate group derating factor.
  - Selection of cable derating factors shall consider the following:
    - Method of installation of the cables: i.e. whether the cable is laid in trench, duct bank or surface mounted.
    - Group and loading of cables: may contain cables carrying load current and standby cables not carrying current. Under such circumstances consider the number and configuration of load carrying cables only.
  - SBC 401 shall be used as reference.
- Cable Derating for SEC feeders:
  - LV cables shall be derated in accordance with SEC Standard DPS-02.
  - MV cables up to 38kV shall be derated in accordance with latest SEC Standard DPS.
- Calculations
  - Cable capacity calculations for services and feeders shall be in accordance with latest SEC Standard DPS-01.

2.3.4.3 Derating of Transformers

- Transformers shall be derated for the environmental conditions where they are installed.
- Where a transformer serves non-linear, high-harmonic loads, the transformer shall be derated to account for excessive heat associated with the increase in harmonic currents.
  - Loads with these non-linear, harmonic-rich currents include electronic lighting ballasts, computers, adjustable frequency drives, and other switch mode power supplies.
  - These types of loads are common for commercial and small industrial facilities and the design of the electrical systems for these facilities shall consider the adverse effects on the electrical transformers.
- Operating limits of transformers shall be derated in accordance with the requirements of IEC 60076.

2.3.4.4 Derating of Distribution Equipment – Switchgear and Switchboards

- Switchgear and switchboards shall be derated for the environmental conditions where they are installed.

- Where distribution equipment serves non-linear, high-harmonic loads, the equipment shall be derated to account for excessive heat associated with the increase in harmonic currents.
    - Loads with these non-linear, harmonic-rich currents include electronic lighting ballasts, computers, adjustable frequency drives, and other switch mode power supplies.
    - These types of loads are common for commercial and small industrial facilities and the design of the electrical systems for these facilities shall consider the adverse effects on the electrical transformers.

2.3.4.5 Equipment Labeling Requirements

- Equipment nameplates shall be provided to indicate the capacity rating of the equipment for the ambient temperature to which the equipment is designed.

2.3.5 Power Calculations and Analyses

2.3.5.1 General

The responsible A/E shall prepare calculations as required to support the selection and sizing of the cables, electrical equipment and components for each facility. Power calculations shall justify the size of cables, raceways, equipment bus, transformers, overcurrent protective devices, generator(s), etc.

- Calculations shall be prepared in accordance with the latest SEC and IEC Standards.
- Calculations shall be prepared for all new construction and renovation projects.
- Submit all calculations to the Entity for approval.
- Submit calculations required by the utility company, SEC, to obtain the necessary approvals for service and equipment sizing.

2.3.5.2 Cable Sizing and Voltage Drop Calculations

- Prepare calculations which confirm compliance with the voltage drop limitations identified in the latest SBC 401, SEC Standards DPS-02 and DPS-09.

2.3.5.3 Power Factor Assessment and Calculations

- The A/E shall prepare a power factor assessment summary which identifies the loads served and anticipated power factor for the facility. The results of this assessment shall be used by the A/E to provide a recommendation on whether power factor correction shall be provided for the facility. The assessment shall be submitted to Entity to obtain confirmation of A/E recommendation.
- For facilities where power factor correction is anticipated to be below 0.85 lagging, The A/E shall prepare and submit calculations which identify the magnitude and approach for this equipment. Refer to SBC 401: Power Factor Improvement.

2.3.5.4 Fault Level Calculations

- Prepare calculations which identify the available fault levels throughout the electrical system for a facility. The results of the calculations shall be used to identify the required equipment ratings on the drawings and equipment specifications.

2.3.5.5 Overcurrent Protective Device Coordination Study

- An overcurrent protective device coordination study shall be prepared to demonstrate the proposed system performance for the specified overcurrent protective devices. This study shall be utilized for comparison of the provided electrical equipment to ensure that the intent of the original design is closely replicated by the manufacturer of the provided equipment.

2.3.5.6 Harmonic Distortion Calculations

- A/E shall prepare a harmonics assessment summary which identifies the potential source and extent of non-linear, high harmonics loads for each facility. The results of this assessment shall be used by A/E to provide a recommendation on whether further harmonic calculations are required. The assessment shall be submitted to the Entity to obtain confirmation of the A/E recommendation.
- For facilities that are determined to have non-linear, high harmonic loads which exceed 15%, the A/E shall prepare and submit calculations for reduction in cable capacities in accordance with the latest SBC 401.
- For facilities that are determined to have non-linear, high harmonic loads which exceed 33%, prepare and submit calculations which identify the anticipated voltage and current total harmonic distortion (THD) at the various electrical equipment throughout the facility. The results of these calculations shall be utilized by the A/E to develop a strategy for application of active and/or passive components to mitigate harmonic distortion.

2.3.5.7 Load Calculations

- Prepare calculations which identify the connected and demand electrical loads for each facility. The calculations shall identify the electrical loads by type and size and shall identify all diversity factors applied in accordance with the latest SEC Standard DPS-01.
- Calculations shall be prepared for each piece of electrical distribution equipment and also summarized for the service entry.

2.3.5.8 Backup Power Assessment Analysis

- The A/E shall prepare an assessment of the requirement for provision of backup power for each facility. The assessment shall identify the occupancy for the facility and establish the critical functions which may warrant the provision of backup power. The assessment shall summarize the A/E recommendation for application of backup power which will be reviewed by Entity.

2.3.5.9 Generator Calculations

- Generator Sizing
    - Prepare calculations which justify the selection of generator, or paralleled generators to supply the backup electrical loads for each facility.
    - The calculations shall be prepared to determine the capacity required and to demonstrate the adequacy of the equipment to accept all of the load types that are supplied.
    - The calculations shall account for the specific load types and adverse effects that may result for motors, non-linear loads, uninterruptable power supplies, etc.
    - The calculations shall identify load type, magnitude, step loading utilized, etc. to justify the equipment selection and establish the loading sequence to be applied for loads controlled by other disciplines.
    - Calculations shall be performed with the generator manufacturer's software and shall include the following:
        - Generator sizing with running kW, starting kW, running kVA, starting kVA, voltage dip, and frequency dip for each load starting step.
- Acoustics

  Prepare calculations to identify the anticipated sound levels for the backup generator installation. The calculations shall be used to demonstrate compliance with IEC Standard 60034, all local ordinances, and the sound performance requirements identified herein this document. Refer to Section - 4.2: Source and subsection Noise.

2.3.5.10 Transfer Switch Application

Prepare transfer switch application recommendations for Entity's approval. Refer to **Table C -** Transfer Switch Application Recommendation.

2.3.5.11 Battery System Calculations

- A/E shall prepare calculations which justify the sizing of the battery system to supply the backup electrical loads for each facility. The A/E shall also submit recommendations for modifications to the backup duration which is different than the minimum identified in this document. Refer to Section – 4.2: Source and subsection - Battery.
- The calculations shall be prepared to determine the capacity required and to demonstrate the adequacy of the equipment to accept all of the load types that are supplied for the desired duration.
- The calculations shall identify load type, magnitude, step loading utilized, etc. to justify the equipment selection and establish the loading sequence to be applied for loads controlled by other disciplines.

2.3.5.12 Uninterruptible Power Supply Calculations

- Prepare calculations which justify the selection of the UPS to supply the backup electrical loads for each facility.
- The calculations shall be prepared to determine the capacity required and to demonstrate the adequacy of the equipment to accept all of the load types that are supplied for the desired duration.
- The calculations shall identify load type, magnitude, step loading utilized, etc. to justify the equipment selection and establish the loading sequence to be applied for loads controlled by other disciplines.
- Prepare calculations which justify the sizing of the battery system to support UPS loads for each facility. The A/E shall also submit recommendations for modifications to the backup duration which is different than the minimum identified in this document. Refer to Section - 4.2: Source and subsection - Battery.

2.3.5.13 Lightning Protection Calculations

- Prepare a lightning risk assessment in accordance with the latest SBC 401 to demonstrate the potential exposure for each facility. The results of these calculations shall be used by the A/E to provide a recommendation on whether a lightning protection system is required. The assessment shall be submitted to the Entity to obtain confirmation of the A/E recommendation.

2.3.5.14 Electrostatic Discharge Assessment

- For facilities where electrical installations are classified as hazardous in accordance with the latest SBC 401, prepare an assessment regarding the potential risks associated for electrostatic discharge for each facility in accordance with IEC Standard 61340. The results of this assessment shall be used by the A/E to provide a recommendation on whether an electrostatic discharge control system is required. The assessment shall be submitted to the Entity to obtain confirmation of the A/E recommendation.
- Hazardous Area Classification;
- For classified area refer to IEC 60079

3.0 ELECTRICAL ROOMS

3.1 General

3.1.1 Electrical Rooms shall be adequately sized to accommodate all electrical equipment and also provide the appropriate clearances for access and maintenance in accordance with IEC 60364 for low voltage electrical installations and in accordance with the following **Table- A for** Working Clearances around exposed live part of electrical equipment.

TABLE A - WORKING CLEARANCES

Working Condition	600 V and below	601 V to 9.0 kV	9.0 kV to 25.0 kV
Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by wood or other insulating materials.	900 mm	1200 mm	1500 mm
Exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick, or tile walls shall be considered grounded.	1100 mm	1500 mm	1800 mm
Exposed live parts on both sides of the working space (not guarded as provided in the first working condition) with operator between.	1200 mm	1800 mm	2800 mm

3.1.2 Electrical Rooms shall be provided with adequate illumination to facilitate maintenance procedures. The lighting for these rooms shall include at least one fixture supplied from the backup power source to facilitate trouble shooting during power interruptions. Refer to Section - 12.0: Lighting for additional information regarding illumination for Electrical Rooms.

3.1.3 Normal and backup power equipment shall be located in separate Electrical Rooms for the main service equipment. This will prevent the catastrophic failure of one system from damaging the alternate power source.

Exception: Where the transfer function between power sources utilizes devices which are mounted integral in the normal equipment.

3.1.4 Refer to Document Number EPM-KEA-GL-000001: Architectural Design Guidelines for additional guidance on the design of Electrical Rooms.

3.1.5 Refer to Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines for additional guidance on heating, ventilation and air conditioning provisions for Electrical Rooms.

3.1.6 Refer to Document Number EX-KEM-GL-000001: Mechanical Design Guidelines - Fire Suppression for additional guidance on fire protection for Electrical Rooms.

3.2 Main Electrical Rooms

3.2.1 The Main Electrical Room shall be located at the service entrance and shall house the normal electric service equipment including but not limited to the following:

- Main switchgear
- Main distribution boards
- Sub main distribution boards
- Distribution boards
- Switchboards
- Motor control centers
- Lighting control relay panels
- Individually mounted enclosed circuit breakers
- Individually mounted disconnect switches
- Individually mounted motor controllers
- Power factor correction equipment
- Harmonics mitigation equipment
- Surge protective devices
- Electrical metering equipment
- Spare fuse cabinet
- Grounding bus bar.

3.2.2 Service transformers are typically located outside of the building however, a situation may arise that warrants installation inside of the building to address aesthetic or security concerns. In this situation, the service transformer shall be located in a separate dedicated room constructed with adequate fire rating, ventilation, access and working clearances for the installed equipment. For indoor installations, the A/E shall consult with the SEC to determine the specific requirements for the service installation.

Refer Working Clearance Table A - Working Clearances for the reference.

3.2.3 Where the building is supported by a backup power source, the electrical equipment associated with the backup power source shall be housed in an Electrical Room separated from the normal electrical equipment.

Exception: Where the transfer function between power sources utilizes device, which are mounted integral in the normal equipment.

3.3 Distribution Electrical Rooms

3.3.1 Distribution Electrical Rooms shall be provided throughout the facility as necessary to accommodate the distribution electrical equipment including but not limited to the following:

- Sub main distribution boards
- Distribution boards
- Lighting control relay panels
- Individually mounted enclosed circuit breakers
- Individually mounted disconnect switches or isolators
- Individually mounted motor controllers
- Harmonics mitigation equipment
- Surge protective devices
- Electrical metering equipment
- Grounding bus bar

4.0 BACKUP POWER SYSTEMS

4.1 General

4.1.1 Emergency and standby power systems shall comply strictly with the latest directives issued in the Kingdom of Saudi Arabia and Saudi Building Code (SBC)

4.1.2 The power distribution system provides for parallel feeders from two different source substations to most of the institutional, commercial and industrial facilities. In case of failure of power on one feeder, the facility can be switched to the other feeder. This dual feeder arrangement provides an inherent service redundancy; however, the provision of a backup power system shall be carefully evaluated and provided where necessary.

4.1.3 The requirement for a backup power supply will depend on the facility type and particular application. The provision of backup power for each facility requires careful determination during the early stages of the design. A list of loads proposed to be supplied from the backup power source shall be provided to Entity to obtain confirmation prior to proceeding with the design. **Table B -** Backup Power Matrix has been developed to assist the consultant with the determination of the backup power loads for each facility.

4.1.4. The containment and the route for the Emergency and backup power supply distribution arrangement shall be independent from the normal power source

Note: To ensure that the fault on the normal power supply won't affect the performance of an Emergency system

4.1.5. The A/E shall consider the backup power source configuration to determine the best approach for the facility.

- Where the facility is a single building, the source configuration would be a single location with one or more backup power source devices as required to satisfy the loads.
- Where the development is multiple buildings, the following backup power source configurations shall be considered
    - Distributed Backup Power Source: A separate backup power source dedicated for each building and distributed throughout the development.
    - Regional Backup Power Plants: Multiple regional plants with one or more backup power sources to supply a district of the development. An underground feeder network would be used to distribute the backup power to the various buildings in each region of the development. This approach shall consider the various distribution voltage opportunities to optimize the feeder network. Medium voltage backup power sources may be suitable but will require careful consideration and may necessitate the provision of transformers at each building.
    - Central Backup Power Plant: One central plant with one or more backup power sources to supply the buildings throughout the entire development. An underground feeder network would be used to distribute the backup power to the various buildings in the development. This approach shall consider the various distribution voltage opportunities to optimize the feeder network. Medium voltage backup power sources may be suitable but will require careful consideration and may necessitate the provision of transformers at each building.

TABLE B - BACKUP POWER MATRIX MINIMUM REQUIREMENTS

Load Description	Facility Types																																	
	Commercial					Schools					University					Civic					Public Safety					Health Safety					Infrastructure					Religious				
	LS	CR	OS	U	N	LS	CR	OS	U	N	LS	CR	OS	U	N	LS	CR	OS	U	N	LS	CR	OS	U	N	LS	CR	OS	U	N	LS	CR	OS	U	N	LS	CR	OS	U	N
Fire Alarm	●					●					●					●					●					●					●					●				
Egress Lighting & Exit Signs	●					●					●					●					●					●					●					●				
Elevators (< 5 Stories)					●					●					●					●					●					●					●				●
Elevator (5 Stories or more)	●					●					●					●					●					●					●					●				
Security Systems	●		●			●		●			●		●			●		●			●		●			●		●			●		●			●		●		
Hazardous Gas Monitoring	●					●					●					NA					●					●					●					NA				
HVAC																																								
Controls					●					●					●					●		●					●					●									●
Smoke Control	●					●					●					●					●					●					●					●				
Stair Pressurization	●					●					●					●					●					●					●					●				
Chiller					●					●					●					●		●					●					●					●			
Chilled Water Pumps					●					●					●					●		●					●					●					●			
Laboratory Exhaust		NA						●					●				NA											●				NA					NA				
Fumehood Exhaust		NA						●					●				NA											●				NA					NA				
Hazardous Exhaust		NA						●					●				NA											●				NA					NA				
Supply Air					●			●					●					●											●									●			
Cooling Towers					●					●					●					●								●									●			
Electrical																																								
Switchgear Controls					●					●			●					●					●					●					●					●			
Generator Accessories																																								
Controls	●					●					●					●					●					●					●					●				
Battery Charger	●					●					●					●					●					●					●					●				
Motorized Louvers	●					●					●					●					●					●					●					●				
Fuel Supply	●					●					●					●					●					●					●					●				
Plumbing																																								
Sump Pumps					●					●			●					●					●					●					●									●
Water Purification					●					●								●					●					●					●									●
RO Water System		NA								●			●				NA					NA					NA					NA					NA				
RO System Pumps		NA								●			●				NA					NA					NA					NA					NA				
Domestic Water Pumps					●					●			●								●		●					●					●									●
Tepid Water Pumps		NA								●			●				NA					NA					NA					NA					NA				
Fire Supression																																								
Fire Pump	●					●					●					●					●					●					●					●				
Jockey Pump					●					●					●					●					●					●					●				●
Dry/Pre-Action Compressors	●					●					●					●					●					●					●					●				
Fire Suppression Controls	●					●					●					●					●					●					●					●				
IT Systems and Equipment																																								
Data Center Servers & Drives				●					●					●					●					●					●												●
Data Center Air Conditioning			●						●				●					●					●					●												●
Data Center Fire Supression	●					●					●					●					●					●					●					●				
Essential Computers			●	●					●				●	●				●	●				●	●				●	●					●					●	
Non-essential Computers					●					●					●					●					●					●											●
Network Switch				●					●					●					●					●					●												●
Infrastructure																																								
Traffic Signals		NA					NA					NA					NA					NA					NA				●					NA				
Pumping Stations		NA					NA					NA					NA					NA					NA				●					NA				

ABBREVIATIONS:

LS	Life Safety
CR	Critical
OS	Optional Standby
U	Uninterruptible Power Supply
N	Normal
NA	Not Applicable

FACILITY TYPE DESCRIPTIONS:

Commercial	Office Buildings, Retail Shops, Hotels, Restaurants, Athletic Clubs
Schools	Facilities for Pre-primary, Primary, Intermediate and Secondary Education
University	College and University Buildings for Instruction, Research, Residency, and Support Activities
Civic	Theaters, Exhibition Halls, Museums, Libraries, Municipality Offices
Public Safety	Police Stations, Fire Stations
Health Safety	Hospitals, Health Centers, Outpatient Facilities
Infrastructure	Traffic Signaling, Pumping Stations, Sewage Treatment
Religious	Mosques

4.1.6 Additional Provisions

- In all cases, each important sub-system in all facilities such as fire alarm, telephone, public address, intercom, emergency and exit lights, and security system shall be provided with an individual, integral, rechargeable battery pack and charger.

- All critical equipment such as computers and life support systems shall be fed from a UPS system, which is generally integral with such equipment.

4.1.7 Backup power systems shall be configured with separate branches for the various load types. Categories for load segregation shall include emergency and standby. Refer to the descriptions for each of these categories in Subsections 4.3: Emergency Systems and 4.4: Standby Systems.

4.2 Sources

4.2.1 The following are the various types of backup power sources which are available. They can be used individually or in combination as required by the facility.

- Local Generators
- Batteries
- Uninterruptible Power Supply.

4.2.2 Generators

- Local generation is advisable where emergency power is required for power and lighting loads.
  - Generators shall be engine driven.
  - Generator rating and fuel source shall be as specified on the specification
  - Generator circuit breaker shall be included in the generator set and shall be suitable, specifically designed and tested for the application.
- Generators are available in various ratings as follows:
  - Standby Rated: Application is to supply emergency power for a limited duration during a power outage. Standby generators shall be used for applications where operation is roughly 200 hours per year and they are not recommended for parallel operation with the utility source.
  - Prime Rated: Application is to supply loads for an unlimited number of hours per year in a variable load setting. It is not advisable to that the variable load exceed 70% average of the prime power rating during any operation period of 250 hours. If operating at 100% of prime power rating, yearly hours should not exceed 500.
  - Continuous Rated: Application to supply a constant 100% load for an unlimited number of hours each year. Continuous power rated units are most widely used in applications where the power grid is unreachable. Such applications include mining, agriculture or military operations.
- Generators for backup power to most facilities shall be standby rated unless there is a specific critical need as determined by the A/E. The justification for use of prime or continuous rated generator(s) shall be submitted to the Entity for review and approval.
  - Generator voltage, frequency and phase relationship shall be the same as the normal system. Size shall be adequate to carry the required emergency loads of the facility. Where the backup power loads exceed the capacity of a single generator, multiple units shall be operated in a parallel configuration. Paralleled units may also be justified for extremely critical loads such as hospitals or data centers. Automatic transfer shall be provided for all emergency loads.
  - Backup generators with standby rating shall be sized to be loaded between 50% minimum and 80% maximum of their nameplate rating. Calculations shall be performed to justify the equipment selection and performance. Refer to Section – 2.3.5: Power Calculation & Analysis and subsection – 2.3.5.9: Generator Calculations.

    Generator sizing shall include 10% spare capacity for load growth.
- Installation Requirements
  - Enclosure
    - For outdoor installations, the enclosure shall be design to withstand the environmental conditions and provide a minimum protection rating of IP65. All

openings for ventilation and access shall be designed to maintain the weather-proof requirement.

- Weather-proof enclosures shall be walk-in type where space permits. If adequate space is not available for the walk-in enclosure, a skin-tight enclosure with access doors is permitted with the approval of the Entity.

- Noise

  The radiated engine noise shall be addressed as follows:

  - Outdoor locations shall incorporate sound attenuation into the enclosure. The level of attenuation shall limit the sound level at the property line to meet the requirements of the Entity.

- Refer Document Number EP-KES-GL-000001: Structural Design Guidelines for additional information regarding installation requirements for generators including:
  - Structural
  - Vibration
- Refer Document Number EPM-KEA-GL-000001: Architectural Design Guidelines for additional information regarding installation requirements for generators including:
  - Indoor space
  - Acoustical considerations
- Refer Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines for additional information regarding installation requirements for generators including:
  - Ventilation
  - Fuel supply

4.2.3 Batteries

- Where the load requirements are not large enough to require local generators, centrally located batteries may be provided as the backup power source. Sealed lead acid, nickel-lead-alkaline or nickel cadmium types may be used. Ampere-hour capacity shall be adequate for power requirements. Battery charging equipment shall be included.
- The initial battery system shall be sized to provide 20% spare capacity to accommodate additional loads in the future.
- Battery storage shall be sufficient to supply the loads (connected and initial spare capacity) for a minimum duration 1.5 hours. Longer backup durations may be desirable or recommended by the A/E for unique conditions. These special considerations shall be presented to Entity for review and approval.
- Batteries shall be located in well ventilated rooms, and mounted on racks to facilitate regular maintenance.

4.2.4 Uninterruptible Power Supply

- UPS systems shall be battery - static inverter type, packaged pre-engineered units. KVA and time rating shall be adequate for the application.
- UPS systems are costly and shall only be applied for critical loads which cannot tolerate even extremely short power interruptions including but not limited to the following:
  - Hospital life support systems
  - Critical data centers
  - Critical computer systems
  - Critical security systems
  - Critical building control systems
  - Critical communications systems
- The initial UPS system shall be sized to provide 20% spare capacity to accommodate additional loads in the future.
- Battery Storage

  - The battery storage for the UPS shall be sized to provide the appropriate backup duration for the application. Battery storage shall be sufficient to supply the loads (connected and initial spare capacity). The minimum duration for a stand-alone UPS system shall be 1.5 hours for the full capacity of the UPS. Longer backup durations may be desirable or recommended by the A/E for unique conditions. These special considerations shall be presented to the Entity for review and approval.
  - The UPS may also be supported by a backup generator as another level of redundancy. When this configuration is implemented, the battery storage associated with the UPS system shall be sized to provide the appropriate duration of backup. Typically, this would include a reduced duration to allow these critical loads to remain operational while the generator is activated and is ramping up to accept the loads. For this situation, a minimum battery backup of 15 minutes for the full capacity of the UPS shall be provided to bridge the outages between the normal and emergency power sources. Longer backup durations may be desirable or recommended by the A/E for unique conditions. These special considerations shall be presented to the Entity for review and approval.
- UPS units are available with modular construction and hot swappable modules. This configuration is beneficial to facilitate system expansion and also allows maintenance to be performed without interruption to the critical loads. The A/E shall evaluate the use of these equipment features and provide recommendations to the Entity for review and approval.
- UPS systems shall be installed in clean dry locations away from occupied areas.
- UPS systems shall be located in well ventilated rooms, and mounted in cabinets to protect the equipment.
- There are additional special occupancies associated with telecommunication systems that warrant the application of a dedicated UPS. These special conditions and the associated requirements are described further in Document Number EPM-KEE-GL-000002: ELV Design Guidelines: Power Distribution, Uninterruptible Power Supply (UPS).

4.3 Emergency Systems

4.3.1 Electrical systems legally required to be installed and that supply loads essential to safety and life. This load category is typically referred to as the Life Safety Branch and supplies the following loads:

- Egress lighting and exit signs
- Fire alarm
- Security systems
- Generator accessories: controls, fuel supply, and motorized dampers
- Fire pumps
- Dry/Pre-action fire protection system compressors
- Fire suppression controls
- Smoke control systems
- Stair pressurization systems
- Elevators (Highrise Buildings)
- Generator battery charger
- Hospital communication systems
- Sewage disposal
- Dangerous industrial processes

4.3.2 Refer Table B - Backup Power Matrix for guidance on emergency power requirements for each building type

4.4 Standby Systems

4.4.1 Alternate power systems for such applications where interruption of normal power would cause discomfort to personnel or damage to product. This load category is typically broken into Critical Equipment and Optional Standby. The loads associated with each of these branches are described as follows:

- Critical Equipment
    - Task Illumination and selected receptacles for the following areas and functions related to patient care in healthcare facilities:
    - Critical Care
    - Patient Care
    - Infant Nurseries
    - Medication Prep
    - Pharmacy Dispensing
    - Selected Acute Nursing Areas
    - Psychiatric Bed Areas
    - Ward Treatment Rooms
    - Nurses Stations
    - Hospital communications systems including nurse call and telephones.
    - Security systems.
- Optional Standby
    - Building management and control systems
    - Security systems
    - Data Center air conditioning systems
    - Laboratory exhaust air systems
    - Laboratory supply air systems
    - Chilled water generation – chillers, cooling towers, and pumps
    - Water purification systems
    - Domestic water pumping system
    - Essential computers
    - Elevators (other than Highrise Buildings)
    - Supply, return and exhaust systems for healthcare facilities including:
        - Operating Rooms
        - Delivery Rooms
        - Airborne Infectious/Isolation Rooms
        - Protective Environment Rooms
        - Clinical Laboratories
        - Nuclear Medicine Areas

Refer Table B - Backup Power Matrix for guidance on emergency power requirements for each building type.

5.0 TRANSFER SWITCHES

5.1 General

A transfer switch is an electrical switch that is able to transfer electrical loads between two sources. There are several types and numerous features for this equipment that shall be considered when selecting the appropriate equipment for each application.

5.2 Types

5.2.1 Manual transfer switches allow electrical loads to be supplied from multiple sources and facilitates manual transfer from one source to another when there is a failure of one source or there is some other special situation to initiate this transfer. Examples for special situations include load balancing between service feeders or in response to a request from the utility company to avoid an overload condition. Manual transfer switches are not used for life safety or critical backup power loads but may be applied to optional standby loads.

5.2.2 Automatic transfer switches allow electrical loads to be supplied from multiple sources and facilitates automatic transfer from the primary to the secondary source when the primary source fails. The automatic transfer switch also occurs from the secondary to the primary source when the primary source returns to normal. Automatic transfer switches are commonly used for all backup power loads including life safety, critical and optional standby.

5.2.3 Bypass isolation automatic transfer switches allow electrical loads to be supplied from multiple sources and, in addition to the automatic transfer capability, provides a means to manually bypass and isolate the transfer switch to allow for maintenance procedures. The bypass isolation switch is connected both in series and in parallel with the automatic transfer switch to facilitate this operation. Bypass isolation transfer switches are used for all backup power loads where the criticality of the load warrants this additional feature to allow for routine maintenance without interruption to the equipment operation. This equipment is most commonly utilized for health safety type facilities such as hospitals but can also be applied to other facilities where the occupancy or function is determined to be critical.

5.3 Operation

5.3.1 Single operator transfer switches utilize a single electrical component to initiate the transfer from one source to the other. This method of operation does not provide the capability to incorporate any delays in the transfer process and is appropriate for the most critical loads which need to transfer as quickly as possible.

5.3.2 Dual operator transfer switches utilize two electrical components to initiate the transfer between power sources. The first initiates the break from the connected source and the second initiates the connection to the alternate source. The dual operator provides flexibility for programming delays that may be desirable for certain types of loads to avoid detrimental impacts to the power distribution system.

5.3.3 Open transition transfer includes a break-before-make operation where there is a delay between separation from one source and connection to the next. This is the typical operation and shall be the normal selection for all facilities.

5.3.4 Closed transition transfer includes a make-before-break operation where the two sources are momentarily paralleled to avoid outages to the critical loads. Use of this operation method requires careful consideration and shall only be selected when it has been justified for the critical application. The A/E shall provide documentation to support the selection of this operating means to the Entity for review and approval. The A/E shall also coordinate with the SEC to establish the acceptability of closed transition transfer and the protective safety features required for implementation of this operation.

5.4 Configuration

5.4.1 Four (4) pole transfer switches include separate poles for all three phases and the neutral. This transfer switch provides isolation of source neutrals and is the preferred configuration. Four (4) pole transfer switches shall be the normal selection for all facilities. This approach requires special attention to the grounding of the backup power source. Refer to subsection-4.2: Source

5.4.2 Three (3) pole transfer switches include separate poles for all three phases but the neutral is solid and does not have the capability to be isolated between the normal and emergency power sources. Applications for this configuration shall be limited to existing facilities where the existing transfer switches are 3 pole type and their use will maintain the electrical system consistency and avoid confusion for maintenance procedures. The selection of this configuration shall be reviewed with the Entity to obtain approval. Refer to Transfer Switch application recommendation process described in Subsection 5.5: Applications and Table -C: Transfer Switch Application Recommendation.

5.5 Applications

The A/E shall consider all of the backup power applications for a facility and shall provide the Entity with recommendations for the transfer switch. Refer to **Table -C:** Transfer Switch Application Recommendation

TABLE C - TRANSFER SWITCH APPLICATION RECOMMENDATION

Transfer Switch No.	Branch	Type			Operation				Configuration		Optional Features			
		MTS	ATS	BITS	Single Operator	Dual Operator	Open Transition	Closed Transition	3 Pole	4 Pole	A	B	C	D
1	Life Safety			•	•		•			•	•	•		
2	Critical Equipment			•		•	•			•		•		
3	Optional standby		•			•	•			•		•	•	

Abbreviations
MTS - Manual Transfer Switch
ATS – Automatic Transfer Switch
BITC- Bypass Isolation Transfer Switch

Optional Features
A Engine-Generator Exercise
B Digital Metering
C Programmed Neutral Switch Position
D In-Phase Monitor

6.0 ELECTRICAL DISTRIBUTION EQUIPMENT

6.1 Medium Voltage Switchgear

6.1.1 General

- All medium voltage switchgear and cables shall be designed in accordance with the latest SEC Specifications SDMS.
- This includes the following medium voltage electrical equipment:
  - Ring Main Units (RMU)
  - Interrupter Switches
  - Oil-filled switches
  - Manual Transfer Switches
  - Automatic Transfer Switches
  - Metal Clad Distribution Switchgear
  - Relays, Instruments and Meters

6.2 Low Voltage Switchgear and Switchboards

6.2.1 General

- All low voltage switchgear and control gear shall be designed in accordance with the IEC 60439 and IEC 60947.
- Low voltage switchgear and switchboards are utilized for distribution of power to the panel boards and electrical loads throughout a facility. This equipment is critical to the operation of the facility and shall be carefully designed to best meet the operational requirements and budget limitations for the facility.
- Switchgear construction offers the following characteristics:

- Lower maintenance costs
- Higher interrupting ratings
- Enhanced coordination capabilities and operational safety
- Higher quality and reliability

- Switchboard construction offers the following characteristics:
  - Lower equipment costs
  - More compact dimensions

6.2.2 Construction

- Switchgear
  - Self-supporting, free-standing equipment with metal enclosure to accommodate the overcurrent protective devices, metering equipment, surge suppression devices and other auxiliary components.
  - Modular construction with individual compartments for each overcurrent protective device.
  - Forms of internal separation between components within the Low Voltage Switchgear shall conform to IEC 60439-1 7.7. This provides higher degree of protection based on the requirement.
  - Integral steel channel base for increased rigidity.
  - Overcurrent protective devices are draw-out type to facilitate maintenance of the devices.
- Switchboards
  - Self-supporting, free-standing equipment with metal enclosure to accommodate the overcurrent protective devices, metering equipment, surge suppression devices and other auxiliary components.
  - Separate cubicles for main circuit breaker and distribution feeder circuit breakers.
- Fault current ratings for equipment shall be in accordance with the results of the fault calculations. Refer to subsection –2.3.5: Power Calculation & Analysis and sub subsection – 2.3.5.4: Fault Level Calculations. Equipment ratings shall be selected for the next standard level above the calculated levels.

6.2.3 Application

- The type of distribution equipment shall be selected to satisfy the requirements of the facility and the application. The A/E shall make recommendations regarding the appropriate equipment type based on consideration for the following criteria:
  - Magnitude of the loads served
  - Type of facility
  - Budget limitations
  - Maintenance capabilities and procedures
  - Economic impact of interruptions
  - Space availability
  - **Table – D:** Switchgear Vs. Switchboard Application Guide has been developed to assist the A/E with the determination of the selection for distribution equipment for each facility type.

TABLE D - SWITCHGEAR VS. SWITCHBOARD APPLICATION GUIDE

Facility Type	Equipment Rating (Amps)	Construction		Access		Main Circuit Breakers		Feeder Circuit Breakers		
		Switchgear	Switchboard	Front Only	Front and Rear	Drawout	Individual Fixed	Drawout	Individual Fixed	Group Mounted
Commercial	≤ 2000		□	□			□			□
	> 2000		□	□			□			□

Facility Type	Equipment Rating (Amps)	Construction		Access		Main Circuit Breakers		Feeder Circuit Breakers		
		Switchgear	Switchboard	Front Only	Front and Rear	Drawout	Individual Fixed	Drawout	Individual Fixed	Group Mounted
	≥ 4000		□		□		□		□	
Schools	≤ 2000		□	□			□			□
	> 2000		□	□			□			□
	≥ 4000		□		□		□			□
University	≤ 2000		□	□			□			□
	> 2000		□		□		□		□	
	≥ 4000	□			□	□		□		
Civic	≤ 2000		□	□			□			□
	> 2000		□		□		□		□	
	≥ 4000	□			□	□		□		
Public Safety	≤ 2000			□			□			□
	> 2000		□	□			□			□
	≥ 4000	□			□	□		□		
Health Safety	≤ 2000		□	□			□			□
	> 2000	□			□	□		□		
	≥ 4000	□			□	□		□		
Infrastructure	≤ 2000		□	□			□			□
	> 2000		□		□		□		□	
	≥ 4000	□			□	□		□		
Religious	≤ 2000		□	□			□			□
	> 2000		□	□			□			□
	≥ 4000		□	□			□		□	

FACILITY TYPE DESCRIPTIONS:

Commercial	Office Buildings, Retail Shops, Hotels, Restaurants, Athletic Clubs
Schools	Facilities for Pre-primary, Primary, Intermediate and Secondary Education
University	College and University Buildings for Instruction, Research, Residency, and Support Activities
Civic	Theaters, Exhibition Halls, Museums, Libraries, Municipality Offices
Public Safety	Police Stations, Fire Stations
Health Safety	Hospitals, Health Centers, Outpatient Facilities
Infrastructure	Traffic Signaling, Pumping Stations, Sewage Treatment
Religious	Mosques

6.3 Panel Boards

6.3.1 General

- Electric systems in commercial and industrial buildings shall include panelboards, which utilize circuit breaker devices. Fused devices are not recommended unless specifically required for specific protection requirements or coordination purposes. An example is fuses may be used for control circuits of instrument or monitoring devices.
- Panelboard's are generally classified into the following categories:
  - Main distribution boards
  - Sub main distribution boards
  - Distribution boards

6.3.2 Features

- Panelboard's and associated circuit breakers shall be fully rated for available fault current. Series rating of the equipment is not acceptable.
- Panelboard's shall be rated to accept the calculated loads and shall include 20% spare capacity for future growth.
- Panelboard's shall be provided with 20% bussed space suitable to accept future circuit breakers.
- Panelboard's shall be provided with 10% spare circuit breakers. Provide at least (1) spare breaker with rating to match the other active breakers in the panelboard.
- Panelboard's shall include door-in-door construction with hinged door to facilitate access to the breakers and wire ways.
- Fault current ratings for panelboard's shall be in accordance with the results of the fault calculations. Panelboard ratings shall be selected for the next standard level above the calculated levels. Minimum ratings shall be as follows:
    - Short circuit rating - 21 kA
    - Overcurrent Protective Devices - 14 kA

6.3.3 Selection of Installation

- Surface mounted panelboard's shall be used in electrical rooms and other spaces where the surface mounted enclosure is not aesthetically objectionable.
- Recessed mounted panelboard's shall be utilized where installed in finished spaces and where surface mounting is undesirable.

6.4 Low Voltage Circuit Breakers

6.4.1 General

- Low voltage circuit breakers shall generally fall under 3 classification
    - Miniature Circuit Breaker (MCB)
    - Molded Case Circuit Breaker (MCCB)
    - Air Circuit Breaker (ACB)
- Circuit breakers shall be a quick-make and quick-break switching device, which will operate both manually for normal switching functions and automatically under overload and short-circuit conditions.
- Circuit breakers shall be electrically and mechanically trip free. The RMS symmetrical interrupting capacity for each breaker shall be adequate for the available fault but shall have a minimum rating of 14 kA for 400 V systems. Circuit breakers shall be either de-rated or calibrated if installed in an ambient temperature higher than 40°C.
    - When ambient temperature is within allowable limits, the circuit breakers shall have electronic trip with long and short time uniform tripping characteristics throughout the temperature range from 25 to 50°C.
    - Circuit breakers located in environments where the temperature varies, while the load is in constant, such as submersible pumps, shall be ambient temperature compensated to 50°C
    - Refer to subsection-2.3.4: Derating Factor – Power Cable and Equipment.
- Circuit breaker selection and application shall be in accordance with the following:
    - Residential facilities – IEC Standard 60898.
    - Commercial, education, public safety, health safety, religious and industrial facilities – IEC Standard 60947.
    - Circuit breaker trip ratings shall be industry standard in accordance with the IEC Standards. The standard ampere rating for circuit breakers shall be considered are1.6, 2, 2.5, 3.2, 4, 5, 6.3, 8, 10, 12.5, 16, 20, 25, 32,40, 50, 63, 80, 100, 125, 160, 200, 225, 25, 320, 400, 500, 630, 800,1000, 1250, 1600

6.4.2 Miniature Circuit Breakers (MCB)

Miniature circuit breakers are preferred for residential, commercial, institutional and industrial branch circuit loads feeding lighting loads, small receptacle loads, etc.

6.4.3 Molded Case Circuit Breakers (MCCB

Molded case circuit breakers are preferred to fuses and shall be used in distribution panelboard's for distribution of power to various loads such as lighting panelboard's, power panelboard's, motor loads, etc.

6.4.4 Air Circuit Breakers (ACB)

- For low voltage switchgear with higher ratings (greater than 1000 amps), Drawout type air circuit breakers are preferred over molded case circuit breakers.
- Air circuit breakers shall be provided with microprocessor based trip units to facilitate the adjustment of the tripping characteristics to best suit the application. These trip units vary in sophistication, communications and metering capabilities including the following:
    - Adjustable protection and coordination
    - System diagnostics
    - System monitoring
    - System communications
    - Optional features for enhanced maintenance
- The type of microprocessor trip unit used for each application shall be determined by the A/E and recommendations shall be submitted to the Entity for review and approval.

6.5 Fuses

6.5.1 General

- Low voltage fuses shall be rated at the voltage levels below 600 V as per SEC standards. Fuses are generally available with the following operating characteristics:
    - Fast-acting which open quickly when their current rating is exceeded. These fuses are generally used for resistive or other type loads with low inrush currents.
    - Time-delay which are designed to open only on an excessive current draw for a defined of time. These fuses are typically used for protection of inductive and capacitive loads that experience heavy inrush currents.
- The use of fuses for overcurrent protection shall be on a limited basis determined by the specific application. The Entity prefers the use of circuit breakers for overcurrent protection but understands that there may be applications which warrant the use of fuses. The A/E shall submit recommendations for fuse applications to the Entity for review and approval.
- Fuse selection and application shall be in accordance with the following:
    - All facility types – IEC Standard 60269.
    - Fuse ratings shall be industry standard in accordance with the IEC Standards.

6.6 Motors

6.6.1 General

Motors requirements are addressed in Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines and refer subsection for Motor and motor controller.

6.7 Motor Controllers

6.7.1 General

Motors requirements are addressed in Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines and refer subsection for Motor and motor controller.

6.7.2 Motor Control Center

- Where multiple motors are located in the same space or area, it is preferred to control them from a centralized location such as a motor control center.
- A motor control center is an assembly of individual starters for various motors mounted on a fixed or draw-out type of chassis and located in a common enclosure. Motor control centers shall be modular construction with a separate compartment for each starter. Common wireways shall be provided in each

6.8 Wiring Devices

6.8.1 The rating and configurations associated with the standard 380/220Volt, 60Hz electrical system as per the local regulation and Saudi standards.

6.8.2 All wiring devices shall be selected to meet the requirements of the latest applicable SASO 444 standard. These standards shall guide the A/E in the selection of wiring devices for the following:

- Plugs and socket-outlets for domestic and similar general use
- Plugs and socket-outlets for commercial and similar purposes
- Plugs, socket-outlets and couplers for industrial purposes
- Switches for household and similar fixed electrical installations.

6.8.3 The selection of wiring devices and installation methods shall be coordinated with the raceway system to facilitate a physically and aesthetically acceptable result.

6.9 Power Monitoring

6.9.1 Power Monitoring System shall be provided as required by the Entity

6.9.2 Power Monitoring Equipment shall be provided to the following as minimum:

- MV and LV Switchboard main and the distribution circuit breakers.
- Secondary low voltage circuit breaker of unit/packaged substation.
- Automatic Transfer Switches.
- Generator Paralleling Switchboards.
- Major distribution panel boards.

6.9.3 Power monitoring functions shall include but not limited to the following:

- Voltage
- Current
- KWh
- kW, kVA and kVAR.
- Power Factor
- Total Harmonic Distortion (Voltage and Current)

7.0 TRANSFORMERS

7.1 General

7.1.1 All service transformers and associated medium voltage switchgear for all residential, commercial, institutional, and industrial facilities shall be in accordance with the latest SEC Specification SDMS.

7.1.2 All features for the service transformers and associated equipment shall be in accordance with the latest SEC Specifications SDMS.

7.1.3 Sizing/rating of all transformers shall be in accordance with the latest SEC Standards DPS-01 and DPS-02.

7.1.4 Configuration and arrangements for transformers and associated equipment shall be in accordance with the latest SEC Standard SDCS-02.

7.1.5 Transformer application restrictions:

- Liquid filled transformers shall not use polychlorinated biphenyl (PCB) fluid.
- Oil filled transformers shall not be utilized for indoor applications to the extent possible.
- In case, the Installation of oil filled transformers for indoor application shall meet NFPA fire protection installation and vault requirement.
- Dry type transformers shall only be used when approval has been obtained from Entity and they shall not be installed outdoor.

7.1.6 Transformer Noise Levels

Service transformer noise levels shall be in accordance with the latest SEC Specifications SDMS.

7.2 Community Area Transformer

- The community area includes residential, commercial, and institutional facilities
- The standard service transformer for facilities in the Community Area shall be outdoor type, liquid filled, self-cooled, dead front, and pad mounted.
- Exceptional cases may allow the use of indoor transformers. The A/E shall provide recommendations regarding the indoor transformer (liquid filled or dry type) and justification for this application to the Entity for approval. Indoor installations will require special provisions for fire separation, noise control, and ventilation. Refer Document Number EPM-KEA-GL-000001: Architectural Design Guidelines and Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines for additional information regarding special provisions for indoor installations.
- Installation Requirements
    - All terminations shall be in accordance with the latest SEC Specification SDMS.
    - All transformers and associated equipment shall be installed on a concrete pad in accordance with the latest SEC Standard SDCS-02

7.3 Industrial Area Transformer

- The standard service transformer for facilities in the Industrial Area shall be outdoor type, liquid filled, self-cooled, dead front, and pad mounted.
- Exceptional cases may allow the use of indoor transformers. The A/E shall provide recommendations regarding the indoor transformer (liquid filled, dry type, or cast coil) and justification for this application to the Entity for approval. Indoor installations will require special provisions for fire separation, noise control, and ventilation. Refer Document Number EPM-KEA-GL-000001: Architectural Design Guidelines and Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines for additional information regarding special provisions for indoor installations.

- Installation Requirements
    - All terminations shall be in accordance with the latest SEC Specification SDMS.
    - All transformers and associated equipment shall be installed on a concrete pad in accordance with the latest SEC Standard SDCS-02
    - The secondary winding of all industrial transformers shall be grounded wye connection.

7.4 Transformers for Existing Facilities with Discontinued Voltages

- The Entity for transition to the new standard voltages for all Entity existing facilities has eliminated various voltage ratings. There are existing facilities which will not be required to transition to the new standard voltage ratings until economically justified.

- For work in existing facilities, the A/E shall develop modification concepts and make recommendations regarding the economic justification for converting from the discontinued voltages to the new standard voltage. This justification shall be submitted to the Entity for review and approval.

- When determined that the discontinued voltages are to remain, transformers shall be used to establish the required voltages for existing equipment and loads. These transformers shall have the following characteristics:
    - Indoor
    - Dry type
    - Enclosed ventilated
    - Encapsulated type is acceptable in controlled environments for ratings 112.5 kVA or less
    - Cast coil type for industrial polluted areas

7.5 References

Refer to Document Number EPM-KES-GL-000001: Structural Design Guidelines for additional information regarding foundation requirements for transformers.

8.0 CONDUITS, DUCTS AND BUSWAYS

8.1 General

- This Section addresses the application requirements for electrical raceways, ducts and busways for the Entity facilities.

- An electrical raceway is any channel of metallic or non-metallic materials designed expressly for holding wires, cables or busbars.

- Electrical raceways and shall be applied in accordance with the latest edition of SBC 401, IEC 61386, and IEC 60529.

8.2 Selection of Raceway Type

8.2.1 The type of raceway shall be selected to suit the location and method of installation which are grouped in the following basic classifications.

- Surface mounted installations include:
    - Raceways concealed in plenums and hollow spaces for residential, commercial and institutional type facilities.
    - Raceways exposed in utility type spaces for residential, commercial and institutional type facilities.
    - Raceways exposed in industrial type facilities.

- Embedded installations include raceways in floor slabs or walls.
- Underground installations include raceways located below the floor slabs inside a building and raceways located below grade outside of the building.

8.2.2 The A/E shall consider the following when selecting the appropriate electrical raceway for the Entity facility:

- Protection of personnel against electrical injury.
- Protection of property from damage resulting from a fire.
- Protection of circuitry against mechanical damage or injury.
- Atmospheric conditions such as corrosive or hazardous environment.

8.3 Raceway Types

The electrical raceway types that are typically used for installation and protection of electrical wiring include the following

8.3.1 Rigid Steel Conduits (RSC)

- Rigid steel conduit shall conform to IEC 61386 and IEC 60981 for extra heavy duty electrical rigid steel conduits.
- Rigid steel conduit larger than Trade Size 6 shall not be used for routing the cables.

8.3.2 Electrical Metallic Tubing (EMT)

- Electrical metallic tubing larger than Trade Size 2 shall not be used.
- Electrical metallic tubing shall generally be used for routing the cables for branch circuits, control circuits and signal circuits.

8.3.3 Rigid Non-Metallic Conduit (RNC)

- Rigid non-metallic heavy wall conduit shall conform to IEC 61386.
- The conduits and fittings shall be made from suitable non-metallic material such as PVC that is resistant to moisture and chemical atmospheres.

8.3.4 Flexible Metal Conduit (FMC)

- Flexible metal conduit shall conform to IEC 61386.
- Flexible metal conduit shall be used for connection between equipment that is subject to vibration such as motors or which requires movement for adjustment and permanent raceways or for connecting two parts of the building across an expansion joint.
- The flexible metal conduit shall be circular in cross section and made of helically wound, formed, interlocked metal strip.

8.3.5 Liquid-tight Flexible Metal Conduit (LFMC)

- Liquid-tight flexible metal conduit shall conform to IEC 61386.
- Liquid-tight flexible metal conduit shall be used for connection between equipment that is subject to vibration such as motors or which requires movement for adjustment and permanent raceways or for connecting two parts of the building across an expansion joint.
- Liquid-tight flexible metal conduit shall be used for outdoor installations and other applications subject to ingress of solid objects and/or water in accordance with IEC 60529.

8.3.6 Flexible Non-Metallic Conduit (FNC)

- Flexible non-metallic conduit (spiral wound) shall be manufactured in accordance with IEC 61386.
- Flexible non-metallic conduit shall be used for connection between equipment which requires movement for adjustment and permanent raceways.
- These conduits shall be used in the places where there is no danger of mechanical damages such as connection between outlet boxes and luminaires in false ceilings.

8.4 Surface Installations

8.4.1 Industrial Facilities

Surface raceway installations shall utilize extra heavy duty rigid steel conduit which satisfies the requirements of IEC Standards 60981 and 61386.

8.4.2 Residential, Commercial and Institutional Facilities

- Electrical raceways shall be concealed above ceilings, in walls or in shafts wherever possible. These raceways shall be medium duty steel conduit which satisfies the requirements of IEC Standard 61386.
- Surface raceway installations in areas subject to physical damage shall utilize extra heavy duty rigid steel conduit which satisfies the requirements of IEC Standards 60981 and 61386.
- Cable trunking or gutters may be used for installations where accessibility of the cables is of prime importance. Cable trunking shall not be used where subjected to corrosive vapors or severe physical damage. Cable trunking shall be steel with painted finish and removable or hinged cover.
- Cable trunking shall conform to IEC 61084.

8.5 Underfloor Installations

8.5.1 Applications

- In commercial and institutional facilities where large open areas are required and/or moveable systems furniture is utilized, underfloor raceways and ducts shall be used for distribution of electrical cables.
- Underfloor raceways and ducts shall be used to support electrical cables for power, lighting, signal, and telecommunications to workstations, work benches and tables which are not located adjacent to a wall.
- Underfloor raceways and ducts shall not be used for hazardous locations or where subject to corrosive vapors or severe physical damage.

8.5.2 Underfloor Raceway Characteristics

- Underfloor raceways and ducts shall utilize welded rectangular steel construction with multiple compartments as necessary to accommodate the various electrical wiring.
- Underfloor raceways shall be sized to accommodate the installed cables. Size of raceways with a minimum of 20% spare capacity for future cable installation.
- Underfloor raceways shall be provided with continuous separators between all different cable types.
- Underfloor raceway system shall include junction boxes to facilitate access to cables and activation fittings to accommodate devices for the various electrical services.

8.6 Underground Installations

8.6.1 Applications

- Underground raceways in areas which are not subjected to traffic and/or severe physical damage may be direct buried conduit.

- Underground raceways in traffic areas or others areas subject to disruption or severe physical damage shall be concrete encased.

8.6.2 Raceway Characteristics

- Direct buried raceways in residential, commercial and institutional areas shall be PVC conduit.
- Direct buried raceways in industrial areas shall be PVC coated extra heavy duty rigid steel conduit.
- Concrete encased raceways shall be PVC conduit.
- Raceways installed in structural or reinforced concrete envelope shall be PVC conduit.
- Underground raceways (direct buried and/or concrete encased) in hazardous areas shall be PVC coated extra heavy duty rigid steel conduit
- Raceways installed below roadways shall be concrete encased.

8.7 Cable Trays and Cable Trenches

8.7.1 Applications

- Industrial Facilities
  - In substations and mechanical and electrical rooms, cable trays and cable trenches may be used.
  - Cable trays shall not be used for outdoor applications unless specifically approved the Entity
- Residential, Commercial and Institutional Facilities
  - In substations and mechanical and electrical rooms, cable trays and cable trenches may be used.
  - Cable trays shall not be used for interior distribution of electrical cables where they are exposed to view unless specifically approved by the Entity.

8.7.2 Cable Tray Characteristics

- Cable trays shall be manufactured in accordance with IEC 61537.
- Cable trays shall be ladder type, aluminum with natural finish or steel with hot dipped galvanized finish.
- Cable trays shall be of the width and depth required to accommodate the installed cables plus a minimum of 20% spare capacity for future cable installation. Minimum depth shall be 100 mm. Rung spacing shall be adequate for support of installed cables but shall not exceed 230 mm.

8.7.3 Cable Trench Characteristics

- Cable trenches shall be of the width and depth required to accommodate the installed cables plus a minimum of 20% spare capacity for future cable installation.
- Cable trenches shall include removable covers to facilitate access to the cables. Covers shall be rated to withstand the environmental conditions.

8.8 Wires and Cables

8.8.1 Copper Conductors

- All wires and cables shall have copper conductors.
- Cables shall be manufactured in accordance with SASO and IEC Standards.
- Cable installation shall be in accordance with the requirements of the latest SEC Standards and Distribution Materials Specifications.
- Standard millimeter size cables shall be used and shall be in accordance with IEC 60228.
- Minimum size power cable used shall be 2.5 mm^2.

8.8.2 Low Voltage Wires and Cables for Major Feeders

Low voltage wires and cable (600 V and below) for major feeders installed in underground ducts and for indoor installation in raceways, conduits and wireways shall be 90°C rated, cross-linked polyethylene (XLPE) insulated and PVC sheathed in accordance with IEC 60502 and flame retardant per IEC 60332-3, B.

8.8.3 Low Voltage Building Wiring

General purpose low voltage building wiring for use in conduit (for receptacle and lighting circuit) shall be PVC Insulated, 85Deg C, 450/750V (IEC 60227 &SASO 55) wires flame retardant in accordance with IEC 60332-1

8.8.4 Low Voltage Cables for Direct Burial

Low voltage cables for direct burial shall be armored, minimum 90°C rated, PVC or XLPE insulated and PVC jacketed in accordance with IEC 60502.

8.8.5 High Voltage Cables

High voltage cables (above 1000 V) shall be 90°C rated, be EPR or XLPE insulated and have metallic shield. Cables used for direct burial purposes shall have an outer jacket.

8.8.6 Cable Ampacity and Electrical Characteristics

- Cable ampacity, electrical characteristics, and insulating thickness shall conform to the latest IEC 60364, IEC 60228 and SBC 401.
- The types of insulation used within a building and their maximum operating temperatures are identified in SBC 401.

8.8.7 Cable Glands shall be in accordance with IEC 62444.

LSZH, LSOH, LSFH, or OHLS (Low Smoke Zero Halogen) material classification in accordance with IEC 60754 and IEC 61034 typically used for cable jacketing for wires which emit limited smoke and no halogen when exposed to a high heat source. This type of cable is required to be used in confined spaces, poorly ventilated areas, such as plenums, with a large amount of cables in close proximity to humans or sensitive electronic equipment. Mass transit and central office facilities are common applications for LSOH cable.

8.9 Busways

- Electrical busways for electrical distribution shall be in accordance with IEC 61439.
- Busways shall utilize copper bus rated and shall be protected with a metal enclosure. Steel or aluminum enclosures are acceptable.
- The busway assembly shall include a separate bus for each phase, neutral and ground. The busway enclosure shall not be utilized as the ground conductor.
- Neutral bus shall be increased in capacity over the phase conductors when the busway supplies the load with high harmonic currents. The A/E shall complete an assessment of the loads served and provide recommendations to the Entity for approval.

8.10 Conduit Fill/Filling Ratio or Space Factor

- For a total of 1 conductor inside the electrical conduit, filling of conduit shall not exceed 53%.
- For a total of 2 conductors inside the electrical conduit, filling of conduit shall not exceed 31%.
- For more than 2 conductors inside the electrical conduit, filling of conduit shall not exceed 40%.

9.0 GROUNDING

9.1 General

- All facilities shall be provided with grounding systems designed in accordance with the requirements of the latest SEC Standards and the latest revision of SBC 401
- Grounding systems shall be designed to achieve the following:
    - Eliminate potential of electrical shock to personnel
    - Enable protection devices to operate correctly to minimize duration of fault currents
    - Equalize the voltage potential of normally non-current carrying metal work
    - Prevent electrostatic charge of facility elements to avoid potential problems.
- A/E shall coordinate the design for all related grounding and protection components including the system grounding, equipment grounding, lightning protection, surge protection, and electrostatic discharge.

9.2 System Grounding

- All low voltage power distribution systems shall have supply transformer secondary neutrals solidly grounded.
- The low voltage earthing system shall be of TN-S type unless installations for special locations are required.
- Medium voltage distribution systems (e.g. 4160 V, 13800 V, 33000 V and 34500 V) shall be resistance grounded to minimize ground fault levels.

9.3 Equipment Grounding

The metal frames of all electrical equipment, machinery, lighting fixtures, enclosures, raceways, cable trays, outlet boxes, appliances and non-electric equipment in close proximity to electrical equipment shall be grounded for safety. Two grounding connections shall be provided to the frames of large electrical equipment such as unit substations, power transformers, motor control centers and switchgear.

9.4 Grounding System Calculations

SBC 401 shall be used as a basis of design for the grounding system. Grounding calculations shall be conducted based on selected calculations method listed in IEEE 142, IEEE 80, or BS 7430. Soil resistivity values from the Geotechnical Investigation Report, as detailed in Document Number EPM-KE0-GL-000002: Geotech, Geotechnical Investigation shall be used for the determination of the grounding calculations. Grounding calculations shall demonstrate that the calculated resistance does not exceed the maximum resistance allowed for the system.

9.5 Grounding of Various System Installations

9.5.1 Substation and Industrial Plant

System and equipment grounding in substations and industrial plants is particularly important because of the multiplicity of electrical equipment and locations in isolated areas. These shall be provided with a ground loop or grid consisting of multiple spaced ground rods interconnected by adequately sized bare or insulated copper cable(s).

9.5.2 Commercial, Institutional and Light Industrial Facilities

For equipment grounding in commercial, institutional and light industrial facilities, a ground loop shall be provided outside the building foundation. If this is not possible, a ground grid shall be provided under the basement or ground floor. System grounding at the facility transformer(s) shall be interconnected to this loop. Interconnection cables may be bare or insulated.

9.5.3 Residential

In residential areas, residences shall be supplied with a single ground rod at the service entrance. Grounding to incoming water supply pipe alone is not acceptable. All exposed metallic pipes shall be bonded to the grounding system.

9.5.4 Communication Equipment

All communications equipment over voltage protection system devices shall be directly grounded to the facility ground rod, grid or loop. Ground leads from power distribution systems or facility metalwork shall not be shared by the communications equipment over voltage protection device ground lead.

9.5.5 Floodlighting

All floodlighting, area lighting, sports lighting, roadway and street lighting fixtures shall be grounded.

9.5.6 Backup Power Source

- It is the preference that backup power sources such as generators are grounded as a separately derived electrical system.
- Existing facilities may not utilize a separately derived ground configuration. A/E shall evaluate the backup power source grounding configuration for an existing facility and provide the Entity with recommendations whether the existing configuration shall remain or be modified. A/E shall obtain approval of this recommendation from the Entity prior to proceeding with the design.
- Refer to subsection 5.0: Transfer Switches for additional information regarding equipment requirements for separately derived and combine grounding for a backup power source.

9.6 Installation Requirements

- All grounding systems shall be interconnected below grade for each facility.
- System grounding and equipment grounding shall use a common ground loop or grid, wherever possible. Separate grounding conductors shall be run from the systems (transformers neutrals) and equipment to terminate on the ground loop or grid via wall mounted ground bus.

9.7 Grounding to Eliminate Hazards from Static Electricity

- Various facilities and occupancies have sensitivity toward electrostatic discharge which may cause damage to equipment or facilities. To address these potential hazards, the A/E shall assess the need for provision of an electrostatic discharge control program in accordance with IEC Standard 61340.

- Typical facilities, occupancies or activities that warrant consideration include but are not limited to the following:

    - Manufacturing of electronic parts, assemblies or equipment
    - Assemble, install, packaging, servicing, testing of electronic equipment
    - Industrial facilities which involve operations with gas, coal, paper, and grain processing and handling
    - Commercial facilities such as dry cleaning plants and others.

- A/E shall complete an assessment and submit recommendations to Entity for review and approval.

9.8 Corrosion Protection for Grounding Systems

9.8.1 General

- The environmental conditions may result in undesirable deterioration to the grounding systems for facilities. To protect against this potential, the following measures shall be implemented to address exposure to underground and atmospheric conditions
- Underground Conditions

  The nature of the soil conditions to be verified and tested. These physical results will help to select or decide the type of system, material and make it easy to obtain good ground resistance values however these same conditions can also cause severe corrosion of metals leading to deterioration of ground resistance values with time. Not only does the grounding copper corrode but buried steel in the vicinity can also be corroded by galvanic interaction with the copper. To avoid the adverse effects of the physical conditions, the following features shall be considered and applied as appropriate:

  - Interruption of Couple: Where possible, the buried steel shall be separated from the grounding system. Buried lengths of pipework shall be fitted with insulated flanges at points of connection to the general mass of grounded equipment. Electrical equipment mounted in such runs of buried or part-buried pipework shall be grounded but insulated from the pipework.
  - Elimination of Buried Steel: Where possible, when choosing between burying or not burying a steel structure, pipe or conduit; the non-buried choice is the Entity preference. The alternative approach shall consider the use of non-ferrous materials.
  - Reduction of Effect of Buried Copper: At any location where ground faults can cause large currents to flow between the body of earth and the grounding system, extensive buried un-insulated grounding conductor is necessary to control voltage gradients and ensure that the whole complex remains as one resistance area. It is therefore not possible to eliminate buried copper but its corrosion effects can be reduced as follows:
    - Grounding conductors shall be lead jacketed or tinned where the corrosion risk is high, otherwise un-tinned conductors shall be used.
    - Where possible, locate grounding conductors at least 7 m away from buried steel work. This applies particularly to the grid conductors extending through plant areas.
    - Grounding conductors linking equipment and ground grid conductors shall be PVC insulated where within approximately 7 m of buried steel work. Connections shall be thermite welded or compression types and coated with bitumen compound protected by PVC green tape.
- Atmospheric Conditions

  The following relates to corrosion resulting from atmospheric conditions on non-buried parts of the grounding system, and is unrelated to any level of soil resistivity. Wherever dissimilar metals are in contact, a risk of corrosion from electrolytic action exists. The following safeguards shall be observed:

  - Where possible, bare grounding conductors shall be spaced from surfaces of a dissimilar metal. Where contact between surfaces is unavoidable and especially outdoors, a coating such as bitumastic No. 50 or equal, shall be introduced between them (except at electrical joint faces).
  - Termination hardware such as Servit connectors, etc., may often be selected for its compatibility with the metals being connected. Manufacturer's catalogs give details in this respect. Care shall be taken in selecting such hardware that it is suitable for its application from a corrosion aspect.
  - Conductors passing through short lengths of metal conduit, such as used for kick-pipes shall be coated with bitumastic No. 50 or equal. The pipes shall be self-draining and the upper ends mastic sealed.

9.8.2 Special Materials

- Ground Rods
  - Materials and dimensions of the earth electrodes shall be selected to withstand corrosion and to have adequate mechanical strength.

- For commonly used materials, the common minimum sizes from the point of view of corrosion and mechanical strength for earth electrodes where embedded in the soil are given in SBC 401.
- All connections between ground rods and conductors shall be coated with bitumastic and mastic tape as part of the final installation.

9.9 Additional Grounding Protection by Residual Current Devices (RCD)

- The use of residual current devices (RCD) is intended only to augment extra measures of protection against direct contact.
- The use of such devices is not recognized as a sole means of protection.
- Application of residual current devices in the system shall conform to the latest SBC.

10.0 LIGHTNING PROTECTION SYSTEMS

10.1 General

10.1.1 Lightning protection shall be considered for all facilities to protect them from damage and/or disruption caused by a lightning strike. Provision of a lightning protection system shall include consideration for the following:

- Impacts to health and safety of the facility occupants
- Economic impacts associated with damage to facility or equipment
- Economic impacts associated with facility downtime
- Impacts or interruption to public services
- Impacts to commercial or industrial activities
- Impacts to individuals in residential facilities
- Impacts to groups in places of assembly.

10.1.2 A/E shall complete a lightning risk assessment in accordance with the latest SBC 401and IEC Standard 62305 to summarize the associated risks and provide a recommendation regarding the need for this protective means for the facility.

10.1.3 Where a lightning protection system is required, the components, features and installation shall be in accordance with the requirements of the latest SBC 401.

10.1.4 The design for the lightning protection system shall be closely coordinated with the grounding and surge protection provisions for each facility.

10.2 Applications

10.2.1 Lightning protection for underground electrical distribution is not anticipated to be extensive due to the routing of the power network below grade. A/E shall determine the characteristics of lightning arrestors at all substations to coordinate with the other surge protective devices for each facility.

10.2.2 Lightning protection for ordinary buildings and structures is typically provided for the following facilities. The final determination shall be the result of the lightning risk assessment and approval by the Entity.

- Buildings and structures over 30 m in height.
- Health safety buildings including hospitals, clinics, etc.
- Public safety buildings including police stations and fire stations
- School buildings
- University buildings
- Places of assembly
- Data centers

10.3 Principal Components for Lightning Protection System

- Principal components for the lightning protection system include air terminals, ground rods and down conductors with adequate number of test points.
- Selection of the appropriate materials will be dependent on the location and construction materials. A/E shall select materials which are compatible with the building finishes to ensure adequate protection and avoidance of any corrosion.
- Materials selections and installation shall be in accordance with the latest SBC 401.

10.4 Minimum Lightning Protection Features

- The lightning protection system shall be designed in accordance with the latest SBC 401.
- Separate ground rods shall be provided for each down conductor. The down conductor shall be directly connected to the ground rod. Adequate number of test points shall be installed. The minimum distance to other earth pits has to be maintained.
- The lightning protection ground rods shall be interconnected below grade to the ground loop which provides the system and equipment ground for the facility.

11.0 SURGE PROTECTION DEVICES

11.1 General

11.1.1 Protection of buildings, equipment, and operations is critical for facilities throughout the Entity premises. Provision of the appropriate surge protection devices shall include consideration for the following:

- Impacts to health and safety of the facility occupants
- Economic impacts associated with damage to facility or equipment
- Economic impacts associated with facility downtime
- Impacts or interruption to public services
- Impacts to commercial or industrial activities
- Impacts to individuals in residential facilities
- Impacts to groups in places of assembly
- Extent and location of protection system devices.

11.1.2 Critical Facilities that warrant special consideration include:

- Health Safety - Hospitals and Health Clinics
- Public Safety - Police and Fire Stations
- Educational - schools and training centers
- Transportation - Signaling
- Data Centers
- Telecommunications
- Industrial.

11.1.3 Determination for surge protection shall include an assessment of the facility to analyze the potential exposure and to develop a recommendation for the level of protection. Refer IEC standards (IEC-62305, 61643-1 for Power and 61643-21 for Telecommunication) to complete this assessment and provide a recommendation to Entity early in the design phase.

11.1.4 Coordinate the surge protection installation with the electrical grounding and lightning protection system provisions

11.1.5 Sample application levels of surge protection for the various facility types are summarized in the following Table -E: Typical Surge Protection Application Levels

TABLE E - TYPICAL SURGE PROTECTION APPLICATION LEVELS

Protection Application	Facility Type							
	Residential	Commercial	Health Safety	Public Safety	Civic	Industrial	Telecommunications	Data Center
Service Entrance	•	•	•	•	•	•	•	•
Distribution Panels			•	•	•	•	•	•
Branch Circuit Panels			•			•	•	•
Critical Equipment		•	•	•	•	•	•	•
Tertiary Devices(Receptacles)							•	•

11.2 Types of the Surge Protection System

11.2.1 Surge Protection Devices (SPD)

Parallel-connected, non-linear protective devices for limiting surge voltages on equipment by discharging, bypassing, or diverting surge current.

11.2.2 Filtering/ Line Condition

Units designed to provide clean AC power by helping to eliminate or dramatically reduce high-voltage transients and low-voltage electrical noise that degrade microprocessor-based equipment.

- Active Tracking Filters (ATF)
- Harmonic Filters
- Line Conditioners
- Uninterruptible Power Supply (UPS)
- Data/Signal Line System
  Devices designed to protect signal lines from harmful surges.

12.0 LIGHTING

12.1 General

The following recommendation covers the minimum mandatory requirements for lighting installations.

- All lighting systems for interior applications shall be designed in accordance with the latest edition of the Illuminating Engineering Society of North America (IESNA) Lighting Handbook.
- In order to optimize the effective utilization of Lighting energy, interior lighting design requirements for new buildings shall be in accordance with the IESNA Lighting Ready Reference / Energy Management IESNA RR-96. Design components for lighting energy management shall be per considerations in IESNA LEM-3.
- Lighting design for Industrial Lighting shall be in accordance with IESNA RP-7,
- Lighting design shall be designed for energy efficient operation.

- Photometric measurements of sports lighting, when required shall be performed as per the IESNA LM-5.
- Lighting system power supplies consisting of 380/220 Volt, 3 phase, three-wire or four-wire; and 400 Volt, two-wire shall be acceptable. The choice of voltage and distribution system for lighting installations shall depend on the area to be supplied and the required lighting load.
- Direct-control switches and switching contacts used on lighting circuits other than fluorescent luminaires shall have a continuous current rating of at least 1.5 times the steady-state current of the lighting load.
- Direct-control switches and switching contacts used on fluorescent lighting circuits shall have a continuous current rating of at least twice the steady-state current of the lighting load.
- Mounting method of luminaires shall be based on the best arrangement for illuminance, as well as easy and safe access during installation and maintenance.
- The A/E shall determine the appropriate lighting solutions based on the best application of light source, lamp types, required illumination levels, distribution configuration, and luminaire type for each application associated with the facility.
- The A/E shall consider the energy efficiency associated with the recommended lighting solutions and explore opportunities to reduce the energy consumption by selecting sources and luminaires with high efficiencies and capitalize on the use of available daylight.
- Energy conservation strategies shall conform to latest SBC 601. Luminaires shall be suitable for the environment where they are installed. Luminaires installed outdoor shall be approved as weather proof and dust tight.
- Luminaires shall be marked, listed or labeled by an independent third party laboratory (notified body) the associated certificate shall state either that the luminaires meet appropriate designated standards or have been tested and found suitable for use in a specified manner.
- All public lighting systems for exterior use shall be designed in accordance with the CEN standards see table in section for full list of applicable standards.
- All lighting systems for exterior and roadway applications shall be designed in accordance with CIE 115 and the associated CEN standards.
- The A/E shall determine the appropriate lighting solutions based on the best application of light source, lamp types, required lighting design criteria, distribution configuration, and luminaire type for each application associated with the facility.

12.2 Light Source

12.2.1 The A/E shall select the light source, which is appropriate for each residential, commercial, institutional, and industrial facility, and shall ensure that the selected light fixtures are available in the local market at the time of design and provide cut sheets showing the fixture performance characteristics and aesthetics to be included in the RFP. Mercury vapor luminaires and incandescent luminaires shall not be used.

12.2.2 Only luminaires with a minimum efficacy of 45 lm/w and lamps with minimum efficacy of 65 lm/w shall be used.

12.2.3 The various light sources have advantages and disadvantages and the A/E shall consider the available sources and provide recommendations regarding the appropriate light sources to be used throughout a facility

Selection of the light source shall consider the following:

- Source efficacy
- Installation requirements
- Color rendition characteristics
- Dimming capabilities
- Maintenance requirements (and associated health and safety risks)

- Availability
- Life cycle cost
- Internal ambient air temperature (35° C)
- Outside ambient air conditions (50° C)
- Desired aesthetic result
- Correlated Color Temperature.

12.2.4 The three commonly used light sources along with their characteristics include fluorescent, high intensity discharge (HID), and light-emitting diode (LED). A relative comparison of the operational characteristics for these light sources is summarized in TABLE -F: Light Source operation **comparison** each characteristic is rated from 1 to 4 where 1 = the highest and 4 = the lowest in that category.

TABLE F - LIGHT SOURCE OPERATION COMPARISON

Light Source	Efficacy	Color Rendition	Lamp Life	Starting Characteristics	Dimmable	Initial Cost
Fluorescent	2	2	2	3	2	2
High Intensity Discharge (HID) Metal Halide	2	1/4	2	4	Note 1	2
High Intensity Discharge (HID) HPS	1/2	4	1-2	4	Note 1	2
Light-emitting Diode (LED)	1/2	1-3	2	1	2	4

Note 1 - Source is only Dimmable with specialized control gear

12.2.5 Lamps

- The lamps selected for each facility shall be standardized as much as possible to minimize the variety of lamps sources used to achieve the desired aesthetic results. This standardization will facilitate the maintenance of the lighting throughout a facility.
- Fluorescent Lamps
    - Fluorescent lamps are acceptable for use in all residential, commercial, institutional and industrial facilities. These lamps have typically been the most common selection due to the color rendition characteristics, source life, availability of lighting fixtures, energy efficiency, and associated cost effectiveness
    - Compact fluorescent lamps are available in various shapes, wattages and color temperatures and have become a replacement alternative for applications that previously utilized incandescent lamps. Compact fluorescent lamps are acceptable for use in each Entity's premises and shall be compared with other source alternatives to determine the most appropriate applications.
    - Energy-Efficient type T5 and compatible energy efficient electronic ballasts having less than l0% THD (voltage total harmonic distortion) shall be used. Efficacy of Compact fluorescent lights (CFL) shall not be less than 65-70 Lumen/Watt.
    - Fluorescent lamps shall be used for the following specific applications:
        - Electrical substations
        - Electrical switchyard buildings
        - Control rooms`
        - Offices
        - Plant rooms
        - Store rooms
        - Large ceiling voids and Maintenance access

- Fluorescent lamps are available in different shapes, diameters, wattages, lumen outputs, and color temperatures. The A/E shall utilize standard fluorescent lamps that are commercially available and minimize the types of lamps used throughout the facility. The following **TABLE – G: Fluorescent Lamps** provides a list of the commonly used lamps types, however other wattage and type shall be discussed and approved by the Entity.

TABLE G - FLUORESCENT LAMPS

Watts	Type Description	Control Gear	Initial Lumens	CRI	Life Hours
8	T5, 288mm	E, DE	380	85	20,000
13	T5, 517mm	E, DE	680	85	20,000
14	T5/HO,549mm	E, DE	1,350	85	20,000
24	T5/HO, 549mm	E, DE	2,000	85	20,000
28	T5, 1149mm	E, DE	2900	85	20,000
35	T5, 1449mm	E, DE	3650	85	20,000
49	T5/HO, 1449mm	E, DE	4900	85	20,000
54	T5/HO, 1149mm	E, DE	5000	85	20,000

- Fluorescent lamps are available with output in a variety of color temperatures ranging from 3000 to 6500° kelvin.
  - The lamp color and temperature output should be selected as appropriate for the application.
  - The lamp color temperature shall preferably be consistent for all fluorescent lamps throughout a facility to facilitate maintenance.

- High Intensity Discharge (HID) Lamps
  - HID lamps are used for the following applications:
    - Indoor and outdoor Industrial facilities
    - Outdoor facilities for public circulation spaces, parks, sporting venues, street lighting and parking
    - Security lighting
    - Indoor Commercial and Institutional facilities
  - HID lamps have good efficiencies and lamp life however, their color rendering index (CRI) is lower than other sources and controllability is less desirable due to warm up and restrike requirements. Specialized Hot restrike control gear is available for special situations such as public venues for instant light.
  - HID lamps are available in the following options:
    - Metal halide lamps are available in a wide range of wattages and have the best CRI but the lowest efficacy of the HID options These characteristics lend themselves towards applications where color rendition is critical to the occupancy. Typical applications include indoor sports facilities, public circulation spaces, and large assembly spaces such as auditoriums, convention halls, and decorative external lighting where white light and high color rendering are important.
  - High pressure sodium lamps are also available in a wide range of wattages and shapes. The efficacy is higher than metal halide but their CRI is lower. These characteristics lend themselves towards applications where color rendition is less critical to the occupancy. Typical applications include indoor storage, loading docks, vehicular circulation and outdoor parking, street lighting and security.
  - Low pressure sodium lamps are outdated technology and shall not be used without prior agreement with the Entity. LED /HPS is the preferred choice for traditional uses. Low pressure sodium lamps are the most efficient of the HID options but have the lowest CRI. The light

output is monochromatic and typically used in limited applications, which do not require distinction of color. Typical application is for outdoor security.

- Where HID lamps are used, the A/E shall utilize standard HID lamps that are commercially available and minimize the types of lamps used throughout the facility. The following Table -H: High Intensity Discharge lamps provides a list of the commonly used lamps types.

TABLE H - HIGH INTENSITY DISCHARGE LAMPS

Watts	Type Description	Initial Lumens	Life Hours	Base
70	High Pressure Sodium	6,000	24,000	Med, E27, Double ended
100	High Pressure Sodium	9,200	24,000	Med, E27, Double ended
150	High Pressure Sodium	16,000	24,000	Med, E27, Double ended
250	High Pressure Sodium	28,000	24,000	Mogul, E40, Double ended
400	High Pressure Sodium	51,000	24,000	Mogul, E40, Double ended
1000	High Pressure Sodium	140,000	24,000	Mogul, E40
70	Metal Halide	5,200	H	MedE27, Double ended
100	Metal Halide	8,500	7,500 Vert. 6,000 Hor.	Med, E27, Double ended
150	Metal Halide	12,800	10,000 Vert. 7,500 Hor.	Med, E27, Double ended
250	Metal Halide	20,800	10,000 Ver. 6,000 Hor.	Mogul, E40, Double ended
400	Metal Halide	36,000	20,000 Ver. 15,000 Hor.	Mogul, E40, Double ended
1000	Metal Halide	108,000	15,000 Ver. 11,000 Hor.	Mogul, E40
1500	Metal Halide	170,000	6,000	Mogul
2000	Metal Halide	220,000	9,000	Double ended

- Light-emitting Diodes (LED) Lamps
  - LED lamps are acceptable for indoor use in all residential, commercial, institutional and industrial facilities. Where a point source distribution is required. Where an area source is required, LED is and an option to be compared with high efficiency linear fluorescent lamp (T5, either HE or HO). These lamps have not typically been utilized due to the availability and cost. Recent developments have increased the availability and reduced the associated costs. These developments have resulted in the use of this source for more applications.
  - LED lamps can have good efficacy and long life but need to be obtained from a reputable manufacturer. Quality of the driver is also an issue. Luminaire lumens (LLm) and not bare LED lumens should be used in calculations. The ambient thermal conditions are critical to the performance of LEDs and Luminaire Manufacturers are required to design their thermal management systems to allow the LEDs to operate to the published values in an ambient air temperature of 35 deg C. which can easily be present in an unventilated ceiling void and 50 deg C externally LEDs and they are available in a wide range of color temperatures. This source is becoming more typical for all types of applications and thus shall be considered for residential, commercial, institutional and industrial facilities.
  - LED for external lighting shall be of high quality manufacturer from recognized major suppliers from the following list:
    - Cree
    - Philips Lumileds
    - Tridonic
    - Osram
    - Nicha
    - LG
    - Citizen
    - GE

    Other LED suppliers may only be used with the express consent of the Entity. ALL LEDs shall be capable of providing a minimum efficacy of 100lm/w at forward design current of less than 500mA with external ambient air temperature of 50 deg C. all LEDs shall be color consistent

within 5 macadam ellipses. The CRI of LEDs shall be not less than 60Ra. The life expectancy shall be quoted at 80% of initial Lumens and for a minimum life of 50000hrs. The early life failure of LEDs shall not be greater than 10% at the quoted life expectancy. All LEDs are to be warranted by the LED manufacturer operating within the luminaire for a minimum of half the rated life of the LEDs.

- The A/E shall complete an economic analysis to compare LED lamps to others options to determine the best solution. This analysis shall be submitted to the Entity for review and approval.
- Designer is responsible for selecting the LED luminaire system components. This includes as applicable; LED driver and luminaire controls, heat-sink, self-ballasted or non-self-ballasted, etc.
- The luminaire manufacturer shall provide certificate issued by third party agency (notified body) verifying the luminaire's performance including declared luminaire lifetime and lumen maintenance based on the operating temperature range specified in this standard.
- Reflectors or filters shall be provided to control the glare and harmful light spectrum to safe level. Guidelines and limits of IEC 62471 and /or the IES handbook shall be applied.
- Additional Requirements for LED
  - The LED circuitry shall prevent flicker perceptible to the unaided eye over the voltage range specified as per IEC 61000-3-3 or IEEE 1453.
  - All LED components to be designed to tolerate between -20°C and 65°C at 100% Relative Humidity (RH) during non-operating/daytime.
  - Voltage THD induced into an AC power line by a luminaire shall not exceed 10%.
  - Thermal management shall be passive by design. The use of fans or other mechanical devices shall not be allowed.

- Control Gear and Drivers

  All ballasts and drivers for fluorescent, HID and LED lamps shall be manufactured to meet the requirements of IEC Standards and Prestandard Specifications for lamp control gear.

  - Fluorescent ballasts shall be DALI HF electronic type. Dimming electronic ballasts shall be standard for all areas where daylight is present.
  - HID ballasts shall be electronic type up to 150 watts.
  - LED drivers shall be DALI electronic type constant current.
  - For external luminaires all ballasts and drivers shall be rated to a minimum of IP 23 and have Ta 50 deg C and Tc 80 deg C.
  - All ballasts and drivers shall have a minimum design life of 50,0000 hrs. in their prescribed operating conditions.
  - ALL LED drivers shall operate to protect the LEDs should the temperature exceed their maximum operating temperature. Firstly by dimming the output of the LEDs up to 80% of full output and then
  - By switching off the LEDs should the temperature still be high. An alarm shall be generated by the ballast in line with the DALI protocol and communicated to the LMS as high level alarm.
  - LED drivers should be capable of being mounted in the base of poles and operating the LEDs remotely for up to 25m distance.

12.3 Interior Lighting

12.3.1 General

Illumination levels for spaces in all residential, commercial, institutional and industrial applications shall be selected in accordance with the procedures and recommendations provided in the latest edition of the IESNA Lighting Handbook.

- Illumination levels shall consider the following criteria:
  - The task being performed
  - The ages of the occupants
  - The importance of speed and accuracy

- Luminaire mounting height
- Work plane height

- The selection of the appropriate light source, lamp and luminaires shall consider the following criteria:
  - Source efficacy
  - Lamp lumen output
  - Lamp operation characteristics including lamp lumen depreciation
  - Environment characteristics and associated dirt depreciation
  - Utilization Factor
  - Room shape and size
  - Room finish characteristics including reflectances
  - Availability of natural daylight
  - Correlated Color Temperature
- The quality of the lighting solution designed for each space shall include consideration for the following:
  - Glare shall be reduced by utilizing the appropriate luminaire features. The application of direct, direct/indirect, or indirect distribution shall be evaluated to apply the appropriate system for each space. The light control mechanism including lens, louver, etc. shall be selected to minimize the adverse effects of glare.
  - The lighting shall be distributed evenly over the task to maintain illuminance uniformity. The following are the average to minimum ratios which should be considered when designed the lighting system for interior applications:
    - Uniformity ratio of 2:1 is considered excellent and should be used for critical tasks.
    - Uniformity ratio of 3:1 is considered good and is the typical uniformity to be used for the majority of applications.
    - Uniformity ratio of 4:1 is considered fair and is appropriate for used in applications which are less critical.
  - Color rendering characteristics of the source is identified as the color rendering index (CRI) and shall be carefully considered when selecting the source for each application.
    - CRI between 75 and 100 is considered excellent.
    - CRI between 65 and 75 is considered good.
    - CRI between 55 and 65 is considered fair.
    - CRI below 55 is considered poor.
- The A/E shall select the appropriate illumination levels for all spaces within a facility. The standard illumination levels for various locations and occupancies are listed in TABLE I - Illumination Level Recommendation by Occupancy.

TABLE I - ILLUMINATION LEVEL RECOMMENDATIONS BY OCCUPANCY

Location/Occupancy	Horizontal Illumination Level in Lux	Vertical Illumination Level in Lux	Elevation of Working Plane (mm)
CONTROL AND DISPATCH			
General	500		800
Vertical Panels		500	1700
Desks	500		800
DINING FACILITIES			
Dining Areas (Leisure Service)	300		800
Dining Areas (Quick Service)	500		800
Food Preparation	500		900
Entrance Hall	300		Floor
ELECTRICAL ROOM			
Substation (General)	200		Floor
Vertical Face of Switchgear		300	1700
Battery Room	300		Floor
TELECOMMUNICATIONS			

Location/Occupancy	Horizontal Illumination Level in Lux	Vertical Illumination Level in Lux	Elevation of Working Plane (mm)
Telecom Equipment Room	200		Floor
OFFICES			
Regular	500		800
Conference Room	500		800
Drafting (Mixed CAD and Paper Tasks)	500		800
Corridors	200		Floor
Stairways	300		Floor
Elevator	200		Floor
Washrooms	300		900
WAREHOUSE			
Indoor Bulk Storage	100		Floor
Indoor Barrel Storage	100		Floor
Countertops	300		1200
Parts Storage	300		900
RELIGIOUS PLACES			
Mosque	300		Floor
SPORTS AND RECREATION			
Volleyball	300		Floor
Basketball	300		Floor
WORK SHOPS			
General	300		Floor
Rough Bench or Machine Work	500		900
Medium Bench or Machine Work	500		900
Fine Bench or Machine Work	3000		900
Corridors	200		Floor
Washrooms	100		900
SCHOOLS			
Chalkboards		500	Task
Classrooms	500		800
Science Laboratories	500	300	900
Shops	500		900
Art Rooms	500		800
Music Rooms	500		800
Library	300		800
Corridors	200		Floor
HOSPITAL			
Examination Rooms	500		800
Patient Rooms	50		900
Procedure Rooms	500		900
Laboratories	500		900
Therapy	300		Floor
Nurse Stations	500		800
Corridors Nursing Areas	100		Floor
Corridors Procedure Areas	500		900
Waiting Room	300		Floor

TABLE I - Illumination Level Recommendation by Occupancy Notes:

1. Illumination levels for locations and occupancies not listed in this table shall be in accordance with IESNA Lighting Handbook.

12.3.2 Residential Lighting

- Residential facilities typically utilize a mixture of LED and fluorescent lamps/luminaires due to the excellent color rendering capabilities, availability of lighting fixtures, dimming capability, and cost.

- Development and availability of compact fluorescent lamps has resulted in the replacement of incandescent lamps.
- Recent developments with LED lamps has improved availability and associated cost and their use is anticipated to increase as the availability of luminaires improves. The LED sources offer good color rendering, high efficacy and excellent control capabilities.
- For decorative purposes, a combination of recessed, pendant, track mounted, and wall mounted luminaires are utilized to provide adequate illumination and satisfy aesthetic objectives.
- The voltages used for residential lighting shall be in accordance with SEC Standard and Saudi Arabia Distribution Code (DPC 2.2): Voltage Level Applications.

12.3.3 Commercial and Institutional Lighting

- Commercial and Institutional type facilities typically utilize a mixture of fluorescent, high intensity discharge and LED lamps/luminaires.
    - Fluorescent lamps/luminaires are the primary source.
        - Compact fluorescent lamps/luminaires are utilized in applications where incandescent lamps/fixtures were typically used.
        - High output fluorescent lamps/luminaires are acceptable for spaces with high ceilings where instant start characteristic of this source is advantageous. These occupancies include gymnasiums, highbay storage spaces and other similar occupancies.
    - High intensity discharge lamps/luminaires may be used for interior high ceiling applications, loading docks, storage areas, parking facilities, and other similar occupancies.
        - Metal halide lamps/luminaires are the preferred source for interior applications where color rendition is critical. Examples include public circulation, indoor sports arenas, gymnasiums, and places of assembly.
        - High pressure sodium lamps/luminaires are applicable to interior occupancies where color rendition is not as critical and include loading docks, storage areas, and parking garages,
        - Recent developments with LED lamps has improved availability and associated cost and their use is anticipated to increase as the availability of luminaires improves. The LED sources offer good color rendering, high efficacy and excellent control capabilities. This source shall be considered for all interior applications in Commercial and Institutional facilities to determine the cost effectiveness.
        - The voltages used for commercial and institutional lighting shall be in accordance with SEC Standard and Saudi Arabia Distribution Code (DPC 2.2).

12.3.4 Industrial Lighting

- Industrial type facilities typically utilize a mixture of fluorescent, high intensity discharge and LED lamps/luminaires.
- Lighting for industrial facilities shall be selected in accordance with the procedures and recommendations provided in the latest edition of the American National Standard Practice for Industrial Lighting: ANSI IESNA RP-7.
    - Fluorescent lamps/luminaires are acceptable for use for industrial facilities.
        - Availability of high output fluorescent lamps has resulted in the increased application of fluorescent lamps/luminaires for highbay spaces. This source is advantageous due to its instant start and instant restrike characteristics.
        - Compact fluorescent lamps/luminaires shall be considered for industrial applications where instant start is required for the application
    - High intensity discharge shall be given preference for use in industrial facilities.
        - Metal halide lamps/luminaires have the higher CRI and shall be applied to occupancies that require this higher color rendering for performance of the tasks.
        - High pressure sodium fixtures have a lower CRI and are acceptable for occupancies where color rendering is not as critical for performance of tasks.

- The voltages used for industrial lighting shall be in accordance with SEC Standard and Saudi Arabia Distribution Code (DPC 2.2): Voltage Level Applications.

12.3.5 Emergency Lighting

- Emergency lighting shall be provided throughout each facility to illuminate the designated means of egress, including the exit discharge, to allow the occupants to safely exit in the event of a power outage. Minimum duration of emergency lighting in the event of normal power failure shall be one-and-one half hours.
    - Illumination levels for the means of egress shall be in accordance with the requirements of the latest SBC 801.
    - The egress path lighting shall be supplied from the life safety branch of the backup power system or may be supplied from a self-contained integral battery power source.
    - Duration of operation for means of egress lighting shall be in accordance with the latest SBC 801.
    - The power source for emergency lighting shall be supplied ahead of the switch or control device.
- Supplemental emergency lighting shall also be considered for special occupancies in critical facilities such as hospitals, important offices, communications centers, etc. to facilitate normal operation of these critical facilities during a normal power interruption.
    - Lighting levels for these special occupancies during normal power interruptions shall be selected to allow safe operation. The A/E shall provide recommendations for the special applications and associated lighting levels to the Entity for approval.
    - These supplemental emergency lighting applications shall be supplied from the standby branch of the backup power system or may be supplied from a self-contained battery power source.
    - The A/E shall coordinate the duration of operation for supplemental emergency lighting with the Entity to ensure that it is sufficient for the criticality of the occupancy.
- Emergency lighting shall be provided in electrical rooms. A minimum emergency illumination level of 100 lux shall be provided at finished floor level.
- Luminaires installed in the control room shall provide shadowless illumination. In addition, lighting for control rooms shall be designed for maximum flexibility to permit flicker-free variation of illumination levels above each group of operator workstations. Luminaires shall be installed to minimize reflections and glare at operating screens.
- Normal and emergency task lighting of at least 200 lux shall be provided for the following;
    - In plant areas to illuminate equipment required for use in emergencies, such as: emergency telephones, shutdown and emergency isolation stations, fire water pump areas, central foam concentrate mixing areas, fire control panels, breathing apparatus & fire extinguisher station, and stand-by generators.
    - In evacuation assembly areas and in off-shore platform escape capsule areas and boat landing.
- The preferred power supply for emergency lighting is the backup power source. However, in the event a central backup power source is not provided as part of the building infrastructure, the emergency lighting may be supplied from a self-contained battery power source.
- Illuminated exit signs shall be manufactured and installed in accordance with NFPA 101 requirements.

12.3.6 Exit Signs

- Exit signs shall be located throughout each facility in accordance with the requirements of the latest SBC 801.
- Exits signs shall be internally illuminated in accordance with the latest SBC 801.
- The preferred power supply for exit signs is the backup power source. However, in the event a central backup power source is not provided as part of the building infrastructure, the emergency lighting

may be supplied from a self-contained battery power source. Nickel cadmium batteries are not permitted.

- Duration of operation for exit signs shall be in accordance with the latest SBC 801.

12.4 Exterior Lighting

12.4.1 General

- This section covers Building floodlighting, Area lighting, Sports lighting, and Security lighting.
    - Refer to Document Number EPM-KEA-GL-000001: Architectural Design Guidelines - Site Lighting for additional information requirements pertaining to exterior lighting associated with Site Development for Buildings.
    - Refer to Document Number EPM-KEC-GL-000001: Civil Design Guidelines -

      Roadway Lighting for additional information and requirements pertaining to exterior lighting associated with roadways, parking areas and sidewalk lighting.
- Illumination levels for exterior spaces in all residential, commercial, institutional and industrial applications shall be selected in accordance with the procedures and recommendations provided in the latest edition of the Illuminating Engineering Society of North America, Lighting Handbook and reference should be made to CIE 115 and the associated CEN standards and guidance for road and exterior lighting. All public spaces are to be lit to the CEN methodology.
- Illumination levels for exterior applications shall consider the following criteria:
    - The task being performed
    - Security and safety of the occupants
- The selection of the appropriate light source, lamp and luminaires shall consider the following criteria:
    - Source efficacy
    - Lamp lumen output
    - Lamp operation characteristics including lamp lumen depreciation
    - Luminaire efficiency
    - Color Rendering Index
    - Correlated Color Temperature
- The quality of the lighting solution designed for each exterior application shall include consideration for the following:
    - Horizontal illumination
    - Vertical illumination
    - Uniformity ratios
    - Color rendering characteristics of the source is identified as the color rendering index (CRI) and shall be carefully considered when selecting the source for each application.
        - CRI between 75 and 100 is considered excellent.
        - CRI between 60 and 75 is considered white light.
        - CRI between 20 and 60 is considered semi-monochromatic.
        - CRI below 20 is considered monochromatic.

      The CIE color groups also give good indication of color rendering and color appearance.
- The A/E shall select the appropriate illumination levels for all exterior applications. The standard illumination levels for exterior locations and occupancies are listed in **TABLE -J**

TABLE J - ILLUMINATION LEVEL RECOMMENDATIONS FOR EXTERIOR

Location/Occupancy	Horizontal Illumination Level in Lux	Vertical Illumination Level in Lux	Elevation of Working Plane	Uniformity Ratio
BUILDING FLOODLIGHTING				
Façade (Dark Surroundings)	Not Applicable	35	Vertical Plane	5:1 Note 2
Facade (Bright Surroundings)	Not Applicable	90	Vertical Plane	5:1 Note 2
AREA LIGHTING				

Location/Occupancy	Horizontal Illumination Level in Lux	Vertical Illumination Level in Lux	Elevation of Working Plane	Uniformity Ratio
Parking - Basic	2 Minimum	1 Minimum	Ground	20:1 Max:Min
Parking – Enhanced Security	5 Minimum	2.5 Minimum	Ground	15:1 Max:Min
Public Park	15 Minimum	20 Avg @ 1.5m	Ground	4:1 Avg:Min
Common and/or Sitting Areas (CEN EN 13201)	6 Minimum	6 Min @ 1.5m	Ground	4:1 Avg:Min
Walkways	6 Minimum	6 Min @ 1.5m	Ground	4:1 Avg:Min
SPORTS LIGHTING				
Soccer (Class IV)	500	Not Applicable	Ground	4:1 or less Max:Min
Volleyball (Class IV)	200	Not Applicable	Ground	4:1 or less Max:Min
Basketball (Class IV)	200	Not Applicable	Ground	4:1 or less Max:Min
Tennis (Class IV)	500	Not Applicable	Ground	4:1 or less Max:Min
SECURITY LIGHTING				
Entrance	100	Not Applicable	Ground	4:1 or less Avg:Min
Perimeter	5	Not Applicable	Ground	4:1 or less Avg:Min

- Luminaires
  - Luminaires shall be heavy-duty, weather-proof type suitable for use in outdoor environment to a minimum of IP 65 IK08.
  - All components and features shall be suitable to withstand the environmental conditions and shall be selected to minimize maintenance requirements.
  - Luminaires use for decorative applications shall use bollards sparingly. Bollards shall be used mainly for aesthetic function and not as the prime illumination source. Bollards can be used as a prime illumination for walkways, gardens, and like places. Typical bollard applications include landscaped areas, shopping arcades, walkways at building entrances, etc.
  - LED luminaires shall be fully designed by the luminaire manufacturer to take account of the high ambient air temperature and relative humidity the light output of the luminaire should be quoted on the basis of a luminaire operation in an environment of 50 deg C and 95% RH min. The luminaire manufacturer shall take overall responsibility for the functioning of the LEDs, drivers and the luminaire body to enable the stated operating parameter of the system to be maintained through life.
  - The luminaire body shall be made of high quality diecast aluminum and shall be coated with a finish which is dust shedding and the body designed to comply with IEC 60068-2 Part 2 Test L.
  - The luminaire optics shall be made of borosilicate glass and shall be treated with a coating to prevent the accumulation of dust. The optic seals shall be tested to ensure that the thermal effects of heating and
  - Cooling does not damage the seals.
  - The luminaire shall be designed to accept the Entity chosen LMS system.
  - The luminaire body shall have 2 separate compartments for Lamp/LEDs and control gear.
- Poles
  - Exterior lighting poles shall be fiberglass, stainless steel, hot-dipped galvanized steel, anodized aluminum or precast concrete. Painted poles can be used if decorative poles are required but with special treatment before paint and also special paint type to resist corrosion Painted poles shall not be used without the express agreement with the Entity. Typical pole selections are summarized in **TABLE-K:** Exterior Lighting Pole application.

TABLE K - EXTERIOR LIGHTING POLE APPLICATIONS

Application	Pole Material			
	Fiberglass	Galvanized Steel	Anodized Aluminum	Precast Concrete
Walkways				
Sports Facilities				
Security				
Freeways				

Application	Pole Material			
	Fiberglass	Galvanized Steel	Anodized Aluminum	Precast Concrete
Expressways				
Collectors				
Interchanges				
Local 2 & 4 Lane				
Residential Road				
Cul-de-sac				
Cycleways				

  - Metallic lighting poles shall be provided with slip-base plate and break away fuses which is designed to slide off a lower plate upon impact, except where the speed limit for the road is less than 60 km/hr or where poles are located behind elevated curbs. In these latter cases, the poles shall be provided with fixed bases.
  - Metallic lighting poles shall be provided with slip-base plate and break away fuses which is designed to slide off a lower plate upon impact, except where the speed limit for the road is less than 60 km/hr or where poles are located behind elevated curbs. In these latter cases, the poles shall be provided with fixed bases. Poles and associated foundations shall be designed using EN 40 for a sustained wind speed of 30m/s and intermittent 3 sec gusts in a 30min period of 45m/s.
  - Poles shall be positioned at the rear of footpaths ideally.
  - The use of outreach arms shall be minimized and outreach arms over 2.5m should not be used without the express approval of the Entity.
  - Where trees are present outreach arms should bring the luminaire to the front of the agreed tree canopy. Trees are to be coordinated with landscape design so the agreed separation distance of 6m can be maintained.
- Grounding
  - Metallic poles, posts, luminaire housings and all non-current carrying metallic parts shall be grounded.
  - Individual ground rods shall be provided for each pole of a minimum of 2.5m in depth to achieve a resistivity of 25 ohms
  - Where the concentration of poles or bollards is heavy, consideration shall be given to sharing the ground rods between locations and/or grounding conductor(s) may be run from the nearest panel i.e. less than a 6mts
  - The A/E shall provide recommendations regarding grounding provisions for exterior lighting to the Entity for approval.
- The voltages used for all exterior lighting shall be in accordance with SEC Standard and Saudi Arabia Distribution Code (DPC 2.2): Voltage Level Applications.

12.4.2 Building Floodlighting

Floodlighting for the exterior of a facility may be considered for security and/or aesthetic purposes.

- Application of building floodlighting for security purposes shall be discussed and approved by the Entity.
- Application of building floodlighting for aesthetic purposes shall only be allowed if specifically requested and approved by the Entity. Facade lighting illuminance shall meet the obtrusive light requirement.

12.4.3 Area Lighting

- Area lighting includes illumination for parking areas, public parks and walkways which are not adjacent to roadways.
- Exterior Area lighting may utilize a mixture of fluorescent, HID and LED lamps/luminaires.
  - HID sources are the most common with metal halide being used where color rendition is critical and high pressure sodium used for less critical applications.

  - Fluorescent lamps/luminaires are utilized for decorative applications and where instant start is required.
  - LED lamps/luminaires for exterior applications shall conform to the Entity Exterior Lighting specification. The A/E shall confirm the acceptability of LED source for exterior application with the Entity.
- Installation requirements
  - Direct buried armored cable shall be used for lighting circuits.
  - Cables routed under roadways shall be routed through concrete encased ductbanks.

12.4.4 Sports Light

- Sports lighting shall utilize either High Intensity Discharge or LED light sources.
  - Metal halide, or LED lamps/luminaires shall be used for most applications to provide good color rendering capabilities of more that 60Ra.
  - High pressure sodium lamps/luminaires may be used for applications where color rendition is not critical. Several example applications include, golf driving range, archery range, and other similar sports venues.
- Installation requirements
  - Underground lighting circuits shall be routed around and not under sports fields and tracks. This will prevent future disruption to playing surfaces.
  - Direct buried armored cable or direct buried PVC conduits with conductors shall be used for lighting circuits.
  - Cables routed in locations subject to possible mechanical damage or under roadways shall be routed through concrete encased ductbanks.
- Sports lighting shall utilize LED light sources.

12.4.5 Security Lighting

- Security lighting shall be provided for selected facilities as determined by the Entity. Security lighting shall be designed in accordance with the Directives of the High Commission for Industrial Security (HCIS) Kingdom of Saudi Arabia.
- Security lighting shall utilize high or low pressure sodium light sources.
- Installation requirements
  - Security lighting shall be located to be inaccessible to intruders and protected from vandalism.
  - Security lighting fixtures shall include vandal resistant features.
  - Direct buried armored cable shall be used for lighting circuits.
  - Cables routed under roadways shall be routed through concrete encased ductbanks.

12.4.6 Illumination of Areas Adjacent to Roadway

- People and objects adjacent to the roadway need to be seen by the driver. Such locations include unmade verges, footways and cycle paths and the emergency lanes of motorways.
- The lighting for these areas should conform to the lighting criteria including surround ratio as stated in Lighting of Roads for Motor and Pedestrian Traffic -International Commission on Illumination Technical Report (CIE 115).

12.4.7 Lighting Recommendations for Conflict Areas

- A conflict area is one in which traffic flows merge or cross, e.g. at intersections or roundabouts, or where vehicles and other road users, are in close proximity, e.g. on a shopping street or at a pedestrian crossing.

- The lighting for these areas should conform to the lighting criteria as stated in Lighting of Roads for Motor and Pedestrian Traffic - International Commission on Illumination Technical Report (CIE 115) Minimum illumination requirement for pedestrian crossings shall be as per CIE S 015/E:2005.

12.5 Lighting Calculation

- Approved lighting criteria shall be developed for all interior and exterior applications.
    - A/E shall prepare a summary of the recommended maintained illumination levels for all interior occupancies. Refer to **TABLE -I:** maintained Illumination Level Recommendations by Occupancy. This summary shall be submitted to the Entity for review and approval. This summary shall be part of the 30% design submissions.
    - A/E shall prepare a summary of the recommended maintained illumination levels for all exterior applications. Refer to **TABLE- J.** maintained Illumination Level Recommendations Exterior. This summary shall be submitted to the Entity for review and approval. This summary shall be part of the 30% design submissions.

- Lighting calculations shall be performed using either the lumen or point-by-point methods utilizing approved Entity software package(s). The A/E shall prepare lighting calculations plan and at the 30% design stage for approval by the Entity. Lighting calculations to be conducted for all differing spaces associated with the facility.
    - Interior calculations should be carried out using approved computer software. Approved software packages are DiaLux, ReLux, and AGI32.
    - Point-by-point method is used for more complicated geometric spaces, where lighting performance is critical, and for exterior applications. These calculations are typically prepared utilizing commercially available software such as Dialux or AGi32 which was developed by Lighting Analysts, Inc.
    - Prepared calculations shall identify the performance of the selected source/fixture with respect to the recommended lighting criteria.
    - The results of these calculations may be presented in tabular or graphic format to illustrate the lighting performance in a formal calculation submission at the 60% design stage for the Entity for review and approval. The result of the calculations shall be summarized in tabular form on the design drawings.
    - The calculations shall be submitted to the Entity for review and approval.

12.6 Lighting Control System

12.6.1 General

- Controls for lighting systems are intended to provide the occupants with the capability to manually operate the artificial lighting for convenience and comfort. In addition, automatic controls are intended to be used to enhance the security for facilities and reduce the energy use associated with artificial lighting throughout a facility.
- Lighting control energy conservation strategies shall conform to the latest SBC 601.

12.6.2 Interior

12.6.2.1 Localized Room Controls

- Manual Switches
    - Local switches shall be applied in all spaces to provide the occupants with capability to manually control the lighting fixtures.
    - A/E shall consider the provision of multiple switches to facilitate zone control and/or multiple lighting levels to suit the functional requirements of the space.
- Occupancy Sensors

- Occupancy sensors shall be applied in spaces to allow the artificial lighting to be automatically turned off when the space is unoccupied.
- Occupancy sensors shall be interconnected with the local switching to facilitate manual operation by the occupants.
- Occupancy sensors types and locations shall be carefully selected for the space controlled.
- Occupancy sensor types and common applications include the following:
  - Ultrasonic sensors are typically applied to corridor applications due to the increased spacing coverage.
  - Dual technology (ultrasonic and passive infrared) are typically applied to most applications
- Occupancy sensor mounting shall utilize the following options:
  - Combination wall switch/occupancy sensor may be used for small rooms where the location of the sensor in the wall switch adequately covers the entire room.
  - Wall or ceiling mounted occupancy sensors separate from the manual wall switches are typical utilized to optimize the coverage. The A/E shall select the appropriate mounting location to provide the best coverage and the least opportunity for false activation.

- Daylighting Sensors
  - Daylighting sensors shall be applied in spaces with ample natural light to automatically turn off artificial lighting when the daylight contributions are sufficient to satisfy the lighting level requirements.
  - Daylighting control may be applied using a space-by-space or central system approach.
    - Space-by-space approach includes provision of photocells to measure the daylight contribution within the spaces and control the lighting fixtures within that space. The daylighting control shall be integrated with the other control means including any manual switches and/or occupancy sensors.
    - Central system approach includes provision of photocell(s) in a space to measure the daylight contribution within the space and control of the lighting in that space through the central lighting control system.
  - Daylighting control may be applied using the following approaches:
    - On/ control of individual off lamps within lighting fixtures.
    - On/off control of banks of lighting fixtures in zones.
    - Dimming control of lamps within lighting fixtures.
- Emergency Transfer Devices

  Occupancies which require emergency lighting for safe egress but require these lights to be turned off for various activities shall utilize an emergency transfer device for the lighting controls. Emergency transfer devices sense the status of the normal power source and automatically energize the emergency lighting in the event of a power interruption regardless of the on/off status prior to the interruption.
- Dimmer Switches
  - Manual dimmer switches shall be applied in spaces where dimming of the lighting fixtures is required.
  - Diming switches shall be selected to coordinate with the lighting source and associated ballast/driver.
- Digital Timer Switch

  Digital timer switches shall be utilized in spaces where occupancy sensors are not appropriate for automatic control of the lighting. Typical applications for digital timer switches include Mechanical Equipment Rooms, Telecom Rooms, and other spaces that are typically only occupied for short durations.

12.6.2.2 Central Lighting Controls

- General

- A central lighting control system shall be applied where the economics of a central system are justified.
- The extent of a central lighting control system may include all spaces in the facility or only a portion of the spaces. The A/E shall provide recommendations for the extent of a central system approach to the Entity for approval.

- Relay Based System

  Typical central lighting control systems utilize a network of intelligent relay panels to control the lighting circuits.

  - The control panels house multiple relays and the lighting circuits are routed through the panels to facilitate control of these circuits.
  - The control panels are interconnected via cable and the system uses a microprocessor to control the lighting from a time clock function and/or other external devices such as switches, occupancy sensors, photocell, etc.

- Wireless System
  - Wireless control is available from many manufacturers' protocols including Enocean and ZigBee. The use of wireless control devices shall be considered by A/E when selecting the appropriate central lighting control system.
  - Use of a wireless lighting control system shall coordinate with other functions in the facility to ensure that there are no impacts to other wireless system in the facility. A/E shall provide recommendations for application of wireless lighting controls to the Entity for approval.
- Integration
  - A/E shall consider the benefits of integrating the lighting control system with the direct digital control system for HVAC.
  - Integration is best done using interposed change over relay contacts or by manufacturer proven protocol interfaces bespoke software/firmware is not recommended.
  - This integration may be desirable to initiate other control function in the facility. Examples of possible control functions include:
    - Use of occupancy sensors to initiate HVAC setback sequence when a space is unoccupied.
    - Use of photocell for activation of ceiling fans for air circulation.

12.6.2.3 Dimming Controls

- Architectural Dimming System

  Occupancies that warrant a multi-zone, preset lighting control system with dimming capability shall be provided with an architectural dimming system.

  - Architectural dimming system shall be provided with dimming and control components necessary for the quantity of zones served.
  - A master control station shall be provided and located to facilitate the setup of preset scenes appropriate for the occupancy.
  - Remote control stations shall be located at all entrances and other appropriate control points such as lectern, demonstration station, control station, etc.
  - Common applications for architectural dimming systems include conference rooms, meeting rooms, seminar rooms, classrooms, public lobbies, etc.
  - Interface with audio visual controls may also be desirable to facilitate a single control point for various applications. A/E shall coordinate between the lighting control and audio visual requirements and provide a recommendation for integration of these systems to the Entity for approval.
  - A standard protocol is to be utilized. DALI is preferred choice alternatives may be submitted for approval at the 10% design stage.

- Theatrical Dimming System

  Various occupancies such as auditoriums, mosques and other performance venues may warrant a more substantial dimming control system to facilitate the required control for the associated lighting equipment. For these unique applications, a theatrical dimming system shall be utilized.

- Theatrical dimming system shall be provided with separate cabinet(s) to house the dimming modules for all required control channels.
- Control stations shall be conveniently located to facilitate setup and control of lighting fixtures from all required control points.
- Interface with audio visual controls may also be desirable to facilitate a single control point for various applications. A/E shall co-ordinate between lighting control and audio visual requirements and provide a recommendation for integration of these systems to the Entity for approval.
- DMX512 is the preferred protocol for theatrical systems.

12.6.3 Exterior

- Building floodlighting circuits shall be switched automatically by photocell controlled lighting contactor(s).
  - Include manual override (On-Off-Auto Selector Switch) and locate at the source panel.
  - Photocell shall be located at a tamperproof height.

- Area lighting circuits shall be switched automatically by photocell controlled lighting contactor(s).
  - Include manual override (On-Off-Auto Selector Switch) and locate at the source panel.
  - Photocell shall be located at a tamperproof height.

- Sports lighting circuits shall be switched on and off by the energizing of master override control. Secondary controls downstream of the master override shall include photocell and time clock controlled lighting contactor(s).
  - Include manual override (On-Off-Auto Selector Switch) and locate at the source panel.
  - Photocell shall be located at a tamperproof height.

- Security lighting circuits shall be switched automatically by photocell controlled lighting contactor(s).
  - Include manual override (On-Off-Auto Selector Switch) and locate at the source panel.
  - Photocell shall be located at a tamperproof height.

12.6.4 Lighting Control Systems Strategies

A/E shall select the appropriate control strategies for each application. The recommended control strategies for typical applications are summarized in **TABLE -L** for interior and **TABLE -M** for exterior. The A/E shall develop recommendations for locations and occupancies not identified in these tables and submit to the Entity for approval.

TABLE L - INTERIOR LIGHTING CONTROL RECOMMENDATIONS

Location/Occupancy	Localized Room Control								Central Control System						
	Toggle Switch – Single Level	Toggle Switches – Multiple Levels	Toggle Switches – Zoned Control	Dimmer Switch	Occupancy Sensor(s)	Photocell for Daylighting Control	Digital Timer Switch	Emergency Transfer Device	Central Relay Panels	Architectural Dimming System DALI	Theatrical Dimming DMX 512	Low Voltage Switches or Preset Stations	Occupancy Sensors (linked to DALI system	Photocells for Daylighting Control (linked to DALI system)	Emergency Transfer Device
Offices		•			•					•			•	•	
Conference Rooms			•	•	•	•		•		•					
Classrooms			•		•	•		•							
Gymnasium			•		•	•									
Assembly Space										•		•	•1		•
Auditorium										•	•	•	•1		•
Public Lobby									•	•			•1		
Atrium									•	•			•1		
Warehouse		•			•										
Repair Shop		•			•										
Central Plant		•			•										
Corridors									•	•			•1	•	
Restroom	•				•								•1		
Electrical room	•														
Mechanical Room	•				•		•								
Telecom Room					•		•								

TABLE - M: EXTERIOR LIGHTING CONTROL RECOMMENDATIONS

Location/Occupancy	Localized Control				Central Control					
	Toggle Switch	Contactor with Astronomical Time Clock	Occupancy Sensor(s)	Photocell at Fixture	Architectural lighting control (DALI)	Multi-pole Contactor	Street lighting LMS (DALI wireless)	Programmed time clock	Occupancy Sensors	Common Photocell
Building Floodlighting					•	•	•			•
Public Park										
Walkways (public)							•			
Parking (public)				•			•			
Walkways (private)					•					•
Parking (private)						•				
Sports Lighting		•		•						
Security					•	•		•		•

13.0 COMMISSIONING

13.1 References

Refer to Document Number EPM-KT0-GL-000003: Testing & Commissioning Guidelines.

- Refer Section – 6.1 and subsection 6.1.4: Preliminary Phase- Pre-commissioning stage
- Refer Section – 6.3: Electrical system standalone Testing & Commissioning
- Refer Section – 6.10: Post Occupancy Testing and Commissioning
- Refer Section – 8.0: Attachments

14.0 INTEGRATION OF ELECTRO – MECHANICAL SYSTEM

14.1 References

For the integration of the Electromechanical system follow the below documents as guidance

1. EPM-KE0-GL-000007 : ELV System Integration Guidelines
2. EPM-KE0-GL-000008 : Fire and Life Safety Integration Guideline
3. EPM-KE0-GL-000009 : Building Management System (BMS) and Mechanical System integration Guideline