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PRESIDENTIAL PALACE- BAABDA

ELECTRICAL SPECIFICATIONS

AUGUST 2025

DIVISION 26

SECTION 260010 - SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Supplemental requirements applicable to Work specified in Division 26.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. A: Ampere, unit of electrical current.
2. AC or ac: Alternating current.
3. AFCI: Arc-fault circuit interrupter.
4. AIC: Ampere interrupting capacity.
5. AL, Al, or ALUM: Aluminum.
6. ASD: Adjustable-speed drive.
7. ATS: Automatic transfer switch.
8. AWG: American wire gauge; see ASTM B258.
9. BAS: Building automation system.
10. BMS: Building Management System.
11. BIL: Basic impulse insulation level.
12. BIM: Building information modeling.
13. CAD: Computer-aided design or drafting.
14. CATV: Community antenna television.
15. CB: Circuit breaker.
16. COPS: Critical operations power system.
17. CU or Cu: Copper.
18. CU-AL or AL-CU: Copper-aluminum.
19. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
20. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
21. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
22. dBm: Decibel absolute power with respect to 1 mW.
23. DC or dc: Direct current.
24. DDC: Direct digital control (HVAC).
25. EGC: Equipment grounding conductor.
26. EMF: Electromotive force.
27. EMI: Electromagnetic interference.
28. EPM: Electrical preventive maintenance.
29. EPS: Emergency power supply.
30. EPSS: Emergency power supply system.
31. ESS: Energy storage system.

32. EV: Electric vehicle.
33. EVPE: Electric vehicle power export equipment.
34. EVSE: Electric vehicle supply equipment.
35. fc: Footcandle, a unit of illuminance equal to one lumen per square foot.
36. FLC: Full-load current.
37. ft: Foot.
38. GEC: Grounding electrode conductor.
39. GFCI: Ground-fault circuit interrupter.
40. GFPE: Ground-fault protection of equipment.
41. GND: Ground.
42. HACR: Heating, air conditioning, and refrigeration.
43. HDPE: High-density polyethylene.
44. HID: High-intensity discharge.
45. HP or hp: Horsepower.
46. HVAC: Heating, ventilating, and air conditioning.
47. Hz: Hertz.
48. IBT: Intersystem bonding termination.
49. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
50. IP: Ingress protection rating (enclosures); Internet protocol (communications).
51. IR: Infrared.
52. IS: Intrinsically safe.
53. IT&R: Inspecting, testing, and repair.
54. ITE: Information technology equipment.
55. kAIC: Kiloampere interrupting capacity.
56. kV: Kilovolt.
57. kVA: Kilovolt-ampere.
58. kVAr or kVAR: Kilovolt-ampere reactive.
59. kW: Kilowatt.
60. kWh: Kilowatt-hour.
61. LAN: Local area network.
62. lb: Pound (weight).
63. LCD: Liquid-crystal display.
64. LCDI: Leakage-current detector-interrupter.
65. LED: Light-emitting diode.
66. LNG: Liquefied natural gas.
67. LP-Gas: Liquefied petroleum gas.
68. LRC: Locked-rotor current.
69. Lux or lx: Lux, a unit of illuminance.
70. MCC: Motor-control center.
71. MDC: Modular data center.
72. MG set: Motor-generator set.
73. MIDI: Musical instrument digital interface.
74. MLO: Main lugs only.
75. MVA: Megavolt-ampere.
76. mW: Milliwatt.
77. MW: Megawatt.
78. MWh: Megawatt-hour.
79. NC: Normally closed.
80. NiCd: Nickel cadmium.
81. NIU: Network interface unit.
82. NO: Normally open.

83. OCPD: Overcurrent protective device.
84. ONT: Optical network terminal.
85. PC: Personal computer.
86. PCS: Power conversion system.
87. PCU: Power-conditioning unit.
88. PF or pf: Power factor.
89. PHEV: Plug-in hybrid electric vehicle.
90. PLC: Programmable logic controller.
91. PLFA: Power-limited fire alarm.
92. PoE: Power over Ethernet.
93. PV: Photovoltaic.
94. PVC: Polyvinyl chloride.
95. pW: Picowatt.
96. RFI: Radio-frequency interference (electrical); Request for interpretation (contract).
97. RMS or rms: Root-mean-square.
98. RPM or rpm: Revolutions per minute.
99. SCADA: Supervisory control and data acquisition.
100. SCR: Silicon-controlled rectifier.
101. SPD: Surge protective device.
102. sq.: Square.
103. SWD: Switching duty.
104. TCP/IP: Transmission control protocol/Internet protocol.
105. TEFC: Totally enclosed fan-cooled.
106. TR: Tamper resistant.
107. TVSS: Transient voltage surge suppressor.
108. UL: Underwriters Laboratories, Inc. (standards) or UL LLC (services).
109. UL CCN: UL Category Control Number.
110. UPS: Uninterruptible power supply.
111. USB: Universal serial bus.
112. UV: Ultraviolet.
113. V: Volt, unit of electromotive force.
114. V(ac): Volt, alternating current.
115. V(dc): Volt, direct current.
116. VA: Volt-ampere, unit of complex electrical power.
117. VAr: Volt-ampere reactive, unit of reactive electrical power.
118. VFC: Variable-frequency controller.
119. VOM: Volt-ohm-multimeter.
120. VPN: Virtual private network.
121. VRLA: Valve-regulated lead acid.
122. W: Watt, unit of real electrical power.
123. Wh: Watt-hour, unit of electrical energy usage.
124. WPT: Wireless power transfer.
125. WPTE: Wireless power transfer equipment.
126. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-S: Steel electrical metallic tubing.
3. ENT: Electrical nonmetallic tubing.
4. ERMC: Electrical rigid metal conduit.

5. ERMC-S: Steel electrical rigid metal conduit.
6. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
7. FMC: Flexible metal conduit.
8. FMC-S: Steel flexible metal conduit.
9. FMT: Steel flexible metallic tubing.
10. FNMC: Flexible nonmetallic conduit. See LFNC.
11. IMC: Steel electrical intermediate metal conduit.
12. LFMC: Liquidtight flexible metal conduit.
13. LFMC-S: Steel liquidtight flexible metal conduit.
14. LFNC: Liquidtight flexible nonmetallic conduit.
15. PVC: Rigid PVC conduit.
16. RGS: See ERMC-S-G.
17. RMC: See ERMC.

C. Abbreviations and Acronyms for Electrical Cable Types:

1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CM: Communications general-purpose cable.
7. CMG: Communications general-purpose cable.
8. CMP: Communications plenum cable.
9. CMR: Communications riser cable.
10. FC: Flat cable.
11. FCC: Flat conductor cable.
12. FPL: Power-limited fire-alarm cable.
13. FPLP: Power-limited fire-alarm plenum cable.
14. FPLR: Power-limited fire-alarm riser cable.
15. IGS: Integrated gas spacer cable.
16. ITC: Instrumentation tray cable.
17. ITC-ER: Instrumentation tray cable, exposed run.
18. LS0H or LSZH: Low smoke zero halogen.
19. MC: Metal-clad cable.
20. MC-HL: Metal-clad cable, hazardous location.
21. MI: Mineral-insulated, metal-sheathed cable.
22. MV: Medium-voltage cable.
23. NM: Nonmetallic sheathed cable.
24. NPLF: Non-power-limited fire-alarm circuit cable.
25. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
26. NPLFR: Non-power-limited fire-alarm circuit riser cable.
27. OFC: Conductive optical fiber general-purpose cable.
28. OFCG: Conductive optical fiber general-purpose cable.
29. OFCP: Conductive optical fiber plenum cable.
30. OFCR: Conductive optical fiber riser cable.
31. OFN: Nonconductive optical fiber general-purpose cable.
32. OFNG: Nonconductive optical fiber general-purpose cable.
33. OFNP: Nonconductive optical fiber plenum cable.
34. OFNR: Nonconductive optical fiber riser cable.
35. PV: Photovoltaic cable.

36. XLPE: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Definitions:

1. Basic Impulse Insulation Level: Reference insulation level expressed in impulse crest voltage with a standard wave not longer than 1.5 times 50 microseconds and 1.5 times 40 microseconds.
2. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.
3. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
4. Designated Seismic System: A system component that requires design in accordance with ASCE/SEI 7, Ch. 13 and for which the Component Importance Factor is greater than 1.0.
5. Direct Buried: Installed underground without encasement in concrete or other protective material.
6. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:

    a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
    b. Concrete Box: A box intended for use in poured concrete.
    c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
    d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
    e. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
    f. Device Box: A box with provisions for mounting a wiring device directly to the box.
    g. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
    h. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
    i. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
    j. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
    k. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
    l. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for

mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.

m. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
n. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
o. Raised-Floor Box: A floor box intended for use in raised floors.
p. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
q. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
r. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
s. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
t. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

7. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that are designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety to human life.
8. Essential Electrical Systems: Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system. (healthcare facilities)
9. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
10. Jacket: A continuous nonmetallic outer covering for conductors or cables.
11. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.
12. Miniature 8-Position Series Jack (8PSJ): Also called an 8-position 8-contact (8P8C) modular jack. An unkeyed jack with up to eight contacts commonly used to terminate twisted-pair and multiconductor Ethernet cable. Shape and dimensions are specified by TIA-1096.

    a. Caution: An 8PSJ is not the same thing as an FCC "registered jack" RJ45S, now called a miniature 8-position keyed jack (8PKJ). Ethernet cable plugs do not have rejection keys. Many manufacturers and suppliers incorrectly use "RJ45" as a generic term to describe any 8-position series plug or jack whether it has a rejection key or not.

13. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.

14. Multi-Outlet Assembly: A type of surface, flush, or freestanding raceway designed to hold conductors, receptacles, and switches, assembled in the field or at the factory.
15. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
16. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
17. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
18. Sheath: A continuous metallic covering for conductors or cables.
19. UL Category Control Number: An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
20. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

    a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
    b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
    c. Extra-Low Voltage: Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V(ac rms), 42 V(ac peak), or 60 V(dc).
    d. Low Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
    e. Medium Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is rated about 1 kV but not exceeding 69 kV.
    f. High Voltage: (1) (circuits) Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 69 kV but not exceeding 230 kV. (2) (safety) Having sufficient electromotive force to inflict bodily harm or injury.

1.3 COORDINATION

1.4 PREINSTALLATION MEETINGS

A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than **10** days after notice to proceed. Agenda topics include, but are not limited to, the following:

1. Electrical installation schedule.
2. Status of power system studies.
3. Utility work coordination.
4. Commissioning activities.
5. Sustainability activities.

1.5 SEQUENCING

A. Conduct and submit results of power system studies before submitting Product Data and Shop Drawings for electrical equipment.

1.6 ACTION SUBMITTALS

A. Coordination Drawings for Structural Supports: Show coordination of structural supports for equipment and devices, including restraints and bracing for control of seismic and wind loads, with other systems, equipment, and structural supports in the vicinity.

B. Coordination Drawings for Ceiling Areas: Provide reflected ceiling plan(s), for the critical areas, supplemented by sections and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment and suspension systems will be attached.
3. Size and location of access panels on ceilings.
4. Elevation, size, and route of sprinkler piping.
5. Elevation, size, and route of plumbing piping.
6. Elevation, size, and route of ductwork.
7. Elevation, size, and route of cable tray.
8. Elevation, size, and route of conduit.
9. Elevation and size of wall-mounted and ceiling-mounted equipment.
10. Access panels.
11. Sprinklers.
12. Air inlets and outlets.
13. Control modules.
14. Luminaires.
15. Communications devices.
16. Speakers.
17. Security devices.
18. Fire-alarm devices.
19. Indicate clear dimensions for maintenance access in front of equipment.
20. Indicate dimensions of fully-open access doors.

C. Coordination Drawings for Cable Tray Routing: Reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Elevation, size, and route of cable trays.
2. Relationships between components and adjacent structural, electrical, and mechanical elements.
3. Vertical and horizontal offsets and transitions.
4. Elevation and size of sleeves for wall, ceiling, and floor cable penetrations.
5. Elevation of ceilings and size of ceiling tiles.
6. Locations of access panels on ceilings.
7. Locations where cable tray crosses or parallels sprinkler piping.
8. Locations where cable tray crosses plumbing piping.
9. Locations where cable tray crosses or parallels ductwork.

10. Locations of access panels on ductwork.
11. Locations where cable tray crosses conduit.
12. Items blocking access around cable trays, including the following:

    a. Light fixtures.
    b. Speakers.
    c. Fire-alarm devices.
    d. Power outlets.
    e. Wall-mounted equipment.
    f. Equipment racks.
    g. Furniture.
    h. Door swings.
    i. Building features.

13. Indicate clear dimension between cable tray and walls or obstructions that are closer than 1 m.
14. Highlight locations where cable tray is greater than 1 m above ceilings. Explain how personnel access will be accommodated for cable tray maintenance.

D. Coordination Drawings for Conduit Routing: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

E. Coordination Drawings for Large Equipment Indoor Installations:

1. Location plan, drawn to scale, showing heavy equipment or truck access paths to loading dock or other freight access into building. Indicate available width and height of doors or openings.
2. Floor plan for entry floor and floor where equipment is located, drawn to scale, showing heavy equipment access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:

    a. Dimensioned concrete bases, outlines of equipment, conduit entries, and grounding equipment locations.
    b. Dimensioned working clearances and dedicated areas below and around electrical equipment where obstructions and tripping hazards are prohibited.

3. Reflected ceiling plans for entry floor and floor where equipment is located, drawn to scale, on which the following items shown and coordinated with each other, based on input from installers of the items involved:

    a. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways **and seismic bracing**.
    b. Location of lighting fixtures, sprinkler piping and sprinklers, ducts and diffusers, and other obstructions, indicating available overhead clearance.

c. Dimensioned working clearances and dedicated areas above and around electrical equipment where foreign systems and equipment are prohibited.

F. Coordination Drawings for Large Equipment Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:

a. Fences and walls, dimensioned concrete bases, outlines of equipment, conduit entries, and grounding and bonding locations.
b. Indicate clear dimensions for fence gates and wall openings.
c. Indicate depth and type of ground cover, and locations of trees, shrubbery, and other obstructions in access path.
d. Indicate clear height below tree branches, overhead lines, bridges, and other overhead obstructions in access path, or where cranes and hoists will be needed to handle large electrical equipment.
e. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways**,** busways, and seismic bracing.
f. Dimensioned working clearances and dedicated areas around electrical equipment.

G. Coordination Drawings for Duct Banks: Signed and sealed by qualified engineer.

1. Show duct profiles and coordination with other utilities and underground structures.
2. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

1.7 INFORMATIONAL SUBMITTALS

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:

1. Submission of power system studies.
2. Submission of specified coordination drawings.
3. Submission of action submittals specified in Division 26.
4. Orders placed for major electrical equipment.
5. Arrival of major electrical equipment on-site.
6. Pre-installation meetings specified in Division 26.
7. Utility service outages.
8. Utility service inspection and activation.
9. Mockup reviews.
10. Closing of walls and ceilings containing electrical Work.
11. System startup, testing, and commissioning activities for major electrical equipment.
12. System startup, testing, and commissioning activities for emergency lighting.
13. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
14. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
15. Requests for special inspections.

16. Requests for inspections by authorities having jurisdiction.

B. Delegated Design Drawings for Structural Masonry Wall Penetrations: Where indicated on Drawings, provide reflected ceiling plan(s), supplemented by elevations, sections, and other details, drawn to scale, signed and sealed by a qualified structural professional engineer, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Location and dimensions of structural members supporting wall.
2. Location and dimensions of columns near penetrations.
3. Location and dimension of headers and lintels.
4. Doors and windows near penetrations.
5. Location and dimensions of penetrating cuts.
6. Sprinkler piping and sleeves.
7. Plumbing piping and sleeves.
8. Ductwork and sleeves.
9. Cable tray and sleeves.
10. Conduit and sleeves.
11. Firestopping assemblies for rated penetrations.
12. Structural supports for piping, ductwork, and conduit on both sides of wall.

C. Certificates:

1. Welding certificates.
2. Seismic-Load Performance Certificates: Provide special certification for designated seismic systems for all Designated Seismic Systems identified on Drawings or in the Specifications.

    a. The following systems and components are Designated Seismic Systems and require written special certification of seismic qualification by manufacturer:

        1) Hangers and supports specified in Section 260529 "Hangers and Supports for Electrical Systems."
        2) Raceways, enclosures, cabinets, boxes, and their mounting provisions specified in Section 260533 "Raceway and Boxes for Electrical Systems."
        3) Cable trays, accessories, and components specified in Section 260536 "Cable Trays for Electrical Systems."
        4) Equipment, overcurrent protective devices, accessories, and components specified in Section 262313 "Paralleling Low-Voltage Switchgear."
        5) Equipment, accessories, and components specified in Section 262413 "Switchboards."
        6) Equipment, accessories, and components specified in Section 262416 "Panelboards."
        7) Equipment, accessories, and components specified in Section 262419 "Motor-Control Centers."
        8) Equipment, accessories, and components specified in Section 262743 "Electric-Vehicle Service Equipment - AC Level 1 and Level 2."
        9) Equipment, accessories, and components specified in Section 262816 "Enclosed Switches and Circuit Breakers."
        10) Equipment, accessories, and components specified in Section 262923 "Variable-Frequency Motor Controllers."

11) Equipment, accessories, and components specified in Section 263100 "Photovoltaic Collectors."
12) Equipment, accessories, and components specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."
13) Equipment, accessories, and components specified in Section 263323.11 "Central Battery Equipment for Emergency Lighting."
14) Equipment, accessories, and components specified in Section 263353 "Static Uninterruptible Power Supply."
15) Equipment, accessories, and components specified in Section 263533 "Power Factor Correction Equipment."
16) Equipment, accessories, and components specified in Section 263600 "Transfer Switches."
17) Luminaires, accessories, and components specified in Section 265119 "LED Interior Lighting."
18) Luminaires, accessories, and components specified in Section 265213 "Emergency and Exit Lighting."
19) Luminaires, accessories, and components specified in Section 265619 "LED Exterior Lighting."

b. Include the following information:

1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4) Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
5) Provide equipment manufacturer's written certification for each designated active electrical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction.
6) Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in **ASCE/SEI 7-05** or **ASCE/SEI 7-10 or ASCE/SEI 7-16**.
7) Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by qualified structural professional engineer.

1.8 CLOSEOUT SUBMITTALS

A. Facility EPM Program Binders:

1. Complete Set: On **approved online or cloud solution**.

B. Operation and Maintenance Data:

1. Provide emergency, operation, and maintenance manuals for each system, equipment, and device listed below:

    a. Diesel-Engine-Driven Generator.

    b. KNX-Based Lighting Controls.

    c. Switchboards.

    d. Panelboards.

    e. Motor Control Centers.

    f. Central Battery Equipment for Emergency Lighting.

    g. Static Uninterruptible Power Supply.

    h. Emergency and Exit Lighting.

    i. Addressable Fire-Alarm System.

2. Include the following information:

    a. Manufacturer's operating specifications.
    b. User's guides for software and hardware.
    c. Schedule of maintenance material items recommended to be stored at Project site.
    d. Detailed instructions covering operation under both normal and abnormal conditions.
    e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
    f. List of load-current and overload-relay heaters with related motor nameplate data.
    g. List of lamp types and photoelectric relays used on Project, with ANSI and manufacturers' codes.
    h. Manufacturer's instructions for setting field-adjustable components.
    i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
    j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
    k. Exterior pole inspection and repair procedures.

C. Software and Firmware Operational Documentation: Provide software and firmware operational documentation, including the following:

1. Software operating and upgrade manuals.
2. Names, versions, and website addresses for locations of installed software.
3. Device address list.
4. Printout of software application and graphic screens.
5. Testing and adjusting of panic and emergency power features.
6. For lighting controls include the following:

    a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.

b. Operation of adjustable zone controls.

D. Software:

1. Program Software Backup: Provide **username and password for approved online or cloud solution**.
2. Provide to Owner upgrades and unrestricted licenses for installed and backup software, including operating systems and programming tools required for operation and maintenance.

1.9 QUALIFICATIONS

A. Welder: Installer possessing active qualifications specified in Section 014000 "Quality, Performance and General Workmanship" with training and certification in accordance with a known certifying association.

B. Electrical Power Monitoring Installers: Installer possessing active qualifications specified in Section 014000 "Quality, Performance and General Workmanship" and able to present unexpired certified Installer credentials issued by manufacturer prior to starting installation.

C. Generator Set Installers: Installer possessing active qualifications specified in Section 014000 " Quality, Performance and General Workmanship" and able to present unexpired certified Installer credentials issued by generator set manufacturer prior to starting installation.

D. Lightning Protection System Installers: Installer possessing active qualifications specified in Section 014000 "Quality, Performance and General Workmanship " and able to present certificate **credentials** prior to starting installation.

E. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment.

1.10 MOCKUPS, if required

A. Simple Mockups for Coordinating Accessibility of Electrical Devices around Fixed Furnishings and Equipment:

1. Build simple mockups using art supplies and other inexpensive materials for verification of general arrangement, actual dimensions, and accessibility by **Architect** prior to fabrication and installation of Work. Depict products from all Divisions requiring coordination including, but not limited to, fixed furnishings, casework, outlet covers and plates, HVAC controls, exposed raceway, exposed plumbing, equipment, and signage.

B. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.

PART 2 - PRODUCTS

2.1 FACILITY ELECTRICAL PREVENTIVE MAINTENANCE (EPM) PROGRAM BINDERS

A. Description: Set of binders containing operation and maintenance data for facility's electrical equipment that was compiled during analysis of installed electrical Work for Facility EPM Program development.

B. Applicable Standards:

1. Regulatory Requirements: Comply with recommendations in NFPA 70B and IEC.
2. General Characteristics:

a. Volume 1 - Introduction:

1) Summarize how Facility EPM Program Analysis was performed, how data were collected, and how volumes are organized.
2) Describe Facility EPM Program and provide recommended policies and procedures for implementing the program and keeping it current.
3) Provide place for Owner to identify contact information for employees responsible for implementing and maintaining Facility EPM Program.

b. Volume 2 - Facility Safety, Hazards Awareness, and Emergency Procedures:

1) Include training requirements for employees and contractors.
2) Include list of known facility hazards impacting IT&R activities.
3) Include approval and permitting procedures for IT&R activities.
4) Include incident emergency response procedures.
5) Include emergency shutdown procedures.
6) Include electrical disaster recovery procedures.

c. Volume 3 - Operating Procedures for Electrical Equipment and Controls.

d. Volume 4 - Facility Diagrams and Schedules:

1) Include single-line diagrams.
2) Include grounding and bonding diagrams.
3) Include essential wiring diagrams.
4) Include system automation diagrams (SCADA, BMS, lighting, HVAC, etc.).
5) Include records of switchgear, switchboard, and panelboard schedules.
6) Include time-current curves for overcurrent protective devices.
7) Include list of load-current and overload-relay heaters with related motor nameplate data.

e. Volume 5 - Inventory of Facility Equipment Using Electrical Power:

1) Include simplified floor plans showing equipment locations.
2) Identify critical equipment (electrical or otherwise).
3) Include identifying designations and nameplate data.
4) Include warranty and maintenance contract information.

f. Volume 6 - Inventory of Facility Tools, Supplies, and Personnel Protective Equipment:

1) Include schedules of maintenance material items recommended to be stored at facility.
2) Include list of lamp types and photoelectric relays used in facility with ANSI and manufacturers' codes.
3) Include calibration and servicing data for each item.

g. Volume 7 - Inspection, Testing, and Repair (IT&R) Plan:

1) Include tables showing frequency of activities for each item.
2) Include annual schedule with activities mapped to specific days of the year.
3) Include exterior pole inspection and repair procedures.

h. Volume 8 - Inspection, Testing, and Repair (IT&R) Forms.

i. Volume 9 - Inspection, Testing, and Repair (IT&R) Procedures.

j. Volume 10 - Spare Parts List:

1) Include list of all parts required to perform IT&R procedures.
2) Identify quantities of which parts are recommended to be stored on-site.
3) Include source contact information and budget cost for each item.

k. Volume 11 - Construction Project Closeout Record Documentation:

1) Include records of power system studies and photometric studies.
2) Include records of risk assessment studies.
3) Include records of electrical system startup and commissioning activities.
4) Include records of baseline inspections and tests.
5) Include records of baseline infrared photographs with normal light photographs showing the location, direction, angle, and conditions necessary for reproducing each infrared photograph.
6) Include records of baseline settings for adjustable equipment and devices.

PART 3 - EXECUTION

3.1 DEVELOPMENT OF FACILITY EPM PROGRAM

A. Facility EPM Program must be developed by qualified EPM specialist.

B. Conduct Facility EPM Program analysis in accordance with NFPA 70B recommendations.

C. Compile operation and maintenance data from Facility EPM Program analysis and submit **updated** Facility EPM Program Binders.

3.2 INSTALLATION OF ELECTRICAL WORK

A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, for installation of Work specified in Division 26. Consult Architect for resolution of conflicting requirements.

3.3 FIELD QUALITY CONTROL

A. Administrant for Low-Voltage Electrical Tests and Inspections:
   1. Administer and perform tests and inspections **with assistance of factory-authorized service representative**.

B. Administrant for Structural Tests and Inspections:
   1. Administer and perform tests and inspections **with assistance of factory-authorized service representative**.

C. Administrant for Field Tests and Inspections of Lighting Installations:
   1. Administer and perform tests and inspections **with assistance of factory-authorized service representative**.

3.4 CLOSEOUT ACTIVITIES

A. Demonstration:

   1. **With assistance from factory-authorized service representatives, demonstrate** to Owner's maintenance and clerical personnel how to operate the following systems and equipment:

      a. Lighting control devices specified in Section 260923 "Lighting Control Devices."
      b. Lighting control systems specified in Section 260943.24 "KNX-Based Lighting Controls."

   2. **Allow Owner to record demonstrations.**

B. Training:

   1. **With assistance from factory-authorized service representatives, train** Owner's maintenance personnel on the following topics:

      a. How to implement **updated** Facility EPM Program.
      b. How to operate normal and emergency electrical systems, including justifications for, and limitations of, protective device settings.
      c. How to adjust, operate, and maintain systems specified in Section 260913 "Electrical Power Monitoring."
      d. How to adjust, operate, and maintain devices specified in Section 260923 "Lighting Control Devices."
      e. How to adjust, operate, and maintain hardware and software specified in Section 260943.24 "KNX-Based Lighting Controls."

f. How to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories specified in Section 262413 "Switchboards."
g. How to adjust, operate, and maintain enclosed controllers specified in Section 262419 "Motor-Control Centers."
h. How to adjust, operate, and maintain equipment specified in Section 262923 "Variable-Frequency Motor Controllers."
i. How to adjust, operate, and maintain equipment specified in Section 263100 "Photovoltaic Collectors."
j. How to adjust, operate, and maintain equipment specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."
k. How to adjust, operate, and maintain equipment specified in Section 263323.11 "Central Battery Equipment for Emergency Lighting."
l. How to adjust, operate, and maintain equipment specified in Section 263353 "Static Uninterruptible Power Supply."
m. How to adjust, operate, and maintain equipment specified in Section 263533 "Power Factor Correction Equipment."
n. How to adjust, operate, and maintain transfer switches and related equipment, including ground-fault protection system, specified in Section 263600 "Transfer Switches."
o. How to adjust, operate, and maintain devices specified in Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits."
p. How to adjust, operate, and maintain luminaires **and photoelectric controls** specified in Section 265619 "LED Exterior Lighting."

2. **Allow Owner to record training sessions.**

END OF SECTION 260010

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aluminum building wire, insulated .
2. Copper building wire, insulated .
3. Copper building wire, insulated
4. Photovoltaic cable, Type PV.
5. Multi-core cable, insulated
6. Life safety cable.
7. Central battery system wire and cable.
8. Connectors and splices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.
3. Section 271513 "Communications Copper Horizontal Cabling" for twisted pair cabling used for data circuits.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Low Voltage Cable:

a. Liban Cables.

2. Cable Connectors:
   a. Percon
   b. Phoenix Contact
   c. Wago
   d. Weidmuller

2.2 COPPER BUILDING WIRE, INSULATED

A. Description: Single Core Insulated Non-Sheathed (Building Wires). Single conductor cables generally with concentric strands and insulated with, for wiring installation on truncking, suitable for wet locations and for conductor temperature of 90 deg. C.

B. Conductor Sizes: are to be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted. Conductors of single core cables 25mm^2 and above are to be compacted. Multi-core cables 35 mm^2 and above are to be of sectoral shape.

C. Standards:

1. Comply with BS EN 50363 for moisture insulation.
2. Wires and cables are to be 450/750 V grade to BS 7211.
3. Comply with IEC 60228 Class 2 for stranded copper.

D. Conductors: Annealed Copper conductors, generally with concentric strands.

E. Conductor Insulation: .

F. Shield: **None**.

2.3 PHOTOVOLTAIC CABLE, TYPE PV

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated **1500V dc**.

B. Standards:

1. Listed and labeled as defined in IEC 62930, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to IEC.

C. Conductors: Stranded copper as per IEC.

D. Conductor Insulation: PVC, Cross-linked insulated power cables with sheath. The cables are designed to operate at a normal continuous maximum conductor temperature of 90 °C. The permissible period of use at a maximum conductor temperature of 120 °C is limited to 20 000 h.

2.4 MULTI-CORE CABLE, PVC INSULATED

A. Description: 600/1000 V grade, Aluminum/Copper conductor, compacted, insulated with PVC. Cores and cross sectional areas are to be as shown on the Drawings. Phases are to be color coded in conformity with the Standards, and overall cable sheath is to be extruded black material

B. Conductor Sizes: are to be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted. Conductors of single core cables 25mm^2 and above are to be compacted. Multi-core cables 35 mm^2 and above are to be of sectoral shape.

C. Standards:

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1. Comply with IEC 60228 Class 2 for stranded Copper.
2. Comply with IEC 61089 Class 2 for stranded Aluminum.
3. Comply with SBC 401:2018 for cable insulation.

D. Conductors: Annealed Aluminum/Copper conductors, generally with concentric strands.

E. Conductor Insulation: PVC.

F. Shield: .

2.5 LIFE SAFETY CABLE

A. Description: Low Smoke Zero Halogen (LS0H) Cables, multi-core plain Aluminum/Copper stranded conductor (size up to 400s.q.mm), fire resistant insulation, galvanized wire armoured, category CWZ, LS0H sheath. Flame retardant Cable rated 600/1000 V, capable of accepting voltage surges up to 5 kV, operating conductor temperature of 90deg. C Conductor is compacted and insulated with extruded material for low smoke emission. Cores and cross sectional areas are to be as shown on the Drawings.

B. Standards:

1. Comply with IEC 60228 Class 2 for stranded copper.
2. Comply with IEC 61034-1 and 2 or BS 50268 and IEC 60754-1 & 2 or BS 50267-2-1.
3. Comply with BS 6387 CWZ and with BS 7655 for low smoke emission of the insulation with extruded material.
4. Comply and passes the test IEC 60332-1 & 3 (category C) or BS 4066-3 for flame retardant properties.
5. LPCB and BASEC certified, audited and marked by embossing on cable sheath for fire resistance category CWZ. 600/1000V grade.
6. Comply with SBC 401:2018 for cable insulation.

C. Conductors: Solid or stranded Copper conductor (in size up to 4s.q.mm)

D. Conductor Insulation: Extruded material for low smoke emission

E. Similar to Prysmian - Type FP 200 Gold, or approved equal

2.6 FIRE RATED WIRE AND CABLE

A. Description: Low Smoke Zero Halogen (LS0H) Cables, Single core stranded plain annealed copper conductors, fire resistant insulation, Low Smoke Zero Halogen (LS0H) composite sheath, flame retardant, rated 600/1000 V, capable of accepting voltage surges up to 5 kV, operating conductor temperature of 90 deg. C.

B. Standards:

1. Comply with IEC 60228 for plain annealed copper conductors.
2. Comply with IEC60331 and category CWZ to BS 6387 when tested in steel conduit for fire resistant insulation.
3. Comply with IEC61034-1 and 2 or BS 50268 and IEC 60754-1 & 2 or BS 50267-2-1 for LS0H composite sheath.
4. Comply and passes the test pass IEC 60332-1 & 3 (category C) or BS 4066-3 for flame retardant properties.
5. Comply with BS7655.
6. LPCB and BASEC certified, audited and marked by embossing on cable sheath for fire resistance category CWZ600/1000 V grade.
7. Comply with SBC 401:2018 for cable insulation.

C. Conductors: Stranded plain annealed Copper conductor.

D. Conductor Insulation: Extruded material for low smoke emission

E. Similar to Prysmian - Type FP 100 Gold, or approved equal

2.7 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled by a qualified testing agency, and marked for intended location and use.

B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

C. Connector - Type A-1: pressure indent type, for terminating or making T-taps and splices on conductors 10 mm2 and smaller. Connector is to be non-ferrous copper alloy applied to conductor by mechanical crimping pressure, with vinyl insulating sleeves or phenolic insulating covers.

D. Connector - Type A-2: bolted pressure split type for terminating or making T-taps and splices on conductors 16 mm2 and larger. Connector is to be cast non-ferrous copper alloy applied to conductor by clamping with minimum of two screws and provided with phenolic insulating cover.

E. Connector - Type B-1: pre-insulated, spring type, for branch circuit and fixture wiring. Connector is to be encased spring with shell, insulated with vinyl cap and skirt.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.2 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

A. Comply with IEC and in accordance with recognized industry practices.

B. Wiring Method: Install wiring in metal pathway according to Section 270528.29 "Hangers and Supports for Communications Systems."

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.

    a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.

3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables.
4. Signaling Line Circuits: Power-limited fire-alarm cables **must not** be installed in the same cable or pathway as signaling line circuits.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.

E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

F. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.

G. Wiring to Remote Alarm Transmitting Device: 25 mm conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.3 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

B. Make splices, terminations, and taps that are compatible with conductor material.

C. Splices are only permitted when the site condition of the installation exceeds the standard manufacturer length.

D. Wiring at Outlets: Install conductor at each outlet, with at least **150 mm** of slack.

E. Comply with requirements in **Section 284621.11 "Addressable Fire-Alarm Systems"** for connecting, terminating, and identifying wires and cables.

3.4 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. After installing conductors and cables and before electrical circuitry has been energized, test **service entrance and feeder conductors and conductors** feeding the following critical equipment and services for compliance with requirements.

3. Perform each of the following visual and electrical tests:

    a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
    b. Test bolted connections for high resistance using one of the following:

        1) A low-resistance ohmmeter.
        2) Calibrated torque wrench.
        3) Thermographic survey.

    c. Inspect compression-applied connectors for correct cable match and indentation.
    d. Inspect for correct identification.
    e. Inspect cable jacket and condition.
    f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
    g. Continuity test on each conductor and cable.
    h. Uniform resistance of parallel conductors.

4. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors of 25 s.q.mm and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

5. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Control cable.
   2. Control-circuit conductors.

B. Related Requirements:

   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   1. Liban Cables

2.2 CONTROL CABLE

A. Description: Multi-core PVC Insulated Control Cables, 0.6/1 kV rating, solid 1.5 mm2, 2.5 mm2 or solid 4 mm2 plain circular copper conductors, with heat resistant PVC/E, rated for 85 deg. C, of 7, 12, 19, 24, 30 or 37 cores. Cores are to be laid up together and filled with non-hygroscopic material, PVC over sheathed, to form compact and circular cable for use in switchgear, control gear and generally for control of power and lighting systems. Armored cable is to have extruded PVC bedding, which may be an integral part of the filling, galvanized

steel wire armoring, and over sheath of PVC type ST2 to IEC 60502, color black. Core identification is to be white printed numbers 1, 2, 3 etc. over black insulation.

PE Insulated Control and Signal Cables: for use on instrumentation or data systems, are to be generally 300 V rating, polyethylene insulated, color coded, tinned copper conductors (0.6 mm diameter), twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075 mm bare copper shielding tape and provided with drain wire and overall PVC sheath.

Control And Signal Cables, enclosed in conduit and raceways with power cables, are to be insulated for same voltage grade.

B. Standards:
   1. Comply with IEC 60227 for heat resistive PVC/E.
   2. Comply with BS 6387 CWZ for low smoke emission of the insulation with extruded material.
   3. Comply with IEC 60331 for fire resistance.
   4. Comply and passes the test IEC 60332-1 & 3 (category C) or BS 4066-3 for flame See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Solid.

2.3 FIRE-ALARM WIRE AND CABLE

A. Description: Low Smoke Zero Halogen (LS0H) Cables, multi-core solid or stranded copper conductor (size up to 4s.q.mm), fire resistant insulation, galvanized wire armoured, category CWZ, laminated Aluminium screen and LS0H composite sheath with tinned earth continuity conductor/drain wire. Flame retardant Cable rated 300/500 V, capable of accepting voltage surges up to 5 kV, operating conductor temperature of 70deg. C. Conductor is compacted and insulated with extruded material for low smoke emission. Cores and cross sectional areas are to be as shown on the Drawings. Phases are to be colour coded in conformity with the Standards, and overall cable sheath is to be extruded black LS0H material.

B. Standards:
   1. Comply with IEC 61034-1 and 2 or BS 50268 and IEC 60754-1 & 2 or BS 50267-2-1.
   2. Comply with BS 6387 CWZ and with BS 7655 for low smoke emission of the insulation with extruded material.
   3. Comply and passes the test IEC 60332-1 & 3 (category C) or BS 4066-3 for flame retardant properties.
   4. LPCB and BASEC certified, audited and marked by embossing on cable sheath for fire resistance category CWZ. 600/1000V grade.

C. Conductors: Solid or stranded copper conductor (in size up to 4s.q.mm)

D. Conductor Insulation: Extruded material for low smoke emission

E. Similar to Prysmian - Type FP 200 Gold, or approved equal

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
   1. Outlet boxes for cables must be no smaller than 102 mm square by **53 mm** deep with extension ring sized to bring edge of ring to within 3.1 mm of the finished wall surface.
   2. Flexible metal conduit must not be used.

B. Install manufactured conduit sweeps and long-radius elbows if possible.

C. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits **75 mm** above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. General Requirements for Cabling:
   1. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
   2. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
   3. Secure and support cables at intervals not exceeding 760 mm and not more 150 mm from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
   5. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
   6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
   7. Support: Do not allow cables to lie on removable ceiling tiles.

8. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
9. Provide strain relief.
10. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
11. Ground wire must be copper, and grounding methods must comply with IEC. Demonstrate ground resistance.

B. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.
2. Use insulated spade lugs for wire and cable connection to screw terminals.
3. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of **1830 mm** of cable in a coil not less than **305 mm** in diameter.

D. Separation from EMI Sources:

1. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment must be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 64 mm.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 150 mm.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 305 mm.

2. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures must be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 75 mm.
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 150 mm.

3. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 1200 mm.
4. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 127 mm.

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

3.5 FIRESTOPPING

A. Comply with requirements in Section 078400 "Penetration Firestopping."

3.6 GROUNDING

A. For data communication wiring, comply with TIA-607-B, "Bonding and Grounding (Earthing)" Chapter.

B. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

3.8 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect cable jacket materials for third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.

    a. Test instruments must meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

B. Document data for each measurement. Print data for submittals in a summary report, or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Related Requirements:

The following Sections include requirements which relate to this section:

1. Division 26 Section "Lightning Protection for Structures".
2. Division 26 Section "Switchboards ".
3. Division 26 Section "Low Voltage Electrical Power Conductors and Cables".
4. Division 26 Section "Diesel-Engine-Driven Generator Sets".
5. Division 26 Section "Raceways and Boxes for Electrical Systems"

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, including for earth rods, connectors and connection materials, and earth fittings.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Earth pits.
2. Ground rods.
3. Ground rings.

B. Equipment Data: prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for earth rods, connecting clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits and tools etc., and samples of conductors as requested.

C. Shop and Construction Drawings: submit drawings for approval including, but not limited to, the following:

1. Exact location of earth pits, rods and details of installation and connections
2. Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering
3. Cross sectional area of all earthing, protective and bonding conductors
4. Layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

D. Report of Field Tests and Observations Certified by the Engineer. All tests shall be carried out in the presence of and be certified by the Engineer.

E. Product Data and Sample: Submit for each type of product indicated including manufacturer's catalogue sheets with catalogue numbers marked for the items furnished, which shall include:
1. Exothermal welding materials, kits and tools.
2. Terminal lugs, clamps, etc.
3. Copper ground cable.
4. Ground rods, test pits, etc.
5. Earthing conductors, protective conductors, and bonding conductors.
6. Connectors and other accessories.
7. Samples of conductors, or any other accessories as requested by the Engineer.

F. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and its locations, Engineer/Consultant and Owner. The firm should have at least two years of success full installation experience. Field inspection reports indicating compliance with specified requirement and submit written test reports to include the following:

1. Test procedures used and test conditions (Method statements for testing of the earthing system for each building/structure and the measurement of soil resistivity).
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

G. Calculations: Grounding calculations detailed enough to reach the required overall earthing resistance. However, the final test report results after installation shall remain the effective proof of reaching the requested earthing resistance value.

H. Shop Drawings: Submit drawings for approval including, but not limited to, the following:
1. Manufacturer's Instruction for Grounding system.
2. Exact location of earth pits, rods and details of installation and connections.
3. Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.
4. Cross sectional area of all earthing, protective and bonding conductors.
5. Layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panel-boards etc., indicating fittings used, insulation, plates, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

I. As-Built Drawings: Scaled drawings, showing actual layout and specification of all components of earthing system include the number of rods driven and their depths at each location, indicate nature of soil, special earthing arrangements, date and particulars of additives to soil or in bore-holes if used, test conditions such as weather and other phenomena that may effect on the tests and results obtained.

J. Compliance Sheet: Contractor to fill-in the compliance data sheet (when attached to a section) and stamp it by the proposed supplier and by the proposed electrical sub-contractor (or himself if no sub-contractor). If the Contractor is assuming two suppliers for one material item in his bid, two data sheets should then be filled and stamped, as mentioned, for the same item.

K. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
1. Instructions for periodic testing and inspection of grounding features at inspection pits.
2. Tests shall be to determine if ground resistance values remain within specified maximums, and instructions shall recommend corrective action if they
3. do not include recommended testing intervals.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. Include the following:

a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
1) Earth pits
2) Ground rods.
3) Ground rings.

1.5 DEFINITIONS

A. "Grounding" or "Ground" used in other sections or divisions of the specification are interchangeably used as "Earthing" or "Earth".

B. Earth: conductive mass of the Earth whose electric potential at any point is conventionally taken as zero.

C. Earth Electrode: conductor or group of conductors in initial contact with, and providing electrical connection to Earth.

D. Exposed Conductive Part: any part which can be readily touched and which is not a live part, but which may become live under fault conditions.

E. Extraneous Conductive Part: any conductive part not forming part of the electrical installation such as structural metalwork of a building, metallic gas pipes, water pipes, heating tubes etc. and non-electrical apparatus electrically connected to them i.e. radiators, cooking ranges, metal sinks etc. and non-insulating floors and walls.

F. Protective Conductor: conductor used for some measure of protection against electric shock and intended for connecting together any of the following parts:

1. Exposed conductive parts
2. Extraneous conductive parts
3. Earth electrode(s)
4. Main earthing terminal or bar(s)
5. Earthed point of the source(s)

G. Electrically Independent Earth Electrodes: earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other(s).

H. Main Earthing Terminal or Bar: the terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.

I. Equipotential Bonding: electrical connection to put exposed and extraneous conductive parts at a substantially equal potential.

J. Earthing Conductor: protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has specialized in installing earthing and bonding systems similar in material, design and extent to those indicated for this project and whose work has resulted in installations with a record of successful in service performance.

B. Standards: Except as modified or supplemented herein, all materials required in this section including their installation shall conform to the applicable requirements of the following standards. Standards current at the time of tender shall be used.
   1. SBC 401:2018, Saudi Building Code..
   2. International Electro-technical Commission-IEC.
   3. SASO IEC 60669 Standard.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: in accordance with the relevant IEC standards and local utility requirements.

B. Description of Work: This section includes complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TNS system arrangement, including:
   1. Main earthing terminals or bars
   2. Exposed conductive parts of electrical equipment
   3. Extraneous conductive parts
   4. Standby generator neutral earthing.
   5. LV Switchgears.
   6. Main earthing terminals or bars in electrical, UPS, mechanical rooms, etc.
   7. Building main ring system of electrodes and conductors.
   8. Separate clean earth for the Telecommunication and security systems and control room.

2.2 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering grounding and bonding products which may be incorporated in the work include, but are not limited to, the following:

Dehn
Furse
GEC
Kingsmill
Wallis
OBO Bettermann

2.3 CONDUCTORS

A. Insulated Conductors: **Copper** wire or cable insulated for 1000 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
1. Stranded Conductors: Soft drawn annealed bare copper with 98% conductivity and shall conform ASTM B3 and/or BS EN 60228 and/or IEC 60228.The cross section shall be 120mm2 unless otherwise indicated on the drawings.
2. Flexible braided cable strap: Copper, 250 mm by 35 mm thick ground post clamps.
3. Clamps shall be of the anti-electrolysis type.
4. Grounding plates: Copper, minimum 600 mm by 600 mm by 3 mm thick.

C. All conductor fittings shall be manufactured from high strength copper alloys with phosphor bronze nuts, bolts, washers and screws. All fittings shall be designed for the specific application and shall not be permanently deformed when correctly installed.

D. Protective Bonding Conductors: Bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid)

E. Exothermic welds: Molds, cartridges, materials and accessories as recommended by the manufacturer of the molds for items to be welded. Molds and powder shall be furnished by the same Manufacturer.

F. Main Earthing Bar: hard drawn copper, 40 x 4 mm where formed into a closed loop, and 50 x 6 mm where open-ended. Earth bar is to be labelled 'Main Earth Bar' and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.

2.4 CONNECTORS

A. Copper or copper alloy, of approved design, compatible with points of connection, and of adequate cross-section and current carrying capacity.

B. Connections to metallic structures for earthing conductors and bonding conductors between electrically separate parts of a structure shall be either by direct exothermic welding or by

bolting using a stud welded to the structure. Drilling of a structural member for a directly bolted connection shall only be carried out to the approval of the Engineer.

1. Bolted Connectors and Clamps: Bolted-pressure-type or compression type connectors and clamps. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys. Bolted connections are not permitted in run of the earthing conductors unless approved by the Engineer.

2. Welded Connectors: Exothermic-welded type, in kit forms, and selected per manufacturer's written instructions. Welded connectors are to be used only in inaccessible locations and at “T” joints and it shall be subject to the approval of the Engineer.

C. Bi-metallic connectors shall be used between conductors of dissimilar materials and insulating material shall be interposed between metallic fittings and structures of dissimilar materials to prevent corrosion.

D. When the reinforcing in concrete is used as a part of the earthing system the fittings used to provide a connection point at the surface of the concrete shall be exothermically welded to a reinforcing bar. This fitting shall be provided with a bolted connection for an earthing conductor. The main bars in the reinforcing shall be welded together at intervals to ensure electrical continuity throughout the reinforcing.

E. No connections shall be made to reinforcing bars and other steelwork, which do not form part of the earthing system and are completely encased in concrete.

F. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

G. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

H. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

I. Conduit Hubs: Mechanical type, terminal with threaded hub.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with **hex head bolt.**

K. Lay-in Lug Connector: Mechanical type, **copper rated for direct burial** terminal with set screw.

L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

N. Straps: Solid copper, **copper lugs**. Rated for 1000 V.

O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal **one** piece clamp.

P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

Q. Water Pipe Clamps:

1. Mechanical type, two pieces with **stainless steel** bolts.

    a. Material: **Tin-plated aluminum**
    b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and **copper ground connector**

2.5 GROUNDING ELECTRODES

A. Ground Rods: copper clad steel rod, 16 mm diameter, 2.5 m length, extendible as necessary to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated

B. Earth Plates (Lattice): Earth Plates e is to consist of parallel and perpendicular stainless steel grade 316 strips (tapes), spacing interval as shown on drawings, burial depth 0.5m minimum below building blinding layer, welded together by exothermic welds to form a 600 x 600 x 3 mm (4x4 matrix) grid. Tape is to be 30 x 3 mm strip conductor. Earth plates are to be bonded to the buried earthing conductor via exothermic welds.

C. Tape Mats: where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4 m apart, welded together by exothermic welds to form a grid. Tape is to be 25 x 2.5 mm strip conductor.

2.6 MATERIALS AND PRODUCTS

A. Earth Pit: precast, square or circular section concrete handhole (minimum 450 mm internal diameter), with concrete cover, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod where connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth Pit - Do Not Remove'.

B. Testing Joints (Test Links): copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.

C. Earthing Accessories: copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross-section and current carrying capacity. Connectors and clamps are to be bolted type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.

D. Telecommunication Systems Main Earthing Bar: similar to above but with minimum dimensions 100 x 6 mm for the main grounding busbar of the main telecommunication room, and 50 x6 mm for equipment rooms grounding busbars.

E. Disconnecting links shall comprise a high conductivity copper PVC insulated link supported on two insulators mounted on a galvanized steel base for bolting to the supporting structure. The two conductors shall be in direct contact with the link and shall not be disturbed by the removal of the link. Links for mounting at ground level shall be mounted on bolts embedded in a concrete base.

F. Disconnecting links mounted at ground level and the connections at the earth rods shall be enclosed in concrete inspection pits, with concrete lids, installed flush with the ground level.

2.7 GENERAL REQUIREMENTS

A. Component Parts of earthing system are to include the following:

1. Earth electrode (rods, tapes etc.)
2. Main earthing terminals or bars
3. Earthing conductors
4. Protective conductors
5. Equipotential bonding conductors
6. Electrically independent earth electrodes for special systems
7. Accessories and termination fittings, bonding, welding kits and other materials.

B. Design Calculations:
1. The design of the earth electrode systems shall be based on the approved earth resistivity data and the system's fault currents and their duration.
2. The design calculations shall be submitted to the approval of the Engineer and shall be based on the methods given in the standards listed.
3. The calculations shall include the following parameters:
   a. Earth resistance of the whole system and its components.
   b. Earth potential rise.
   c. Step, touch and mesh potentials inside and outside the perimeter fence.
   d. Requirements for a high resistance surface layer.
   e. Conductor ratings.
   f. Step, touch and mesh potentials shall be within the limits calculated in accordance with the standards given in IEEE 80 and BS 7430 for the proposed surface layer. The formula for allowable body current shall be used for 50 Kg body weight.

C. Earth Electrode is to consist of one or more earth rods/lattices, interconnected by buried earthing tape or cable, which is to have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, not exceeding 5 ohms. Distance between two rods is not to be less than twice the length of one rod driven depth.

D. Ring Type Earth Electrode is to consist of earthing conductors, in a closed loop, buried in exterior wall foundations underneath the water-proofing, or alternatively at 0.6 m around the perimeter of the building foundations, or, as shown on the Drawings, to which all earthing conductors are to be connected. Insulated connection flags into the building, of same material as earthing conductors, are to be located at positions of service entrance and main switchboard rooms, terminating in bolt-type earth points (studs) or test- links for connection of main earth bar(s). Additional earth rods/lattices connecting with the earth ring are to be provided, as necessary, to bring down earth electrode resistance to an acceptable value.

E. Alternative Earth Electrode: provide other types of earth electrode that may be used, after approval, including:

1. Cast iron pipes with special surround material
2. Copper plate(s)
3. Tape mats (strips).

F. Main Earthing Bar provide at point of service entrance or main distribution room, and as described in the Specification or shown on the Drawings, to which all earthing conductors, protective conductors and bonding conductors are to be connected. Two insulated main earthing conductors are to be provided, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 120 mm2 or as otherwise required by the particular Section of the Specification.

G. Testing Joints (Test Links) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar and earth electrode.

H. Protective Conductors are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes. Selection of sizes is to be in accordance with IEC.

I. Protective Conductors are not to be formed by conduit, trunking, ducting or the like. Where armoured cable is specified and armour is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.

J. Continuity of Protective Conductors: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/or brazing to continuous protective conductors which are to be insulated by moulded materials.

K. Identification: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labelled in accordance with the Regulations, as follows:

L. Identification: protective and earthing conductors are to be identified by green color of insulation or by painting bar conductors with this color, as approved.

M. Identification: source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labelled 'neutral earthing'.

N. Functional Earth Electrode provide separately from, but interconnected to, other earth electrode(s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.

O. Ensure by calculation that Earth Fault Loop Impedance values for final circuits are to satisfy the requirements of BS 7671 regulations.

P. Earth Fault Loop Impedance: For final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on over-current occurs within 0.4 seconds. For final circuits supplying only fixed equipment, earth fault loop

impedance at every point of utilization is to be such that disconnection occurs within 1 second. Use appropriate tables and present same for approval by the Engineer.

Q. Supplementary Equipotential Bonding: Connect all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armor to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor shall not be less than half of the protective conductor connected to respective earthing terminal with a minimum of 4-mm2.
   1. Individual components of metallic structures of plant shall be bonded to adjacent components to form an electrically continuous metallic path to the bonding conductor.
   2. Small electrically isolated metallic components mounted on non-conducting building fabric need not be bonded to the main earth bar.
   3. Bolted joints in metallic structures including pipework, which do not provide direct metallic contact shall be bridged by a bonding conductor or both sides of the joint shall be separately bonded to earth unless the joint is intended to be an insulated joint for cathodic protection or other purposes.

R. Main Equipotential Bonding: Main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premise side of the meter. Cross-sections of conductors are not to be less than half that of the earthing conductor connected thereto, and minimum 6 mm2.

S. Exposed external earth / grounding conductor connection joints are to be protected from corrosion with grease caps or bituminous tape or approved equal.

T. In general earthing conductor connections to structures, connections within the lightning protection system conductors, are to be exothermic copperweld type unless stated otherwise.

U. Ground wires for equipment receptacles for noncurrent carrying hardware, installed in conduit must be soft drawn copper, in accordance with ASTM B 3, stranded, with green insulation.

V. Grounding and bonding fasteners and connectors must conform to the requirements of UL 467, and Section 26 27 26 “WIRING DEVICES”.

W. Grounding and bonding fasteners must be copper.

X. Bonding straps and jumpers for shock-mounted devices with pivot, hinged & swivel joints must be made of flat tinned-copper woven-wire braid flexible stranded wire.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with IEC62305 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are (50 mm) below finished floor or final grade unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2. Use exothermic welds for all below-grade connections.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

G. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   2. Make connections with clean, bare metal at points of contact.
   3. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
   4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

H. Continuity: ensure that complete earthing system is electrically continuous and mechanically secure.

I. Earth Rods: while siting earth rods, ensure that resistance areas associated with individual rods do not overlap. Earth rods are to be located at a distance greater than 600 mm from foundations of buildings. Where rock is encountered, a hole of sufficient size is to be drilled before lowering the rod. Marconite or equal filler that will not corrode is to be provided around the rod.

J. Buried Earthing Conductors are to be laid at a depth not less than 0.8 m from ground surface.

K. Earthing Conductors are to follow shortest path between earth rods and main earthing terminals or bars, and are to run in PVC conduit (duct) fastened to building structure by approved supports and extending 0.2 m above level, and are to be protected against mechanical damage and corrosion.

L. Protective Conductors: separate protective conductors, which are not part of a cable, are to be fixed on same support or drawn into same conduit as circuit conductors.

M. Protective Bonding: remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.

N. Protection Against Corrosion: protect bolted connections against corrosion either by filling with vaseline or coating with a special anti-corrosion compound and proper capping.

O. Connections: earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.

P. Connections: where earth connections between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound, or by wrapping with protective tape to exclude moisture.

3.2 EQUIPMENT GROUNDING

A. EARTHING OF MAIN DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES

1. Main Earthing Bar is to be provided in main distribution room and connected to earth electrode by two insulated conductors (minimum 120 mm2) via testing joints.
2. Earthing Bars Of Main Distribution Boards are to be connected, by bare earthing conductor, directly to main earthing bar at main distribution room and by protective conductor run with incoming feeder from respective supply point.
3. Distribution, Lighting And Power Panelboards are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main distribution board earthing bar.
4. Socket Outlets are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.

5. Final Ring Subcircuits: protective conductor of every final ring sub-circuit is to be in the form of a ring having both ends connected to earth terminal at origin of circuit in panelboard.
6. Lighting Fixtures And Other Exposed Conductive Parts of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panelboards.

B. GENERATOR PLANT EARTHING

1. Generator Neutral (Star Point) is to be connected by insulated earthing conductor through the neutral earthing link or device to main earthing bar. Neutral earthing conductor is to be suitably sized to carry maximum earth fault current for time it takes the system protection to operate with final conductor temperature not exceeding 160 deg. C, but not less than 30 mm2 per 100 kVA of generator rating, with a minimum of 50 mm2.
2. Generator Earthing Terminal is to be connected to main earthing bar by bare copper conductor of cross section not less than 20 mm2 per 100 kVA of generator size, with a minimum of 35 mm2.
3. Switchgear (ATS) And Control Gear: earthing terminals or bars of switchgear and control gear are to be connected by separate protective conductors to respective normal and emergency main distribution board earth bars.
4. Extraneous Conductive Parts including steel frames, battery racks, day-tank, pumps and piping are to be connected by bare copper earthing conductors to main earth bar in compliance with bonding regulations.

C. TRANSFORMER SUBSTATION EARTHING

1. Medium Voltage (MV) switchgear is to have a separate main earthing bar connected to MV switchgear room earth bar by two insulated earthing conductors not less than 120 mm2 or as required by SEC, unless otherwise shown on drawings.
2. LV switchgear (main distribution board) is to have separate main earthing bar connected to LV room earth bar by two insulated earthing conductors not less than 50 mm2, unless otherwise shown on drawings.
3. Transformer room is to have a separate MV main earthing bar, to which the transformer earthing terminal is to be connected by insulated copper earthing conductor not less than 120 mm2, unless otherwise shown on drawings.
4. Transformer neutral (star point) is to be connected by insulated earthing conductor (color black) to transformer room MV main earthing bar. Neutral earthing conductor is to be sized for maximum earth fault current for 1 second with final conductor temperature not exceeding 160 deg. C or sized not less than 120 mm2 for transformer ratings below 500 kVA and 240 mm2 for higher ratings unless otherwise indicated on drawings.
5. Lightning arresters are to be directly connected to common earthing termination network, following the shortest path as shown on drawings.

D. MECHANICAL PLANT ROOMS AND FIXED MACHINERY

1. Main Earthing Bar Or Loop is to be conveniently located in mechanical plant rooms, and connected by earthing conductors to exposed conductive parts of motor control centre at its earthing bar, and to motors, switches and other electrical equipment etc. at their earthing terminals, using 20 x 2 mm bare copper strips or 35 mm2 bare copper conductor (minimum size) or as required to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200 deg. C. Conductors are to be securely

fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.

2.

3. Main Earthing Bar Or Loop is to be connected at two extremely separate points to earth electrode, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.

4.

5. Motor And Other Equipment Earth Terminals are to be connected also by protective earth conductors of each branch circuit to earth terminal/bar at motor control centre, panel or distribution unit.

3.3 CLEAN EARTH GROUNDING

1. Clean earth grounding or low noise earth shall be provided as required, to ensure that the level of induced or conducted interference from external sources, including the facility power grounding system, does not produce incidence of malfunction of the equipment, which is unacceptable for the operating system.
2. Clean earth grounding system shall not be connected to any other earthing or grounding system.
3. Clean earth grounding cables shall not be run parallel with other grounding cables or power cables.
4. Clean earth grounding system shall comply with IEC 60950 and BS EN 50310.
5. Clean earth grounding pits shall be separated from other earthing pits by a distance of at least 1800mm.
6. In general clean earth grounding shall be provided for data system, telephony and other communication systems, unless otherwise recommended and required by systems providers.
7. Clean earth grounds shall have an earth impedance of less than 1 ohm unless otherwise indicated.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal. Make tests at ground rods before any conductors are connected.
4. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
5. Electrical Continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.
6. Earth Fault Loop Impedance of all circuits is to be measured and checked against calculated impedance figures.
7. Operation of residual current protective devices is to be checked.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Support, anchorage, and attachment components.
2. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. Fischer
2. Hilti
3. OBO Bettermann

B. Source Limitations: Obtain components and accessories from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design hanger and support system.

B. Surface-Burning Characteristics:

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.3 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 10 mm diameter holes at a maximum of 200 mm on center in at least one surface.
1. Material for Channel, Fittings, and Accessories: Galvanized steel.
2. Channel Width: Selected for applicable load criteria.
3. Metallic Coatings: Hot-dip galvanized after fabrication.

B. Conduit and Cable Support Devices: galvanized steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.

D. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325M.
6. Toggle Bolts: All steel springhead type.
7. Hanger Rods: Threaded steel.

2.4 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
1. NECA NEIS 101
2. NECA NEIS 105.

B. Comply with requirements in Section 078400 "Penetration Fire stopping" for fire stopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."

D. Provide seismic controls with hangers and supports in accordance with requirements specified in "Section 260548.16 "Seismic Controls for Electrical Systems."

E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC to be based on calculation and submitted to the Engineer for approval. Minimum rod size must be 6 mm in diameter.

F. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 INSTALLATION OF SUPPORTS

A. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus 90 kg.

B. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 100 mm thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 100 mm thick.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

C. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Submit welding certificates.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 100 mm larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 20.7 MPa, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup:

1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting.

a. Apply paint by brush or spray to provide minimum dry film thickness of 0.05 mm.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint.

END OF SECTION 260529

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Type EMT-S raceways and elbows.
2. Type ERMC-S raceways, elbows, couplings, and nipples.
3. Type FMT raceways.
4. Type IMC raceways.
5. Type LFMC raceways.
6. Type rigid UPVC raceways and fittings.
7. Type flexible UPVC raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Threaded metal joint compound.
10. Solvent cements.
11. Surface metal raceways and fittings.
12. Surface nonmetallic raceways.
13. Strut-type channel raceways and fittings.
14. Wireways and auxiliary gutters.
15. Underfloor truncking
16. Metallic outlet boxes, device boxes, rings, and covers.
17. Nonmetallic outlet boxes, device boxes, rings, and covers.
18. Termination boxes.
19. Hoods for outlet boxes.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Wireways and auxiliary gutters.
2. Surface metal raceways.
3. Surface nonmetallic raceways.
4. Floor boxes.
5. Cabinets, cutout boxes, and miscellaneous enclosures.

B. Sustainable Design Submittals:

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details. Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness at location where boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.

D. Samples: For wireways, nonmetallic wireways, surface raceways, and floor boxes for colors and textures specified, 300 mm long.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. Adaptaflex
2. Al Fanar
3. Barton
4. Clipsal
5. EGA Tube
6. G.E.C.
7. Legrand
8. MK
9. OBO Bettermann
10. O.Z/Gedney
11. Thomas & Betts (Steel City)

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

2.2 TYPE EMT-S RACEWAYS AND ELBOWS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 797 and UL Category Control Number FJMX.

B. Steel Electrical Metal Tubing (EMT-S) and Elbows:
1. Material: Steel.
2. Options:

a. Exterior Coating: Zinc.
b. Interior Coating: Zinc.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
d. Colors: As indicated on Drawings.

2.3 TYPE ERMC-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. BS 4568 Part 1 and BS 31 Class B (threaded), with class 4 protection for rigid steel conduit, zinc coated inside and outside by hot-dip process.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use Or IEC 61386-1, BS EN 50086-1.
2. Exterior Coating: Zinc.
3. Options:

a. Interior Coating: Zinc.
b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.4 TYPE FMT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1652 and UL Category Control Number ILJW or BS EN 50086-1.

B. Steel Flexible Metallic Tubing (FMT):
1. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Colors: As indicated on Drawings.

2.5 TYPE IMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1242 and UL Category Control Number DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):
1. Options:

a. Exterior Coating: Zinc.
b. Interior Coating: Zinc.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
d. Colors: As indicated on Drawings.

2.6 TYPE LFMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 360 and UL Category Control Number DXHR.

B. Steel Liquidtight Flexible Metal Conduit (LFMC-S):
1. Material: Steel.
2. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Colors: As indicated on Drawings.

C. Stainless Steel Liquidtight Flexible Metal Conduit (LFMC-SS):
1. Material: Stainless steel.
2. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Colors: As indicated on Drawings.

2.7 TYPE RIGID UPVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: CEE 26, BS 4607 and BS EN 50086-1, IEC 61386-1, IEC 61386-21, DIN 49016 or other equal and approved standards conforming to IEC 60423.
2. General Characteristics: Rigid Heavy Gauge UPVC.
3. Options:

a. Minimum Trade Size: Metric designator 20 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

2.8 TYPE FLEXIBLE UPVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: CEE 26, BS 4607 and BS EN 50086-1, IEC 61386-1, IEC 61386-21, DIN 49016 or other equal and approved standards conforming to IEC 60423.
2. General Characteristics: Non-corrugated Flexible UPVC and Corrugated Flexible UPVC.
3. Options:

a. Minimum Trade Size: Metric designator 20 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

2.9 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use or in accordance with IEC or BS EN 50086-1.

B. Fittings for Type ERMC and Type IMC:
   1. General Characteristics: UL 514B and UL Category Control Number DWTT or BS EN 50086-1.
   2. Options:

      a. Material: Steel.
      b. Coupling Method: Compression coupling.
      c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203 or BS EN equivalent.
      d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper or BS EN equivalent.

C. Fittings for Type EMT Raceways:
   1. General Characteristics: UL 514B and UL Category Control Number FKAV.
   2. Options:

      a. Material: Steel.
      b. Coupling Method: Compression coupling.
      c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203 or BS EN equivalent.
      d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper or BS EN equivalent.

2.10 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use or in accordance with BS EN.

2.11 SOLVENT CEMENTS

A. Performance Criteria:

   1. Regulatory Requirements: Listed and labeled in accordance with IEC and marked for intended location and use.
   2. General Characteristics: As recommended by conduit.
   3. Sustainability Characteristics:

B. Solvent Cements for Type PVC Raceways and Fittings:

2.12 SURFACE NONMETALLIC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Marked for intended location and use in accordance with IEC or BS EN..

B. Surface Nonmetallic Raceways and Fittings with Nonmetallic Covers:
1. Options:

a. Provide texture and color selected by Architect from manufacturer's standard colors.
b. Wiring Channels: Single, Dual or more as indicated on drawings. Multiple channels must be capable of housing a standard device flush within the raceway.

C. Surface Nonmetallic Raceways and Fittings with Metallic Covers:
1. Options:

a. Manufacturer's standard enamel finish in color selected by Architect.
b. Wiring Channels: Single, Dual or more as indicated on drawings.

2.13 STRUT-TYPE CHANNEL RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use or in accordance with BS EN.
2. General Characteristics: UL 5B and UL Category Control Number RIUU or BS EN.

B. Strut-Type Channel Raceways and Fittings with Metallic Covers:
1. Options:

a. Manufacturer's standard enamel finish in color selected by Architect.

C. Strut-Type Channel Raceways and Fittings with Nonmetallic Covers:
1. Additional Characteristics: self-extinguishing characteristics.
2. Options:

a. Provide texture and color selected by Architect from manufacturer's standard colors.

2.14 WIREWAYS AND AUXILIARY GUTTERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use or in accordance with IEC or BS EN.
2. General Characteristics:

a. UL 870 and UL Category Control Number ZOYX. Or,
b. Metallic Type: To BS EN 50085-1 and BS EN 50085-2-1, BS EN ISO 1461 for galvanization.
c. Nonmetallic Type: To BS 4678.

B. Metal Wireways and Auxiliary Gutters:
1. Additional Characteristics:

a. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
b. Finish: Manufacturer's standard enamel finish.

2. Options:

a. Degree of Protection: IP21 for indoor, IP65 for outdoor.
b. Wireway Covers: Flanged-and-gasketed type unless otherwise indicated.

C. Nonmetallic Wireways and Auxiliary Gutters:
1. Additional Characteristics:

a. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings must match and mate with wireways as required for complete system.
b. PVC Solvents and Adhesives: As recommended by wireway manufacturer.

2. Sustainability Characteristics:
3. Options:

a. Material:

1) Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover must be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections must be flanged and have stainless steel screws and oil-resistant gaskets.
2) PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

2.15 UNDERFLOOR TRUNKING

A. Type: For installation in floor screed, laid on unfinished concrete floor, secured and grouted flush with screed.

B. Material: 3.3 m lengths of 2 mm thick (14 gauge) galvanized sheet steel, protected by corrosion resistant coating on inside and outside surfaces. Single, double or triple systems, as required, Dimensions are to be as required. Covers to be minimum 3 mm thick. Galvanizing to be at least 270 gms/m2.

C. Openings: Ducts are to have 32 mm openings spaced at 600 mm with screw plugs for receiving initial or future installation of outlet boxes. Screw plugs are to be replaced by brass ferrules, inserted and securely fastened by crimping tool, for installation of pedestal type outlet boxes.

D. Fittings: Ducts are to be supplied with approved standard manufacturer's fittings, couplings, adjustable duct supports, duct to conduit adapters, horizontal 45 and 90 degree bends, vertical

90 degree bends, terminal bushings to cabinets, cross-unders, offsets, plugs, ferrules and complete set of tools for installation and maintenance after installation.

E. Junction Boxes: Flush, cast iron, or galvanized sheet steel or die-cast metal protected by corrosion resistant coating and suitable for double or triple duct systems, as required. Openings are to be provided for ducts and conduits. Interior of boxes is to be partitioned for two or three services; completely isolating each duct system and providing straight cross-junctions. Leveling and anchoring of boxes is to be by adjusting screws at four corners. Flush cover plates are to form smooth surface with flooring.

F. Flush Outlet Boxes: Factory designed, with accessories necessary to accommodate specific outlets or cable outlets as required for signal or control services, with cordgrip nipples.

G. Supports are to be capable of adjustment for height and arranged for maintenance of alignment and spacing of raceways during concreting.

H. Recessed Service Fittings: Modular fittings that match with preset inserts and include covers/ receptacles, outlets and associated device plates to provide service indicated at each location. Covers are to be flush with floor and have a recess to match floor finish and level with the area. Boxes' covers are to be firmly held in place and non-rocking. Coordinate with architectural designs and materials approved for finishes and for electrical devices. Internally mounted receptacle / outlets are to be as required.

2.16 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use or in accordance with BS EN.

B. Metallic Outlet Boxes:

1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
2. Options:

    a. Material: Sheet steel.
    b. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing up to 23 kg and marked with maximum allowable weight.
    c. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 32 kg.

C. Metallic Conduit Bodies:

1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point.

D. Metallic Device Boxes:

1. Description: Box with provisions for mounting wiring device directly to box.
2. Options:

a. Material: Sheet steel.

E. Metallic Extension Rings:

1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

F. Metallic Floor Boxes and Floor Box Covers:

1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

G. Metallic Raised-Floor Boxes and Floor Box Covers:

1. Description: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.

H. Metallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

1. Description: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

I. Metallic Concrete Boxes and Covers:

1. Description: Box intended for use in poured concrete.

2.17 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use or in accordance with IEC or BS EN.
2. General Characteristics:
   a. UL 514C and UL Category Control Number QCMZ. Or,
   b. IEC or BS EN.

B. Nonmetallic Outlet Boxes:

1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.

C. Nonmetallic Conduit Bodies:

1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point.

D. Nonmetallic Device Boxes:

1. Description: Box with provisions for mounting wiring device directly to box.

E. Nonmetallic Extension Rings:

1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

F. Nonmetallic Floor Boxes and Floor Box Covers:

1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

G. Nonmetallic Raised-Floor Boxes and Floor Box Covers:

1. Description: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.

H. Nonmetallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

1. Description: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

I. Nonmetallic Floor Nozzles:

1. Description: Enclosure intended primarily as housing for receptacle, provided with means, such as collar, for surface-mounting on floor, which may or may not include stem to support it above floor level, and is sealed against the entrance of scrub water at floor level.

J. Nonmetallic Concrete Boxes and Covers:

1. Description: Box intended for use in poured concrete.

2.18 TERMINATION BOXES

A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.

B. Termination Boxes and Termination Bases for Installation on Line Side of Service Equipment:
1. Additional Characteristics: Listed and labeled for installation on line side of service equipment.

C. Termination Boxes and Termination Bases for Installation on Load Side of Service Equipment:

1. Additional Characteristics: Listed and labeled for installation on load side of service equipment.

2.19 CABINETS, CUTOUT BOXES, JUNCTION BOXES, PULL BOXES, AND MISCELLANEOUS ENCLOSURES

A. Recessed and Concealed Boxes: Galvanized pressed steel, with knock-outs for easy field installation. Special boxes are to be punched as required on Site.

B. Exposed Surface Mounted Boxes: Galvanized cast iron with threaded hubs.

C. Outdoor Surface or Recessed Boxes: Galvanized cast iron with threaded hubs and PVC gaskets to ensure water tightness and with stainless steel or non-ferrous, corrosion resistant screws.

D. Floor Boxes - Type A: Watertight, cast iron or cast metal alloy with corrosion resistant finish, adjustable mounting, standard duty, round or square, factory drilled and tapped for required conduit sizes, and with brass cover and flange with brushed finish free from markings other than required for mounting screws.

E. Floor Boxes - Type B: non-standard size, flush floor mounted, cast metal alloy, with watertight neoprene gasket and hinged cover for each service. Box to be ready with factory drilled and tapped conduit entries and adjustable mounting fittings. Metal barriers are to separate services for power and low current.

A. Flame-Proof Boxes: Malleable iron or cast iron, with gas threaded hubs, special covers with silicon rubber gaskets, gas tight, and water-tight. Boxes are to comply with the Regulations for explosive areas.

2.20 HOODS FOR OUTLET BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:

    a. Reference Standards:

        1) UL 514D and UL Category Control Numbers QCIT and QCMZ.
        2) Receptacle, hood, cover plate, gaskets, and seals comply with UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.

    b. Mounts to box using fasteners different from wiring device.

B. Retractable or Reattachable Hoods for Outlet Boxes:
1. Options:

    a. Provides weatherproof, "while-in-use" cover.

C. Extra-Duty, While-in-Use Hoods for Outlet Boxes:
   1. Additional Characteristics: Marked "Extra-Duty" in accordance with UL 514D.
   2. Options:

      a. Provides weatherproof, "while-in-use" cover.
      b. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 - EXECUTION

3.1 SELECTION OF RACEWAYS

The specified products for raceways, boxes, and cabinets shall be used as suitable to the environment. Follow the Bill of Quantities.

3.2 INSTALLATION OF RACEWAYS

A. Installation Standards:
   1. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
   2. Install raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
   3. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts.
   4. Raceway Terminations at Locations Subject to Moisture or Vibration:

      a. Provide insulating bushings to protect conductors, including conductors smaller than 25s.q.mm.

B. General Requirements for Installation of Raceways:

   1. Complete raceway installation before starting conductor installation.
   2. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 0.6 m above finished floor.
   3. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 300 mm of changes in direction.
   4. Make bends in raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with IEC minimum radii requirements. Provide only equipment specifically designed for material and size involved.
   5. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
   6. Support conduit within 300 mm of enclosures to which attached.

7. Install raceway sealing fittings at accessible locations in accordance with IEC and fill them with listed sealing compound. For concealed raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings in accordance with IEC.
8. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of raceways at the following points:

    a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
    b. Where an underground service raceway enters a building or structure.
    c. Conduit extending from interior to exterior of building.
    d. Conduit extending into pressurized duct and equipment.
    e. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

9. Do not install raceways or electrical items on "explosion-relief" walls or rotating equipment.
10. Do not install conduits within 50 mm of the bottom side of a metal deck roof.
11. Keep raceways at least 150 mm away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
12. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
13. Install pull wires in empty raceways. Provide polypropylene or monofilament plastic line with not less than 90 kg tensile strength. Leave at least 300 mm of slack at both ends of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

C. Requirements for Installation of Specific Raceway Types:

1. Types ERMC and IMC:

    a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

2. Types FMC and LFMC:

    a. Provide a maximum of 915 mm of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

D. Raceways Embedded in Slabs:

1. Run raceways larger than metric designator 27 (trade size 1) parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place raceway close to slab support. Secure raceways to reinforcement at maximum 3 m intervals.
2. Arrange raceways to cross building expansion joints with expansion fittings at right angles to the joint.

3. Arrange raceways to ensure that each is surrounded by a minimum of 25 mm of concrete without voids.
4. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.

E. Stub-ups to Above Recessed Ceilings:

1. Provide EMT, IMC, or ERMC for raceways.
2. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

F. Raceway Fittings:
1. EMT: Provide compression, steel fittings.
2. Flexible Conduit: Provide only fittings listed for use with flexible conduit type.

G. Expansion-Joint Fittings:

1. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 17 deg C and that have straight-run length that exceeds 7.6 m. Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 55 deg C and that have straight-run length that exceeds 30 m.
2. Install type and quantity of fittings that accommodate temperature change listed for the following locations:

   a. Outdoor Locations Not Exposed to Direct Sunlight: 70 deg C temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 86 deg C temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 70 deg C.
   d. Attics75 deg C temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.06 mm per meter of length of straight run per deg C of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.0115 mm per meter of length of straight run per deg C of temperature change for metal conduits.
4. Install expansion fittings at locations where conduits cross building or structure expansion joints.
5. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

H. Raceways Penetrating Rooms or Walls with Acoustical Requirements:

1. Seal raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

3.3 INSTALLATION OF SURFACE RACEWAYS

A. Install surface raceways only where indicated on Drawings.

B. Install surface raceway with a minimum 50 mm radius control at bend points.

C. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 1200 mm and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's written instructions. Tape and glue are unacceptable support methods.

3.4 INSTALLATION OF BOXES AND ENCLOSURES

A. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.

B. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

C. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.

D. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

E. Locate boxes so that cover or plate will not span different building finishes.

F. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.

G. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.

H. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.

I. Set metal floor boxes level and flush with finished floor surface.

J. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

K. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.

L. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.

M. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:

1. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
2. Provide gaskets for wallplates and covers.

3.5 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078400 "Penetration Firestopping."

3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.7 CLEANING

A. Boxes: Remove construction dust and debris from device boxes, outlet boxes, and floor-mounted enclosures before installing wallplates, covers, and hoods.

END OF SECTION 260533

SECTION 260536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ladder cable tray.
2. Wire-mesh cable tray.
3. Solid-bottom cable tray.
4. Cable tray accessories.
5. Warning signs.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

a. Vertical and horizontal offsets and transitions.
b. Clearances for access above and to sides of cable trays.
c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Delegated Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer who is licensed in the state where Project is located and who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   1. Legrand
   2. MK
   3. OBO Bettermann
   4. Swift
   5. Thomas & Betts
   6. Unitech
   7. Wibe

B. Source Limitations: Obtain components and accessories from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design cable tray supports and seismic bracing.

2.3 GENERAL REQUIREMENTS FOR CABLE TRAY

A. Cable Trays and Accessories: Identified and marked for intended location, application, and grounding.

   1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: Refer to Drawings for specific requirements for types, materials, sizes, and configurations.

C. Cable trays shall be of very heavy duty of minimum thickness shall be 2mm with height of 10cm

D. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:

   1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
   2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
   3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.4 LADDER CABLE TRAY

A. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: 150 mm, 300 mm, 400 mm, 600 mm,900 mm unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 75 mm.
4. Straight Section Lengths: 3.0 m, except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: 300 mm on center.
6. Radius-Fitting Rung Spacing: 225 mm at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 22 mm width with radius edges.
8. No portion of the rungs must protrude below the bottom plane of side rails.
9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 90 kg concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: 300 mm.
11. Splicing Assemblies: Bolted type using serrated flange locknuts.
12. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
13. Covers: Ventilated-hat type made of same materials and with same finishes as cable tray.

B. Materials and Finishes:

1. Steel:

   a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M.
   b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
   c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
   d. Finish:

      1) Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2, with galvanized, ASTM B633 hardware.

2.5 WIRE-MESH CABLE TRAY

A. Description:

1. Configuration: Galvanized-steel wire mesh, complying with NEMA VE 1.
2. Width: 50 mm, 100 mm, 150 mm, 200 mm, 300 mm, 400 mm, 500 mm, 600 mm, 900mm, unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 50 mm.
4. Straight Section Lengths: 3.0 m, except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 90 kg concentrated load, when tested according to NEMA VE 1.

6. Splicing Assemblies: Bolted type using serrated flange locknuts.
7. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.

B. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish:

1) Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2, with galvanized, ASTM B633 hardware.

2.6 SOLID-BOTTOM CABLE TRAY

A. Description:

1. Configuration: Two longitudinal side rails with a nonventilated continuous bottom.
2. Width: 150 mm, 225 mm, 300 mm, 450 mm, 600 mm, 750 mm, 900 mm unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 75 mm.
4. Straight Section Lengths: 3.0 m, except where shorter lengths are required to facilitate tray assembly.
5. No portion of the continuous bottom must protrude below the bottom plane of side rails.
6. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 90 kg concentrated load, when tested according to NEMA VE 1.
7. Fitting Minimum Radius: 300 mm.
8. Splicing Assemblies: Bolted type using serrated flange locknuts.
9. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
10. Covers: Solid type made of same materials and with same finishes as cable tray.

B. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish:

1) Mill galvanized before fabrication complying with ASTM A653/A653M, G90 (Z275), with galvanized, ASTM B633 hardware.

2.7 CHANNEL CABLE TRAY

A. Description:

1. Configuration: Single, formed sheet with a ventilated bearing surface, complying with NEMA VE 1.
2. Width: 75 mm, 100 mm, 150 mm unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 30 mm.
4. Straight Section Lengths: 3.0 m, except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 90 kg concentrated load, when tested according to NEMA VE 1.
6. Fitting Minimum Radius: 300 mm.
7. Splicing Assemblies: Bolted type using serrated flange locknuts.
8. Splicing Assembly Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
9. Covers: Ventilated-hat type made of same materials and with same finishes as cable tray.

B. Materials and Finishes:

1. Steel:

a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish:

1) Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2, with galvanized, ASTM B633 hardware.

2.8 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.9 WARNING SIGNS

A. Lettering: 40 mm high, black letters on yellow background, with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Comply with Section 260553 "Identification for Electrical Systems."

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays.

PART 3 - EXECUTION

3.1 INSTALLATION OF CABLE TRAY

A. Install cable tray and support systems according to NEMA VE 2.

B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Fasten cable tray supports to building structure and install seismic restraints.

F. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 90 kg. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems. "Comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."

G. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.

H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

I. Support assembly to prevent twisting from eccentric loading.

J. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

K. Do not install more than one cable tray splice between supports.

L. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

M. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps according to applicable standard.

N. Make changes in direction and elevation using manufacturer's recommended fittings.

O. Make cable tray connections using manufacturer's recommended fittings.

P. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078400 "Penetration Firestopping."

Q. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

R. Install cable trays with enough workspace to permit access for installing cables.

S. Install permanent covers and cover clamps, if used, after installing cable.

T. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

U. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to IEC unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Cable trays with electrical power conductors must be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

D. Bond cable trays to power source for cables contained within with bonding conductors sized according to IEC.

3.3 INSTALLATION OF CABLES

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 450 mm.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure must be no more than 1800 mm.

E. Tie mineral-insulated cables down every 900 mm where required to provide a two-hour fire rating and every 1800 mm elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
4. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
6. Check for improperly sized or installed bonding jumpers.
7. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
8. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and must remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 260536

SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Restraints - rigid type.
2. Restraints - cable type.
3. Restraint accessories.
4. Post-installed concrete anchors.
5. Concrete inserts.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.2 COORDINATION

A. Tests and Inspections:

1. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and provide notice at least seven days in advance.
2. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load capacity for each seismic-restraint device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
3. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression.
4. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated Design Submittal, signed and sealed by qualified structural professional engineer, for Each Seismic-Restraint Device:

1. For each seismic-restraint device, including **restraint - rigid and cable type, restraint accessory, and concrete anchor and insert** that is required by this Section or is indicated on Drawings, submit the following:

    a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
    b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
    c. Seismic Design Calculations: Submit input data and loading calculations based on the project seismic parameters.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Welding certificates.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Amber/Booth Company, Inc.
2. Fisher
3. Hilti
4. Loos & Company, Inc.
5. OBO Bettermann
6. Powerstrut.
7. Thomas & Betts Corp.
8. Unistrut Corporation.

B. Source Limitations: Obtain components and accessories from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design seismic control system in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and the project’s seismic parameters.

B. Seismic-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a

nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: **ICC-ES product listing, UL product listing, FM Approvals** or **an agency acceptable to authorities having jurisdiction**.

C. Consequential Damage: Provide additional seismic restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component does not cause failure of any other essential building component.

D. Fire/Smoke Resistance: Seismic-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested and labeled by an NRTL in accordance with ASTM E84 or UL 723.

E. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of an NRTL.

2.3 RESTRAINTS - RIGID TYPE

A. Description: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.4 RESTRAINTS - CABLE TYPE

A. Seismic-Restraint Cables: **ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel** cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

B. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.5 RESTRAINT ACCESSORIES

B. Hanger-Rod Stiffener: **Steel tube or steel slotted-support-system sleeve with internally bolted connections** to hanger rod. Non-metallic stiffeners are unacceptable.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to **rigid channel bracings and restraint cables**.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.6 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
   1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:
   1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in seismic and wind-load applications.
   1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
   2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 7.46 kW that is not vibration isolated.
   1. Undercut expansion anchors are permitted.

2.7 CONCRETE INSERTS

A. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.

B. Comply with MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by **an agency acceptable to authorities having jurisdiction**.

B. Hanger-Rod Stiffeners: Install where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC-RESTRAINT DEVICES

A. Provide seismic-restraint devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind-Load Controls Schedule, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

1. Install equipment and devices to withstand the effects of earthquake motions.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of seismic restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.

D. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 3.2 mm.
2. Install seismic-restraint devices using methods approved by **an agency acceptable to authorities having jurisdiction** that provides required submittals for component.

E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 3.2 mm.
2. Install seismic-restraint devices using methods approved by **an agency acceptable to authorities having jurisdiction** that provides required submittals for component.

F. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 3.2 mm.
2. Install seismic-restraint devices using methods approved by **an agency acceptable to authorities having jurisdiction** providing required submittals for component.

G. Install cables so they do not bend across edges of adjacent equipment or building structure.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Field tests must be witnessed by **Architect**.

B. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Test no fewer than **four** of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 260548.16

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Labels.
2. Bands and tubes.
3. Tapes and stencils.
4. Tags.
5. Signs.
6. Cable ties.
7. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. American Labelmark Co. Calpico, Inc.
2. Emed Co., Inc.
3. Ideal Industries, Inc
4. LEM Products, Inc.

5. Markal Corp.
6. Critchley Ltd.
7. H.F. Codison Ltd.

B. Source Limitations: Obtain components and accessories from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. A.Firms regularly engaged in manufacture of electrical identification products of types required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. IEC Compliance: comply with IEC 113, 117, 391, 445, 446 as applicable to electrical equipment.

C. Compliance: Comply with Local wiring regulations and standards.

2.3 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase-and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

1. Color shall be factory applied or field applied for sizes larger than 10 s.q.mm if authorities having jurisdiction permit.
2. Colors for 230-V Circuits:

    a. Phase A: Red.
    b. Phase B: Yellow.
    c. Phase C: Blue.

3. Color for Neutral: Black
4. Color for Equipment Grounds: Bare copper, Green, Green with a yellow stripe.
5. Colors for Isolated Grounds: Green with two or more yellow stripes.

C. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 915 MM."

F. Equipment Identification Labels:

1. Black letters on a white field.

2.4 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

C. Self-Adhesive Wraparound Labels: Preprinted, 0.08-mm-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels:

a. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 0.08-mm-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Minimum Nominal Size:

a. 37 by 150 mm for raceway and conductors.
b. 76 by 127 mm for equipment.

2.5 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves 50 mm long, with diameters sized to suit diameters and that stay in place by gripping action.

B. H.F. Codison Ltd. (England Heat-Shrink Preprinted Tubes): Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 93 deg C. Comply with UL 224.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 0.08 mm thick by 25 to 50 mm wide; compounded for outdoor use.

E. Tape and Stencil: 100-mm-wide black stripes on 250-mm centers placed diagonally over orange background and are 300 mm wide. Stop stripes at legends.

F. Floor Marking Tape: 50-mm-wide, 0.125-mm pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

G. Underground-Line Warning Tape:

1. Tape:

   a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
   b. Printing on tape shall be permanent and shall not be damaged by burial operations.
   c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:

   a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
   b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE"
   c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE"

3. Tape Type I:

   a. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Width: 75 mm.
   c. Thickness: 0.1 mm.
   d. Weight: 9.0 kg/100 sq. m.
   e. Tensile according to ASTM D882: 133.4 N and 17.2 MPa.

4. Tape Type II:

   a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Width: 75 mm.
   c. Thickness: 0.3 mm.
   d. Weight: 17.6 kg/100 sq. m.
   e. Tensile according to ASTM D882: 1780 N and 79.2 MPa.

5. Tape Type ID:

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 75 mm.
c. Overall Thickness: 0.125 mm.
d. Foil Core Thickness: 0.00889 mm.
e. Weight: 13.7 kg/100 sq. m.
f. Tensile according to ASTM D882: 311.3 N and 31.7 MPa.

6. Tape Type IID:

a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 75 mm.
c. Overall Thickness: 0.2 mm.
d. Foil Core Thickness: 0.00889 mm.
e. Weight: 16.6 kg/100 sq. m.
f. Tensile according to ASTM D882: 1334 N and 86.1 MPa.

H. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 25 mm.

2.6 TAGS

A. Metal Tags: Brass or aluminum, 50 by 50 by 1.3 mm, with stamped legend, punched for use with self-locking cable tie fastener.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.38 mm thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

C. Write-on Tags:

1. Polyester Tags: 0.25 mm thick, with corrosion-resistant grommet and cable tie for attachment.
2. Marker for Tags:

a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
b. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
3. 6.4-mm grommets in corners for mounting.
4. Nominal Size: 180 by 250 mm.

B. Metal-Backed Butyrate Signs:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 1-mm galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
3. 6.4-mm grommets in corners for mounting.
4. Nominal Size: 250 by 360 mm.

C. Laminated Acrylic or Melamine Plastic Signs:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
2. Engraved legend.
3. Thickness:

    a. For signs up to 129 sq. cm, minimum 1.6 mm thick.
    b. For signs larger than 129 sq. cm, 3.2 mm thick.

    c. Engraved legend with white letters on a dark gray background
    d. Punched for mechanical fasteners with 6.4-mm grommets in corners for mounting.
    e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 5 mm.
2. Tensile Strength at 23 Deg C according to ASTM D638: 82.7 MPa.
3. Temperature Range: Minus 40 to plus 85 deg C.
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 5 mm.
2. Tensile Strength at 23 Deg C according to ASTM D638: 82.7 MPa.
3. Temperature Range: Minus 40 to plus 85 deg C.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 5 mm.
2. Tensile Strength at 23 Deg C according to ASTM D638: 48.2 MPa.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 46 to plus 140 deg C.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 10-mm-high letters for emergency instructions at equipment used for power transfer Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

K. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

L. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 13-mm- high letters on 38-mm-high label; where two lines of text are required, use labels 50 mm high.

P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

S. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 150 mm where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

T. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

V. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 150 to 200 mm below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 400 mm overall.

2. Install underground-line warning tape for direct-buried cables and cables in raceways.

W. Metal Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized cable ties.

X. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized cable ties.

Y. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized cable ties.

Z. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 13-mm-high letters on minimum 38-mm-high sign; where two lines of text are required, use signs minimum 50 mm high.

AA. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 13-mm-high letters on 38-mm-high sign; where two lines of text are required, use labels 50 mm-high.

BB. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 13-mm- high letters on 38-mm-high sign; where two lines of text are required, use labels 50 mm-high.

CC. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 75-mm-high, black letters on 500-mm centers.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 3-m maximum intervals.

D. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Vinyl wraparound labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 7.6-m maximum intervals in congested areas.

E. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30A and 120V to Ground: Identify with self-adhesive vinyl tape applied in bands.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 7.6-m maximum intervals in congested areas.

F. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

G. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 7.6-m maximum intervals in congested areas.

H. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

I. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

J. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

K. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

L. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

M. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 300 mm of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

N. Workspace Indication: Apply floor marking tape or tape and stencil to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

O. Instructional Signs: Self-adhesive labels, including the color-code for grounded and ungrounded conductors.

P. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Metal-backed, butyrate warning signs.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Power-transfer switches.
b. Controls with external control power connections.

Q. Operating Instruction Signs: Baked-enamel warning signs.

R. Emergency Operating Instruction Signs: Baked-enamel warning signs with white legend on a red background with minimum 10-mm-high letters for emergency instructions at equipment used for power transfer and load shedding.

S. Equipment Identification Labels:

1. Indoor Equipment: Metal-backed butyrate signs.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Motor-control centers.
j. Enclosed switches.
k. Enclosed circuit breakers.
l. Enclosed controllers.
m. Variable-speed controllers.
n. Push-button stations.
o. Power-transfer equipment.
p. Contactors.
q. Remote-controlled switches, dimmer modules, and control devices.
r. Battery-inverter units.
s. Battery racks.
t. Power-generating units.
u. Monitoring and control equipment.
v. UPS equipment.
w. Fire Alarm master station or control panel.
x. Security Monitoring master station or control panel.

END OF SECTION 260553

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

H. MV: Medium Voltage.

I. LV: Low Voltage.

J. OEM: Original Equipment Manufacturer.

K. MDB: Main Distribution Board.

L. SMDB: Sub-Main Distribution Board.

M. DB/FDB: Final Distribution Board.

N. CB: Circuit Breaker.

O. ACB: Air Circuit Breaker

P. MCCB: Molded-Case Circuit Breaker.

Q. MCB: Miniature Circuit Breaker.

R. RCBO: Residual Current Circuit Breaker with Overcurrent Protection.

S. ELCB: Earth Leakage Circuit Breaker.

T. SPD: Surge Protection Device.

U. SLD: Single Line Diagram.

V. THD: Total Harmonic Distortion.

W. FAT: Factory Acceptance Test.

X. SAT: Site Acceptance Test.

Y. CMS: Circuit Monitoring System.

Z. BMS: Building Management System.

AA. DPM: Digital Power Meter.

BB. Icu: Rated ultimate short circuit breaking capacity.

CC. Ics: Rated service short circuit breaking capacity.

1.4 GENERAL DESCRIPTION

A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for Distribution panel boards (DB), Power Panel board (PP), Lighting, and appliance branch-circuit panel boards (LP).

B. In general installation shall comply with the requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Key interlock scheme drawing and sequence of operations.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. **Submit final versions after load balancing.**

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: **Two** spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: **Two** spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.9 CODES AND STANDARDS

A. The following standards shall apply as a minimum:
1. IEC 61439-1 & IEC61439-2 "Low Voltage Switchgear and Control Gear Assemblies".
2. IEC 61439-3 "Low Voltage Switchgear and Control Gear Assemblies - Distribution boards intended to be operated by ordinary persons (DB)".
3. IEC 60947-1 "Low Voltage switchgear and control Gear- General Rules".
4. IEC 60947-2 "Low Voltage switchgear and control gear - circuit breakers".
5. IEC 60947-3 "Low Voltage switchgear and control gear - Switches, disconnectors, switch- disconnectors and fuse-combination units circuit breakers".
6. IEC 60529: Degrees of protection provided by enclosures.
7. IEC 61140: Protection against electric shocks-common aspects for installation and equipment.
8. IEC 60947-4-1 "Low Voltage switchgear and control gear - Contactors and motor-starters - Electromechanical contactors and motor-starters".
9. IEC 60051-1, IEC 61010-1: Measuring instruments, Direct acting indicating analogue electrical measuring instruments and their Accessories.
10. IEC 60947-5-1, IEC 60947-5-1, IEC- 60536. Indicating lamps, push buttons, switches.
11. IEC 60898-1 "Miniature circuit breakers".
12. IEC 61008: Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)
13. IEC 61009 "Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)".
14. IEC 62262: Mechanical impact strength.
15. Other components where not specified shall comply with the relevant IEC standards.

1.10 QUALITY ASSURANCE

A. Manufacturer Qualifications: Original Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 10 years.

1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.

2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis:

3. Subject to compliance with the specifications and drawings, obtain the whole board equipment such as Enclosures, Components, Bus-bars and other accessories from one single manufacturer:

B. The Assembly Manufacturer (The Panel-builder) of this equipment shall have produced similar electrical equipment for a minimum period of seven (7) years. Local manufacturers shall be approved only if they can meet the presented specifications, and if they can submit an up-to-date assembly certification as per IEC 61 439-1& 2 from the original panel board manufacturer that shall be at list 5 years old. When requested by the engineer, an acceptable list of installations

with similar equipment shall be provided demonstrating compliance with this EN/IEC 61439 or EN/IEC 60439.

C. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing switchboards similar in type and scope to that required for this Project.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards;

B. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.

C. Deliver materials to the Project site in supplier’s or manufacturer’s original wrappings and containers, labeled with supplier’s or manufacturer’s name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.

D. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

E. Deliver in shipping splits of lengths not exceeding 2Lm each split and that can be moved past obstructions in delivery path as indicated.

1.12 WARRANTY

A. Provide complete system warranty in which the Manufacturer and Contractor are jointly and severally liable and agree to repair/replace all defective components of the warranted system. Warranty shall include both material s and workmanship.

B. Warranty period shall be 1 year from the date of the substantial completion of the project.

C. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

D. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: **Five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All enclosures, switching and protection devices such as circuit breakers, switches, and isolators shall originate from a single reputable original equipment manufacturer (OEM). Panel assemblers, only officially authorized by the OEM, shall be acceptable.

B. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   1. ABB
   2. Eaton
   3. Schneider Electric
   4. Siemens

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

2.2 GENERAL REQUIREMENTS

A. SMDB's specified herein refer to LV panels located in the second level of LV distribution, i.e., fed from MDB's and have typical ratings from 160A up to 630A.

B. Rated insulation voltage shall be in accordance with the respective standards.

C. Panelboard shall comply with IEC 61439-1&2 standards. Valid design verification certificates issued by independent third-party accredited laboratories such as DEKRA, KEMA, ASTA, ACAE, or other recognized body shall be provided as per IEC 61439-1&2 for approval.

D. Panelboards shall be totally enclosed, dead front type, and have Form 2 separation as per IEC 61439-1 with ingress protection code IP 42 for indoor installations, IP55 for installations in both wet areas, in accordance with IEC 60529, and shall be factory designed and assembled.

E. Panelboard shall have 415V rated operational voltage, 800V rated insulation voltage, and 6KV rated impulse withstand voltage as per IEC 61439 1-2.

F. Earthing bar shall be half size the phase busbars.

G. Neutral bar shall be sized as the phase bus bars.

H. Protection shall be fully rated throughout the systems.

I. Panelboard shall be fully rated for the maximum prospective short-circuit fault current at its point of installation in the network for a duration of 1 second based on the approved short circuit calculation and coordination study.

J. Series (backup) coordinated protection (integrated equipment short-circuit ratings) will only be acceptable within final branch circuit panelboards, between branch circuit breakers and the main incoming circuit breaker, in accordance with an integrated series combination chart prepared by

the manufacturer, tested and certified in the country of origin by an internationally authorized organization, where short-circuit ratings are beyond available fully rated types specified, and with the approval of Engineer.

K. SMDB manufacturer/assembler shall provide all necessary interfaces, relays, transducers necessary for interface with the BMS as specified in the BMS schedules and/or shown on the project drawings/schedules unless stated otherwise.

L. Door lock shall be standard for all SMDB's.

M. SMDB's shall be able to be monitored and controlled from BMS/SCADA system as per the requirements. Additionally, SMDB MCCB functional units shall be able to communicate through internet/cloud platforms.

N. Circuit breakers shall be non-fused type.

O. Circuit Breaker Arrangement: Panelboards shall have one main incoming circuit breaker or switch and the required number of branch circuit breakers, arranged as shown on the schedules, including spare circuit breakers and spaces for future expansion. Three-phase panelboards shall be designed for sequence phase connection of branch circuit devices.

P. Branch Circuit Numbering: On 3-phase panelboard schedules, circuits 1 and 2 shall be connected to brown (BN) phase, 3 and 4 to black (BK) phase, 5 and 6 to grey (GY) phase etc. to conform with branch circuit numbering shown on the drawings.

2.3 PANELBOARD ENCLOSURES

A. Type: General purpose type, suitable for relevant ambient conditions, wall mounted (flush or surface) or floor mounted as shown on the drawings, comprising box, trim, or trim and door to approved manufacturer's standards and sizes.

B. Construction: Box, trim and doors where required, shall be Electro/hot dip-galvanized sheet steel of gauges not less than specified and in accordance with the standards. Welded joints shall be galvanized after manufacture. Gutter spaces shall conform to the standards, adequate for the utilized cables/wires subject to the Engineers' approval and in no case less than 100 mm on all sides. Enclosure shall have pre-designed angles or threaded end studs to support and adjust mounting of interior panelboard assembly.

C. Panelboard enclosure shall have mechanical impact resistance of IK09 as per IEC 62262. Type test certificates for mechanical impact resistance shall be provided for approval, otherwise enclosure thickness shall be minimum 2 mm.

D. Trims shall cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims shall be fixed to cabinet/box by quarter-turn clamps engaging flange of box (use of screws engaging holes in flange of box is not acceptable). Screws where used shall be oval-head, countersunk and flush. Trims for flush mounted panelboards shall overlap box and front shields by at least 20 mm. Trims for surface mounted panelboards shall be exactly sized to form flush fit to box.

E. Doors shall have concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high shall have vault-type handle and multiple point latch mechanism. Locks shall be keyed alike.

F. Panelboard shall be provided with an internal rigid shrouding to avoid accidental contacts after opening the front door.

G. Finish: Inner and outer surfaces of cabinet/boxes, trims, doors etc. Shall be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, aging and corrosion and of standard gray color RAL7035 otherwise to the approval of Engineer.

H. Directories under glassine, or an approved alternative durable arrangement, shall be provided on inside face of doors, or in metal label holders when trim without doors are specified. Directories shall be typed to identify panelboards and clearly indicate circuit number and description of load.

I. Where single core cables are used, top / bottom cable entry plates shall be made of bakelite or Aluminum with adequate thickness and rigidity to support cables.

2.4 BUSBARS

A. Type: One piece, 98% pure electrolytic copper, tin-plated, based on total maximum operating temperature of 90 deg C at any point of the bus, at full continuous rating. Bolted or clamped contact surfaces shall be properly tin or silver plated as necessary, and shall have maximum current density not exceeding requirements of the approved standards. Aluminum shall not be used for busbars or panelboard parts.

B. Design: Busbars shall be rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Interiors shall be factory assembled into a unit. Busing shall be full size without reduction. Busing and blank plates shall allow installation of future circuit devices, where indicated on the drawings.

C. Main horizontal busbars and vertical distribution busbars shall be insulated unless bare busbars are recommended by the manufacturer and used in the type test.

D. Split Bus: Vertical buses divided into individual vertical sections.

E. Rating: Busbar rating shall be at least equal to main-circuit breaker frame size. Where no main circuit breaker is required, busbars shall have main lugs or disconnect switch, with nominal rating equal to 1.25 times the upstream circuit breaker trip rating, and as shown on the drawings.

F. Terminals and connections shall be anti-turn, solder-less screw-pressure type. Screws and bolts used for making copper/copper connections shall be hard copper alloy with lock washers (riveted bus connections are not acceptable).

G. Neutral bar shall be solid and fully insulated from cabinet or box. One solder-less box type set-screw connector shall be provided for neutral wire of each branch circuit and one bolted clamp-

type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral shall be fully sized and rated as for phase busbars.

H. Earthing bar shall be copper, brazed to panelboard cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

2.5 MOLDED CASE CIRCUIT BREAKERS (MCCBs)

A. Constructed and tested in accordance with IEC 60947 family of standards.

B. Type: Tested to approved standards, Current limiting type up to 1000A, totally enclosed, molded case, constructed from high quality, high temperature resistant, molded insulating materials, for normal operation at maximum temperature within enclosures at point of application, and provided with front operated single toggle type handle mechanism for manual operation of main contacts in addition to automatic operation under over-current conditions. Multi-pole breakers shall have common integral trip bar for simultaneous operation of all poles. Ampere rating shall be clearly visible. All terminals shall be box lug or clamp type with set screws, suitable for copper or aluminum conductors.

C. MCCBs shall be 160 A minimum frame size.

D. Circuit Breaker Trip Units: Unless otherwise specified or shown on the drawings, moulded case circuit breakers of final branch circuit panel boards (DBOs) shall be thermal magnetic type.

E. Thermal magnetic circuit breaker trip units: shall have adjustable bi-metallic inverse time delay over-current element for small overloads and adjustable instantaneous magnetic over-current trip element for operation under short-circuit conditions on each pole.

F. Deration: Thermal and Electronic over-current trips shall be ambient temperature derated at specified ambient conditions and corresponding temperature within the enclosures. MCCB shall not be derated if the space where the panels are installed is air-conditioned.

G. Electronic trips units, applicable to circuit breakers 250 A and larger, shall be solid state equipped with color touch screen display for easy navigation, and with long time delay settings between 0.5 and 1.0 times maximum trip rating, short time delay range of 3 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units shall be insensitive to changes in ambient temperature between -20 and +55 deg C. Earth fault protection shall be built into trip unit where specified, and shall be suitable for connection to external current sensor. Push-to-trip button shall be provided on cover for testing the trip unit.

H. Electronic trip unit shall be smart and able to be upgraded at any time with advanced measurements & protection functions using the embedded low energy blue-tooth connection and without changing the existing trip unit.

I. Electronic trip unit shall be equipped with integrated communication module without the need of any external devices or gateways to support one or more of the common communication protocols (Modbus TCP/IP, Modbus RTU, Profibus, Device Net, Profinet, IEC61850, Ethernet/IP) with the ability to use two communication protocols simultaneously.

J. Electronic trip units shall be capable of incorporating one or more communication modules for monitoring and control purposes. Additionally, it shall be capable of incorporating a cloud communication module to communicate the collected data to the electrical power monitoring/energy management system (EPMS/EMS) platform for analysis and visualization of power and energy parameters.

K. Switching Mechanism: Quick-make, quick-break type, with positive trip-free operation so that contacts cannot be held closed against excess currents under manual or automatic operation. Contacts shall be non-welding silver alloy with approved arc-quenching devices of metallic grid construction.

L. Trip current rating (amps) indicates nominal maximum rating at which overload element is set to operate.

M. Advanced version of the electronic trip unit with embedded metering functions shall be available, without the need of extra CT's or meters or increasing the dimensions of the circuit breaker to have the measurements of current, voltage, frequency, power, power factor, energy, and THD.

N. All information displayed directly on the trip unit display shall be possible to be displayed on a smartphone, tablet or PC using the front port of the trip unit and the appropriate communication cable.

O. MCCBs for distribution boards -with busbar rating up to 630A- fed from submain distribution boards: Comply with IEC 60947-2 test sequences I, II, utilization category A –up to 630A-, and shall have rated ultimate short circuit breaking capacities (sequence III) to meet the electrical requirements at the panelboard location, with preferred ratings in accordance with following tables.

P. MCCBs for submain distribution boards -with busbar rating up to 1000A- fed from MDBs: MCCBs frames larger than 630 A shall have utilization category B (Tested for 1sec), and shall have rated service short circuit breaking capacities (sequence II) with suitably selected frame sizes and trip ranges to meet the electrical requirements at the distribution panelboard location and schedules shown on the drawings. MCCBs frames up to 630 A shall have utilization category A with rated service short circuit breaking capacity to meet the electrical requirements at the panel boards locations.

Q. MCCB manufacturer shall provide selectivity and coordination tables with other protective devices such as ACB's, MCB's, switches of the same make.

R. MCCB shall be designed to accommodate standard attachments including motor mechanism, shunt-trip, under-voltage release, and auxiliary/alarm switches. Padlocking devices shall be provided, where shown on the drawings.

S. Tripped Position: When tripped automatically by over-current condition, operating mechanism of circuit breaker shall assume an intermediate position clearly indicated by the handle between on and off positions.

T. Sealing: Circuit breakers with non-interchangeable trip units shall be sealed. Circuit breakers with interchangeable trip units shall have trip unit covers sealed to prevent tampering.

U. Accessories: Circuit breakers shall be designed to accommodate standard attachments including shunt-trip, under-voltage release, combined auxiliary and alarm switches, and open / close electrical motor operator to any circuit breaker of rating (frame size) 160 A and over. Padlocking devices shall be provided, where shown on the Drawings.

2.6 MOLDED CASE SWITCHES (MCSs)

A. Molded Case Switch: Similar to circuit breakers but without overload/short circuit protection. Short time rating of switches shall not be less than twelve times the maximum rated operational current for 1 second. Switches shall comply with IEC 60947-3. Switches shall have utilization category AC-22B to IEC 60947-3.

2.7 MINIATURE CIRCUIT BREAKERS (MCBs)

A. Type: Thermal magnetic non-adjustable type, tested in accordance with IEC 60898-1. For residential/household applications and similar installations, MCB's shall comply with IEC 60947 instead.

B. Minimum short-circuit breaking capacities to be according to IEC 60898-1 and IEC60947-2.
   1. 6 - 125A MCB:
      a. 10 kA 230/240 - 400/415 V A.C as per IEC60898-1.
      b. 15 kA 230/240 – 400/415 V A.C as per IEC60974-2.

C. Construction: MCBs shall be tropicalized for operation at ambient temperatures up to 55 degree C within panelboard enclosure and humidity up to 95%, and shall be constructed from high quality, high temperature, molded insulating materials. Guaranteed duties and characteristics shall be submitted for temperatures at and above 40 deg. C.

D. MCBs and combination devices shall be modular, of unified profile and suitable for mounting either to a standard din rail, or a plug-in system.

E. Operation: Under overload conditions, thermal tripping shall provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip shall operate at 5 - 10 times normal rated current (Curve C). Magnetic operation shall be in the current limiting region and opening time shall not exceed 5 milliseconds.

F. Ratings: Preferred rated currents shall be 6, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100 and 125 A, calibrated at 30deg.c, available as 1, 2, 3 and 4-pole circuit breakers. De-rating tables above 30 deg. C shall be submitted.

G. MCB operating mechanism shall be effectively sealed, trip-free with indication for on-off positions, separate trip position indication.

H. MCB terminals/exposed parts shall be protected against unintentional contacts.

I. MCB shall have manual closing/opening in case of normal operation and automatic tripping on fault.

J. Residual current devices for earth leakage protective circuit breakers shall be add-on devices, or built-in and integral with the standard circuit breaker. Non-adjustable sensitivities of 30 mA, 100 mA and 300 mA shall be available for all ratings of 2-pole and 4-pole circuit breakers. RCCB's shall be available in types (AC, A, B) depending upon the waveform of the earth leakage current and the suitable type shall be installed considering these requirements.

K. Auxiliaries where shown on the drawings, shall include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which shall be modular additions to the circuit breakers.

L. Residual current operated circuit-breakers with integral overcurrent protection (RCBOs) type A to IEC 61009 are provided as add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth fault current, in addition to over-current and short-circuit protection, shall be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits shall be 30 mA or 100 mA, and for main breakers ratings shall be as shown on the Drawings. Circuit breakers shall include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be held closed against earth faults. Test push button shall be provided to verify correct function of the RCBO.

2.8 SWITCH DISCONNECTORS

A. Switch disconnectors shall be non-fusible, single throw type, with utilization category as per IEC 60947-3 depending on load type, with arc quenching devices on each pole capable of interrupting at least six times its rated current and shall simultaneously interrupt power supply to all line conductors.

B. Operating mechanism shall be quick-make quick-break type, with external operating handle mechanically interlocked with the door to necessitate disconnecting switch to be in OFF position for access to inside of enclosure. Means shall be provided for by passing the interlock. Position of isolating switch to be clearly on cover.

C. Switch disconnectors shall be operated by an external handle that shall indicate the position of the contacts with complete reliability in all situations. If the contacts are welded together, the handle shall not reach the OFF position but shall remain between ON-OFF, maintaining the door interlock and preventing pad locking.

D. It shall be possible to install switch disconnectors in any direction; horizontal, vertical, or even at the ceiling.

E. Switch disconnectors provided for rotating machines shall have secure safe working condition for service personnel.

F. The rating of switch disconnectors shall be valid in harsh ambient with pollution degree 3 according to IEC 60947.

G. It shall be possible to connect two parallel cables to the terminals of the switch disconnector for easier installation and space saving. It shall be possible to mark the line and load terminals.

H. All the terminals shall meet the requirements of IP20 degree of protection with separate terminal shrouds.

I. All the metal parts shall be protected against corrosion.

J. The contact surfaces shall be silver-plated to minimize contact resistance.

K. Accessories such as terminal shrouds and auxiliary contacts shall be mountable without any special tools (i.e., snap on mounting).

L. The auxiliary contacts shall be early break and late make silver-plated auxiliary contacts with self-cleaning function.

2.9 FINAL BRANCH PANELBOARDS

A. DB's specified herein refer to LV panels located in the final level of LV distribution, i.e., fed from SMDB's and directly feeding final loads. DB's shall have typical ratings from 40A up to 250A.

B. Type: Rated insulation voltage rating of 690V as a minimum and 4KV rated impulse withstand voltage as per IEC 61439 1-2.

C. DB's shall comply with IEC 61439-1&2 standards. Valid design verification certificates issued by independent third-party accredited laboratories such as DEKRA, KEMA, ASTA, ACAE, or other recognized body shall be provided as per IEC 61439-1&2 for approval.

D. Internal Assembly: Comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly shall be complete with neutral terminal block, earthing bar and one piece insulated bolt-on/comb- type phase busbar. Busbars shall be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Busbars withstand short-circuit current of 17 KA/0.25sec. Panelboards shall comply with IEC 61439-3.

E. Panels to be as per IEC61439 with ingress protection of IP41 as per IEC 60529 for indoor installations FDB enclosure shall have a minimum mechanical impact resistance of IK07 as per IEC 62262. Type test certificates for mechanical impact resistance shall be provided for approval, otherwise enclosure thickness shall be minimum 2 mm.

F. Internal Assembly: Comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with busbars in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly shall be complete with neutral terminal block, earthing bar and one-piece insulated phase busbar. Busbars shall be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation shall be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards.

G. SPN type panelboards shall be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.

H. SPN type main circuit breaker shall be double-pole MCB, with or without earth leakage device (RCBO), as shown on the Schedules.

I. Single-pole and double-pole MCBs for 240 V service, shall have trip ratings between 6 A and 125 A, with ICs as required in the Schedules.

J. TPN type panelboards shall be suitable for up to 415 V A.C. maximum service voltage, 3-phase and neutral, with MCBs on branch circuits and 3 or 4-pole MCCB or MCS main incoming, as shown in the Schedules or on the Drawings.

K. Triple-pole branch circuit breakers shall have trip ratings between 6 A and 125 A, with IC as required in the Schedules.

L. FDB’s shall be either way-type (fish bone) or row-type.

M. For way-type FDB, outgoing ways shall be up to 72 ways. For residential/household applications only, outgoing ways shall be up to 48 ways and as per the FDB load schedule.

N. Row-type FDB shall have up to 6 rows accommodating up to 96 modules of 18mm modular devices. For residential/household applications only, FDB shall have up to 5 rows accommodating up to 80 modules of 18mm modular devices and as per the FDB load schedule.

O. All final branch circuits feeding sensitive electronic equipment such as: electronic equipment and telecom racks shall be equipped with class III surge protective devices as specified under Division 26 Section "Surge Protection for Low-Voltage Electrical Power Circuits"..

P. TPN type panelboard main circuit breakers shall be MCCB or MCS as shown on the drawings, 160A frame size as shown on the Drawings, with trip range from 32 A to 160A.

Q. Short-circuit Rating: TPN panelboards may only have integrated equipment (series) short-circuit ratings in accordance with clause paragraph F of Article 2.1 "GENERAL REQUIREMENTS" hereof.

2.10 POWER PANELBOARDS

A. The contractor shall supply and install the distribution and power panel boards as indicated on the panel boards’ schematics and as shown on the drawings.

B. Power and Distribution panel boards shall be equipped with molded case circuit breakers having inter-changeable Themo-magnetic trip units for ratings 250A and below and as described under “Circuit Breakers”. Breakers with rating above 250A shall have inter-changeable electronic trip units as described under “Circuit Breakers”. Frame and trip ratings will be as shown on the drawings

C. Panel boards shall be wall mounted or floor standing rated 630A and above, with short circuit current interrupting capacity equal to or greater than the integrated equipment rating shown on the drawings but not less than Icw = 25kA for 1 second.

D. The panel-boards shall be totally compartmentalized and manufactured to Form2 rating as per EN/IEC 61439-1&2 and as indicated on drawings. Each device or group of devices being mounted on a dedicated mounting plate and housed in its own ‘zone’. The devices zone has to be accessible in one operation and should facilitate the current maintenance with infra-red measurement

E. The panel-boards shall be suitable for operating on 3Phase, 4Wires, 380Volts, 50/60Hz supply. The IP will be 31 for Panel-boards installed in dry area and 54 for panels installed in wet area to EN/IEC 60529. Shock protection shall be IK10 according to IEC 62262.

F. Panel-boards shall be compliant with “Design verifications” according to standard IEC 61439-1&2, form 3b or 2b.

G. Original Manufacturer must carry out the original design and the design verifications that have to be certified through an independent certification body such as but not limited to ASEFA, ACEA and DEKRA, for the most critical configurations.

H. Panel boards are to have one main incoming circuit breaker or switch disconnector as shown on the drawing installed alone in a separate zone at the top of the panel or at the bottom.

I. The outgoing devices shall be homogeneous mounted vertically on a unified and common base and support which is occupying modular and horizontal zone of the panel-board.

J. If the panel-boards include at the same time MCBs and MCCBs, they should not be mixed in the same zone in any circumstance.

K. Contactors, Surge arrestors and any device other than the breakers will be grouped in an accessible and independent zone.

L. Surge arrestor protection shall be installed at feeder entry point and shall be coordinated with protection provided upstream in main switchboard feeding distribution panel board.

M. Distribution panels (DB) shall include digital instrumentation as described in section 262413 2.7 INSTRUMENTATION.

2.11 METERING AND MEASURING DEVICES

A. Current Transformer (CT): Indoor dry type, rated secondary current of 5 or 1 Amp. CT rated primary current, core size, and accuracy shall be determined in accordance with nominal current of the load, short-circuit level at point of installation, and the burden of the connected measuring/protection devices.

B. Voltage Transformer (VT): Provide where required, complete with primary and secondary fuses/MCB’s and disconnecting devices. VT’s shall have a burden suitable for the connected measuring/protection devices.

C. Generally, metering and measuring devices shall be housed in enameled, square, metal cases for flush installation. Scales and markings shall be protected and sealed. Accuracy of instruments shall be within 2% unless otherwise specified.

D. Wherever required and unless stated otherwise, Voltmeters shall be moving-iron type, with center zero adjuster, range 1.25 times nominal system voltage, 90-degree angle, size 96 x 96 mm. Voltmeter shall carry CE marking and shall comply with IEC 60051. Enclosure shall be suitable for a relative humidity of 95 percent non-condensing. Voltmeter selector switch shall be 7-position rotary type.

E. Wherever required and unless stated otherwise, Ammeters shall be moving-iron type with center zero adjuster, range 2 times nominal circuit amperage, 90-degree angle, size 96 x 96 mm. Ammeter shall carry CE marking and shall comply with IEC 60051. Enclosure shall be suitable for a relative humidity of 95 percent non-condensing. Ammeters shall carry “dead rider” indicator needles to indicate maximum values recorded, these shall be of the re-settable type.

F. Wherever required and unless stated otherwise, Power-Factor Meters shall be moving-iron type with center zero adjuster, size 96 x96mm.

G. Digital Multifunctional Power Meter Units:

Digital multifunctional power meter units shall be provided where shown on the drawings and shall have the following features:

1. Unit shall be microprocessor based the and shall support true RMS measurement.
2. Unit shall provide all the below electrical measurements:
   a) Voltage (L-N), Voltage (L-L)
   b) Current (L1, L2, L3, N)
   c) Frequency
   d) Power Factor
   e) Active, Reactive and Apparent Power
   f) Maximum Demand (active, reactive and apparent power)
   g) Active, Reactive and Apparent Energy
   h) Total Harmonic Distortion for Voltage and Current
   i) Total operating hour counter
3. Unit accuracy shall comply with IEC 61557-12 and shall have the following minimum measurement accuracies:
   a) Current, Voltage - 0.2%.
   b) Active energy, Active power – 0.5%.
   c) Reactive energy – 2%.
   d) Reactive power – 2%.
   e) Frequency - 0.1%.
   f) Unbalances (current, voltage) - 0.2%.
   g) Harmonics and THD – 1%.
4. Unit operating temperature shall be -25 to +75 deg C.
5. Unit user interface shall be a color HMI display embedded on the power meter with pushbuttons for configuration.
6. Unit configuration shall be protected by password.
7. Unit shall support one or more of the communication protocols: Modbus RTU, Modbus TCP/IP, Profibus DP-V0, BACnet/IP.
8. Unit shall keep memory for historical data logging.

Alternatively, if the breaker electronic trip unit shall have the above-mentioned metering features built-in into it and is supporting the above-mentioned communication capabilities, then no separate power meter shall be required.

2.12 MULTI-CHANNEL CIRCUIT MONITORING SYSTEM (---------- WHENEVER REQUIRED ----------)

A. Whenever required, a multi-channel circuit monitoring system (CMS) shall be installed to monitor the branch circuits of final distribution boards (DB's or FDB's). CMS shall measure the voltage, current, active, reactive, and apparent power, power factor, and THD from the mains and calculate energy and power for branch circuits.

B. CMS shall consist of a central control unit and a no. of sensors selected between measurements ranges and mounting possibilities.

C. CMS shall collect information both from the DB mains and from the DB branches via sensors directly connected to each branch. All sensors of a DB shall be connected to a single control unit which shall accept up to 96 sensors.

D. The system shall comply to electrical safety as per IEC 61010-1.

E. Input information from the sensors shall be transmitted through data cables only to ensure security and reliability of data transmission.

F. Positioning of the sensors shall be fully flexible and for customized use.

G. Sensors shall be available in open and closed versions as per installation requirement and measure AC, DC & mixed type current.

H. Current rating of sensors shall range from 20A, 40A, 80A, 160A.

I. Sensors shall be installed at breaker terminals, universal din rail mounted and cable with tie.

J. Measured data shall be communicated remotely with different protocols: Modbus RTU, Modbus TCP, SNMP v1 and v2 and the encrypted v3. Two interfaces – LAN and RS485 – shall guarantee straightforward integration into any IT infrastructure.

K. CMS shall be configured through web user interface.

L. Connectivity to a cloud-based energy measurement and analysis system shall be possible using simple connection to the control unit (using LAN or RS485 interfaces).

M. All measurements shall be able to be analyzed and viewed using the cloud-based system.

2.13 ELECTRICAL POWER MONITORING/ENERGY MANAGEMENT SYSTEM (EPMS/EMS) (---------- WHENEVER REQUIRED ----------)

A. Whenever required, Smart LV Devices shall incorporate a communication module to communicate the relevant electrical data collected from the field to the electrical power monitoring/energy management system (EPMS/EMS) platform for analysis and visualization of power and energy parameters.

B. System shall collect data from the electrical devices in the field and store information in one system accessible via Cloud. System shall provide status, alarms, alerts, and maintenance indicators as per the preconfigured model for the electrical network.

C. System shall have a web-based application with preconfigured widgets to provide real-time monitoring of electrical parameters and power consumption. The application shall also provide dashboards, trend graphs, historical performance, and data logging necessary for the analysis of energy consumption and electrical network performance over a selectable period of time based on the collected data. Data monitored and parameters measured shall depend on the electrical devices connected. Because the application is web-based, it shall be accessible on PC, tablet, or smartphone without the need for any special software.

D. System shall be designed to monitor following data without storage limitations:
   1. Consumption measures:
      (Currents, Voltages, Power, Energy, Power Factor, …)
   2. Power quality data:
      (THD, Voltage Unbalance, Voltage Spike/Swell/Sag …)
   3. Maintenance data:
      (Contact wear, Number of trips, Total no. of operations, …)

E. System shall be compatible to integrate with MV and LV electrical devices and it shall support multiple vendors for breakers and meters.

F. System shall have high degree of flexibility enabling the addition of electrical devices in the future and the integration with the already installed devices with limited impact on existing architecture.

G. System shall be able to send different alerts for each device as per the preconfigured setting through e-mail and/or SMS to the user.

H. System shall include a module for evaluation of LV and MV breakers condition, it shall be based on mechanical and electrical data as well as environmental conditions to define accurate performance trend and predictive maintenance plan.

I. System shall provide the last date of maintenance and propose next date for maintenance.

J. Export of data and trends in excel shall be possible on-demand. It shall be possible to generate reports for all information managed or generate customized reports.

K. Commissioning shall be easy with the simple use of a free software provided by the manufacturer. Automatic recognition of devices shall be ensured so that there will be no need for programming.

L. System shall have embedded TSL protocol (Transport Layer Security) to provide encrypted communication and hence ensure the maximum communication security.

M. It shall be possible to define different profiles for user with different access/view rights.

2.14 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in **transparent card holder.**

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.15 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to relevant IEC standards.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to relevant IEC standards.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim **2286 mm** above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mount surface-mounted panelboards to steel slotted supports **16 mm** in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub four 25 mm empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 25 mm empty conduits into raised floor space or below slab not on grade.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties **after completing load balancing**.

P. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads **after balancing panelboard loads**; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers **and low-voltage surge arrestors.** Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262419 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes MCCs for use with ac circuits rated 600 V and less, with combination controllers and having the following factory-installed components:

1. Automatic power transfer.
2. Feeder-tap units.
3. Measurement and control.
4. Auxiliary devices.
5. Panelboards.
6. Transformers.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCC: Motor-control center.

C. MCCB: Molded-case circuit breaker.

D. MCP: Motor-circuit protector.

E. OCPD: Overcurrent protective device.

F. PID: Control action; proportional plus integral plus derivative.

G. PT: Potential transformer.

H. SPD: Surge protective device.

I. SCR: Silicon-controlled rectifier.

J. VFC: Variable-frequency controller.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

L. MV: Medium Voltage

M. LV: Low Voltage

N. OEM: Original Equipment Manufacturer.

O. MDB: Main Distribution Board.

P. CB: Circuit Breaker

Q. ACB: Air circuit breaker.

R. DOL: Direct-on-line motor starter.

S. YD: Start-Delta motor starter.

T. SS: Soft Starter motor starter.

U. VFD: Variable Frequency Drive motor starter.

V. THD: Total Harmonic Distortion.

W. FAT: Factory Acceptance Test.

X. SAT: Site Acceptance Test.

Y. BMS: Building Management System.

Z. DPM: Digital Power Meter.

AA. Icu: Rated ultimate short circuit breaking capacity.

BB. Ics: Rated service short circuit breaking capacity.

1.4 ACTION SUBMITTALS

A. Contractor shall be responsible for carrying out the Voltage drops, Harmonics, Short circuit and Earth fault current calculations, Protective discrimination and Reactive power compensation studies for the entire LV distribution system. Detailed reports shall be submitted for approval.

B. Product Data: Provide manufacturer's standard catalogue pages and data sheets for switchboards, enclosures, overcurrent/earth fault protective devices, and other installed components and accessories.

1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.

2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

C. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.

1. Include dimensioned plan and elevation views of MCCs and adjacent equipment with all required clearances indicated.
2. Include wiring diagrams showing all factory and field connections.
3. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
4. Include documentation of listed breaker frame/trip ratings upon request.
5. Include documentation demonstrating protective coordination upon request.
6. Submit compliance sheet point by point and not by paragraph. Compliance must be highlighted/cross referenced to the page and paragraph in the catalog or data sheets for each item in the submittal.
7. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation. Any deviation not clearly submitted for approval by the contractor will be rejected even after execution.
8. Submit required product data and shop drawings specific to each product and accessory proposed. In addition, include the following information, including dimensions and manufacturer's technical data on features, performance, ratings and finishes.
9. Shop drawing file for each panel should include the following pages:
    a. Header page giving all the details of the panel-board such as but not limited to: Panel rating and Short-circuit ratings of bus-bars and functional units, Horizontal and vertical bus capacities, dimension of the panel, entry of cables, IP etc..
    b. List of components/material used.
    c. Front view with door closed.
    d. Front view with door opened showing the mounting of all the components.
    e. Bus-bars mounting view with manufacturer chart justifying the selection.
    f. Incoming and outgoing cables arrangement, terminal fittings and busbars connections.
    g. Power diagram with all the electrical characteristics.
    h. Control diagrams.
    i. Plans and elevation and exact dimensions and weights.
    j. Arrangement of the board inside the room allocated.
    k. Foundation and installation details.
    l. Manufacturer Design Verification documentation.
    m. Verification of temperature rise & thermal stability using calculations as per EN/IEC 61 439-1&2.
    n. Panel-boards drawn to scale in the electrical/technical rooms.
    o. Available working clearances around the Main Distribution Boards.
    p. Features, characteristics, ratings, and factory settings of individual over current protective devices and auxiliary components.
    q. Full coordination and selectivity study with breakers in MDB, EMDB, Totalizing boards.
    r. Other needed data if any.
10. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.
11. All the accessories such as but not limited to Mounting plates, Internal separations, bus-bars holders, busbars, bolts, doors, sides and rear panels etc.. must be imperatively imported from the original manufacturer. Panel-builder to clearly confirm this requirement and to highlight and cross reference all the accessories in the relative catalogue. It will not be allowed to manufacture any part of the panels locally.

12. Provide complete copies of certificates (including drawings) for rating and short circuit withstand strength for the incoming bus-bars, outgoing bus-bars and main horizontal bus-bars.

D. Workshop drawings for MCCs shall be submitted to the MEPD Engineer for approval and shall indicate the following:
   1. General arrangement drawing.
   2. Bill of Materials.
   3. Protective device types, characteristics and ratings.
   4. CT and VT ratios and class.
   5. Metering.
   6. Relay settings and characteristics.
   7. Dimensioned drawing with elevations and floor fixing plan.
   8. Starter control and interlocking circuits
   9. Terminal block details
   10. Cable entry details.
   11. Schedule of labels.

E. As-Built (record) Drawings: Submit hard and soft copies. Carry out specified routine & field tests and submit test sheets after taking approvals on the testing formats.

F. Maintenance Data: Replacement parts list for starters & controllers.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for MCCs, overcurrent protective devices, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each MCC.

C. Source quality-control reports.

D. Field Quality-Control Reports.

E. Load-Current and Overload Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

F. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

G. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
   b. Manufacturer's written instructions for setting field-adjustable overload relays.
   c. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
   d. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
   e. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to **10** percent of quantity installed for each size and type, but no fewer than **three** of each size and type.
2. Control Power Fuses: Equal to **10** percent of quantity installed for each size and type, but no fewer than **two** of each size and type.
3. Indicating Lights: **Two** of each type and color installed.
4. Auxiliary Contacts: Furnish **one** spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish **three** spares for each size and type of magnetic contactor installed.

1.8 CODES AND STANDARDS

A. The following standards shall apply as a minimum:

B. BS 7671 - Requirements for electrical installations: IET Wiring Regulations - Latest edition.

C. IEC 60034 – Rotating electrical machines : Latest edition

D. IEC 60204 - Safety of machinery, Electrical equipment of machines; Part-1: General requirements: Latest edition.

E. IEC 60255-4 - Single input energizing quantity measuring relays; Latest edition.

F. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code); Latest edition.

G. IEC/EN 61000-3-2 & IEC/EN 61000-3-12 - Electromagnetic Compatibility (EMC) - Limits for Harmonic current emissions.

H. IEC 61000-4 - Electromagnetic Compatibility; Latest edition.

I. IEC/EN 61800- 2, 3 & 5 - Adjustable speed electrical power drive systems

J. IEC/EN/BSEN 60947-1 & 2 - Low Voltage Switch gear and Control Gear; General Rules and Circuit Breakers - Latest edition.

K. EN / IEC 60898 - Circuit breakers for overcurrent protection for household and similar installations.

L. IEC 60664-1 - Insulation coordination for equipment within low-voltage systems; Latest edition.

M. IEC 61000-4-1 - Electromagnetic compatibility; Latest edition.

N. IEC/EN/BSEN 61439-1 & 2 - Low-voltage Switchgear and Control gear assemblies; Latest edition.

O. IEC 61557-12 - Performance measuring and monitoring devices (PMD); Latest edition.

P. IEC/EN 61800 - Adjustable speed electrical power drive systems

Q. IEC 61800-3 Semiconductor power converters for adjustable frequency drive systems environments 1 and 2; Latest edition.

R. IEC 61800-5-1 - Adjustable speed electrical power drive systems safety requirements – Electrical, thermal and energy; Latest edition.

S. IEEE 519 - Recommended Practices and Requirements for Harmonic Control of Electrical Power Systems.

T. IEC 60068-2 -Environmental testing; Latest edition.

U. BEAMA Low Voltage Switchgear and Control gear assemblies.

V. IEEE 519 – Recommended Practices and Requirements for Harmonic Control of Electrical Power Systems.

W. IEC 60269 – Low voltage fuses.

X. IEC 60529 – Degrees of protection provided by enclosures (IP Code)

Y. IEC 60909 – Short-circuit currents in 3 phase AC systems calculations.

Z. Relevant IEC standard for all other products when not specifically stated.

AA. Local Authority Requirements and Regulations and SBC 401:2018.

1.9 QUALITY ASSURANCE

A. Conform to the requirements of IEC/EN/BSEN Standards as applicable.

B. Panel Builder Qualifications:
   1. Panel Builder / Assembler shall have a minimum experience of 7 years in the field of switchgear assembly and past experience with the same manufacturer under the license agreement. The Original manufacturer and licensed panel builder/ assembler shall have a quality management system conforming to ISO-9001 and shall be certified by an approved certification body.
   2. The licensed panel builder shall have local stock holding facility and also provide after-sales service and shall depute their technical representative within 24hrs to the project site for any emergency service calls.
   3. The panel builder's own technical facilities should be locally based ensuring site 24hr support.

C. Complete design verification certification of proposed MCCs to IEC/EN 61439-1&2 shall be provided which has been issued by an internationally accredited independent certifying body such as ASTA, DEKRA etc. Accreditation of the certifying body as well as the testing laboratories shall be submitted for approval.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver MCCs in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside MCCs.

C. Receive, inspect, handle, and store MCCs in accordance with manufacturer's instructions.

D. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.

E. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover/wrappings to protect units from dirt, water, construction debris, and traffic.

F. Handle carefully to avoid damage to MCCs internal components, enclosure, and finish.

G. Inspect equipment to ensure that no damage has occurred during shipment.

1.11 WARRANTY

A. Provide complete system warranty in which the Manufacturer and Contractor are jointly and severally liable and agree to repair/replace all defective components of the warranted system. Warranty shall include both material s and workmanship.

B. Warranty period shall be 1 year from the date of the substantial completion of the project.

C. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

D. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: **Five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All enclosures, switching and protection devices such as circuit breakers, switches, contactors, relays, motor starters, VFD's, and isolators shall originate from a single reputable original equipment manufacturer (OEM). Panel assemblers, only officially authorized by the OEM, shall be acceptable.

B. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. ABB
2. Eaton
3. Schneider Electric
4. Siemens

C. Source Limitations: Obtain MCCs, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. In general installation shall comply with the requirements of SBC 401:2018.

2.2 SYSTEM DESCRIPTION

A. Motor Control Centres shall be from the same manufacturer of MDBs/SMDBs/DBs and assembler shall be a licensed panel builder partner to the MEPD Consulting Engineers' approval and are to conform to the relevant IEC/EN/BS Standards and respective utility requirements.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than 5 deg C and not exceeding 50 deg C, with an average value not exceeding 35 deg C over a 24-hour period.
2. Maximum Relative Humidity Rating: 50 percent (noncondensing).
3. Altitude Rating: Not exceeding 700 m.

C. Motor Control Centers shall conform to the requirements of IEC /EN /BSEN 61439- 1&2 standards and shall be fully design verified and certified by ASTA, DEKRA, ACEA or equivalent independent certifying bodies. Test certificates shall be provided in full to ensure compliance.

2.3 GENERAL REQUIREMENTS

A. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to project's classification or as per the following level as minimum,

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified **and the system will be fully operational after the seismic event**."

2. 0.6g of shock level according to IEE Std 693.

3. Zone 4 according to IEC 68-3-3.

4. Scale 7 according to Richter scale.

5. Scale 9 according to Mercalli scale.

Vibrations performance: All Switchgear shall be certified for vibration performance according to IEC 60068-2-57.

B. Ratings of circuit breakers serving electric motors are design values and must be checked and readjusted, if need be, to conform to motor actual power and rating as recommended by motors Manufacturers.

C. Control voltage for starters and control circuits shall not exceed 230 volts.

D. Power and control wiring to run in conduit unless otherwise specified.

E. Power and control wiring to run in separate conduits.

F. Rigid conduits are not to terminate in nor be fastened to a motor frame or base.

G. Flexible conduits to be used at motor. Allow sufficient slack to permit motor to slide over adjustable length of motor base. Length and radius to be sufficient to permit bending of feeder cables without damage to conductor or its insulation. Flexible conduits are not to used in place of rigid conduit except at motor connections, unless otherwise specified.

H. Conduits are to be supported with conduit supports in an adequate approved manner.

I. Conduits are not to cross pipe or vent shafts, ducts or openings. They are to be run a minimum 100 mm away from pipes of non-electrical services.

J. Detailed control wiring diagrams and a list of control equipment with descriptive literature are to be submitted for approval. Free hand field wiring diagrams or sketches will not be accepted.

K. Circuits to be arranged to satisfy operating requirements specified for various equipment driven by electricity and other requirements pertaining to proper functioning and operation of equipment.

L. Circuits to be protected with high rupturing capacity fuses or circuit breakers. Auxiliary supply for controls other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

M. Motors to be earthed by connecting green insulated conductor from earthing bushing in starter to motor frame. Run earth conductor together with circuit wiring and terminate in motor terminal box, provided earth terminal in box is connected to motor frame. If this is not feasible, extend earth conductor through insulated bushed opening in terminal box and connect to motor base.

N. Equipment to be earthed by connecting non-current carrying metal parts of system to earth source. Non-current carrying metal parts include conduits, cable trays, outlet boxes, cabinets, enclosures, doors, grilles, and barriers protecting or shielding electrical equipment from direct access.

O. Detailed wiring diagram is to be fixed inside each starter enclosure cover to clearly indicate circuits.

P. Control and power wires are to be identified either by distinctive colored insulation, engraved tags or other approved method.

Q. Circuit breakers earth fault detection and interruption are to be coordinated with those of main incoming breaker on main distribution panel.

2.4 MOTOR CONTROL CENTER

A. MCC's specified herein refer to LV panels having all or part their outgoing feeders feeding LV motors in the form of fixed motor starters. MCC's specified herein shall have typical ratings from 1600A up to 6300A. MCC's specified herein shall be directly fed from MV/LV distribution transformers or LV generators or a combination of both. Alternatively, MCC's can be fed from MDB's as per the project SLD and drawings.

B. MCC's shall comply with IEC 61439-1&2 standards. Valid design verification certificates issued by independent third-party accredited laboratories such as DEKRA, KEMA, ASTA, ACAE, or other recognized body shall be provided as per IEC 61439-1&2 for approval.

C. MCC enclosures shall have mechanical impact resistance of IK10 as per IEC 62262. Type test certificates for mechanical impact resistance shall be provided for approval, otherwise enclosure thickness shall be 2 mm thick electro/Hot dip -galvanized sheet steel and electrostatic epoxy powder coated. MCCs shall have IP54 rating for indoor installation and IP 55 for outdoor installation & in wet areas (e.g. pump rooms).

D. Floor mounting MCCs of rating 630 Amp and above shall be designed and constructed to Form 4b form of separation as defined in the 'Guide to forms of separation' by EIEMA (The Electrical Installation Equipment Manufacturer's Association) and shall be in full compliance to IEC/EN/BSEN 61439-1&2. MCCs of rating less than 630A shall have Form 2b Type 2 form of separation.

E. Construction: Totally enclosed, free-standing sectionalized type, modular, compartmented suitable for frame ratings of main circuit breaker and busbars of 630 A or above, form 4b to IEC61439-1&2 with separate withdrawable or fixed section for each motor starter as mentioned on the drawing, and separate fixed section for main incoming breaker / switch and each outgoing feeder circuit breaker. Each functional unit shall have its own compartment with

separate door, segregations shall be IP2X, with the circuit breaker/starter provided with a rotary handle interlocked with the compartment door to prevent opening the door in the normal duty.

F. MCC shall be extendable and designed to allow other sections to be easily added or removed.

G. Floor standing MCCs shall have mechanical impact strength for the enclosure doors & covers of IK10 to IEC 62262.

H. MCC's shall be front and rear accessible; front and rear aligned, unless otherwise recommended by the manufacturer and approved by the Engineer. MCC's shall have compartmentalized construction consisting of front modular functional unit compartments, busbar system compartments and rear cable termination compartments unless otherwise recommended by the manufacturer and approved by the Engineer, with insulating barriers between front compartments and busbar compartments and between rear compartments and busbar compartment (removable for maintenance). Panels shall be only front accessible in case the electrical room dimensions limit the access to the front only. MCC's shall have individually mounted fixed, plug-in, or withdrawable MCCB or ACB distribution sections in addition to fixed motor starters sections as project SLD and drawings.

I. Where single core cables are used, top / bottom cable entry plates shall be made of non-ferrous metal or Aluminum with adequate thickness and rigidity to support cables.

J. Compartment doors shall be interlocked so that isolators or breakers must be in OFF position before door can be opened.

K. Components: Motor control centers shall include the following:
   1. Main incoming circuit breaker or isolating switch as shown on the drawings for terminating incoming supply cables and isolating the busbar system.
   2. Main copper horizontal full-length busbar.
   3. Branch copper vertical full height busbars.
   4. Neutral copper busbar rated at full capacity of main busbar and distributed throughout whole motor control center.
   5. Earth copper busbars rated at half capacity of main busbars extending full length of motor control center.
   6. Digital multimeter unit with necessary current transformers at incoming feeder(s) as specified elsewhere.
      a. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
      b. Switch-selectable digital display of the following:
         1) Phase Currents, Each Phase: Plus or minus 1 percent.
         2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
         3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
         4) Three-Phase Real Power: Plus or minus 2 percent.
         5) Three-Phase Reactive Power: Plus or minus 2 percent.
         6) Power Factor: Plus or minus 2 percent.
         7) Frequency: Plus or minus 0.5 percent.
         8) Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
         9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

c. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

7. Starters, circuit breakers, push buttons, indicating lights, switches, relays, contactors and accessories as shown on the Drawings.
8. Interconnecting and interlock wiring.

L. Main horizontal full-length bus bars, sleeved tinned copper, rated as shown on the drawings. Main and vertical busbars shall be designed to withstand 35kA three phase symmetrical short-circuit for 1 second (Icw). Vertical bus bars, sleeved tinned copper, of adequate capacity shall distribute power to each feeder breaker and starter served. If the prospective short-circuit level at the location of MCCs is more than 35 kA, MCCs with Icw 50 kA-1 second shall be proposed.

M. Connections from busbar to switching element and starter shall be rated to carry full continuous current rating of the switching element frame as a minimum, unless otherwise shown on drawings.

N. MCC's shall have internal arc withstand of at least 65KA/0.1Sec (criteria 1 to 7) in accordance with IEC TR 61641 to achieve personnel protection, assembly protection, and limited operation in case of internal arcing inside the panel as follows:
1. The doors, covers, etc. shall be secured correctly.
2. The parts of the assembly, which may cause a hazard, shall not fly off. This includes large parts and sharp edges, such as inspection windows and pressure relief.
3. Arcing shall not cause holes to develop in the freely accessible external parts of the enclosure because of burning or other effects.
4. The indicators arranged vertically shall not ignite, indicators ignited as a result of paint or stickers burning are excluded from this assessment.
5. The protective circuit for accessible parts of the enclosure shall still be effective.
6. The assembly shall confine the arc to the defined area where it ignited, and the arc shall not propagate to other areas within the assembly.
7. After clearing the fault or after isolation/disassembly of the affected functional units in the defined area, the emergency operation of the remaining assembly shall be possible, verified by a dielectric test with a value of 1.5 times the rated operational voltage for 1 min.

O. Feeder MCCBs shall be provided with electronic trip release unit for ratings above 250A and with provision for remote BMS/Fire Alarm tripping. MCCBs shall conform to IEC/BSEN/EN 60947-2 standard. All MCCBs shall be provided with two N.O. and two N.C. auxiliary contacts wired to terminal blocks.

P. Each MCC cubicle shall be equipped with anti-condensation heater which must be suitably sized and controlled by a thermostat & humidistat with ON/OFF selector switch.

Q. Each MCC shall be provided with its own suitably sized two winding isolation type of control transformer, located in an independent compartment, to facilitate easy maintenance.

R. All internal wiring and cabling shall be terminated with tinned copper lugs. The panels shall be fully wired internally at the manufacturer works to terminal strips. Control wire protection shall be through high rupturing capacity fuses or circuit breakers.

S. All cabling within the panel shall be run within appropriately sized slotted side PVC trunking fitted with appropriate retaining clips. Cables to control gear shall then leave trunking slot

adjacent to their location, with any quantity of cables from trunking to control item being formed into a loom using plastic straps. A 50% space factor shall be allowed in all trunking and loom strap to cater for both the cooling and spare capacity requirements.

T. All motors greater than or equal to 5kW shall be star-delta connected and greater than or equal to 11kW shall be of soft starter unless otherwise shown/specified.

U. General Construction: Rigidly framed and bolted, with epoxy powder coating sheet steel, gray color RAL7035 unless otherwise specified.

V. Motor starters shall be of an approved type and specified, and be complete with:
1. On-load TP incomer MCCB mechanically interlocked with the starter component door and capable of breaking the motor starting current & making onto a fault at the motor terminals. Breakers shall be motor protection type. Necessary auxiliary contacts shall be provided wired to terminal block.
2. Three Pole AC-3 contactors with two normally open and two normally closed auxiliary contacts. All the auxiliary contacts shall be wired down to the respective starter terminal block.
3. Thermal/electronic overload relay with single phase protection.
4. External mechanical hand reset push button on each compartment.
5. Under voltage and phase sequence protection.
6. Motor running (green), Motor stopped (red), breaker/overload tripped (amber) indicating lamps.
7. Start & Stop push buttons, Hand/Off/Auto selector switch and Duty/Standby selector switch where applicable.
8. For motors of rating 5kW and above, ammeter shall be provided for the starter.
9. For Star-Delta starters mechanical & electrical interlocking and appropriate time delay devices shall be provided.

W. Thermal overloads shall be of sufficient scale range that set point of the overload will be approximately at mid-scale for each particular motor to be protected.

X. Motor Circuit Protector shall comply with the requirements of IEC60947-4-1, thermomagnetic or electronic type with adjustable instantaneous setting suitable for motor protection.

Y. All relays, contactors, starters and VFCs shall be from the same manufacturer as that of the distribution switchgear and shall comply with the respective IEC/EN standards.

Z. Where busway is used as an incoming or outgoing feeder of the MCC, the MCC manufacturer shall provide all necessary accessories as recommended by the busway manufacturer such as adaptor box for the MCC to be able to accept the busway flange. The contractor is responsible for coordination between the two manufacturers.

AA. All starter configurations shall ensure to limit the starting current to the requirement and approval of utility.

BB. The supply to chillers shall be through motor operated circuit breakers with electronic release having facility for remote closing and tripping.

CC. Rotary switches shall be of cam type, with a minimum rating of 6 A at 230 volts single phase, having engraved plastic faceplates for usage designation. Where called for they shall be key operated type, supplied with three sets of keys.

DD. Push buttons shall be with square/round face, multi-contact, build-up type, with shrouds if installed in outdoor locations.

EE. All indicating lamps shall be of low voltage LED type, with facility for legends indicating lamp signal designation.

FF. Time switches shall be plug-in type for 24/7 operation and with weekend feature for altering times of operation on weekends separately and automatic rechargeable battery 50-hour reserve to keep unit operational during power failures.

GG. To avoid heavy current inrush on plant start-up for plants of over 100kW connected load, sequence controllers must be provided to start the plant with a minimum of 10 seconds time delay between each start-up of subsequent motors or equipment rated 5kW and over.

HH. Sequence controllers shall automatically recycle to zero position after power interruption or normal plant shutdown.

II. Starter ammeters shall be of suppressed scale type. Incoming section at the MCCs shall be provided with voltmeter with selector switch, ammeters and RYB phase indicating lamps.

JJ. All motor starters shall comply with type-2 coordination with manufacturer’s tables/test reports for compliance.

KK. MCCs shall be equipped with test class II surge protection devices complying with IEC 61643-1 and with surge discharge current rating of Imax 40kA as specified under division 26 4300.

LL. Under voltage relay unit & timer shall be provided to comply with utility regulations for all Air Conditioning units.

MM. Configuration of control panels/MCC shall comply to functional requirements of relevant mechanical specification. All required signals, volt-free contacts and communication parameters shall be made available as per agreed BMS points list/requirements.

NN. All relays, contactors and motor starters shall have 24 Volts single-phase coils unless otherwise specified. Control relays shall be rated for 6A at 230 Volts, minimum rating per contact.

OO. Refer respective specification clauses for VFCs and Soft starters.

PP. Labels: Starters, switches, electrical devices and accessories to be clearly labeled in English for their function and reference number. Labels to be permanently fixed under each component.

QQ. Schematic and wiring diagrams to be firmly fixed within the motor control center, showing each component and cross- referenced with component labels.

RR. Coordinate with Building Management System BMS/DCS/SCADA supplier and provide all necessary interface necessary for the functions specified elsewhere and/or shown on the drawings. Coordinate with the respective contractor for proper implementation of all

BMS/DCS/SCADA requirements so that the system shall be seamlessly integrated. Additionally, MCC functional units shall be able to communicate through internet/cloud platforms.

SS. It shall be ensured that all live parts are fully shrouded. Certified rigid metallic partitions shall be used in the switchgear assembly.

TT. Voltage presence indication lights shall be provided for the MCC main incomer(s) power terminals.

UU. The number of outgoing feeders per MCC vertical section (cubicle) shall be carefully selected taking into consideration the future maintenance and avoiding congested installations.

VV. Motor Control Centers shall comply and perform satisfactorily at the below listed special design conditions as minimum:
1. Ambient temperature : 50ºC
2. Relative humidity : 90%

2.5 MOTOR CONTROL PANEL

A. MCP's specified herein refer to LV panels having all or part their outgoing feeders feeding LV motors in the form of fixed motor starters. MCP's specified herein shall have typical ratings from 160A up to 1250A. MCP's specified herein shall be fed from MDB's or other upstream LV panels as per the project SLD and drawings.

B. Type: floor mounted, wall mounted or unit mounted, free standing, with matching vertical sections to form a continuous integral and rigid multi-cubicle structure assembly lockable type, IP 54 for indoor installation and IP 55 for installation in outdoor or wet areas, form 2a to IEC 61439-1.

C. MCP's shall comply with IEC 61439-1&2 standards. Valid design verification certificates issued by independent third-party accredited laboratories such as DEKRA, KEMA, ASTA, ACAE, or other recognized body shall be provided as per IEC 61439-1&2 for approval.

D. Construction: hot-dip galvanized steel sheet, finished with one coat etch primer and one coat stove enamel internally and externally for cabinet/box; suitable for mechanical impact resistance of IK10 to IEC 62262 for enclosures protection degree IP55 and higher and IK08 to IEC 62262 for enclosures protection degree lower than IP55. Test certificates for mechanical impact are to be submitted for approval; otherwise enclosure thickness is not to be less than 1.5mm.

E. General Construction: Rigidly framed and bolted, with epoxy powder coating sheet steel, gray color RAL7035 unless otherwise specified.

F. Panels installed outdoors to have weatherproof totally sealed water and dustproof enclosures.

G. Panels are to contain necessary breakers, starters, push button switches, selector switches, relays, indicating lights, interconnecting and interlock wiring and all devices and accessories required for automatic or manual operation of equipment as specified under equipment concerned.

H. MCP's shall be front and rear accessible; front and rear aligned, unless otherwise recommended by the manufacturer and approved by the Engineer. MCP's shall have compartmentalized construction consisting of front modular functional unit compartments, busbar system compartments and rear cable termination compartments unless otherwise recommended by the manufacturer and approved by the Engineer, with insulating barriers between front compartments and busbar compartments and between rear compartments and busbar compartment (removable for maintenance). Panels shall be only front accessible in case the electrical room dimensions limit the access to the front only.

I. Labels starters, switches, electrical devices and accessories to be clearly labelled in English as to function and number. Labels to be permanently fixed under each component.

J. Schematic and wiring diagrams to be mounted in permanent approved manner on inside of panel door. Diagrams are to show each component cross referenced with component labels.

K. MCP manufacturer/assembler shall provide all necessary interfaces, relays, transducers necessary for interface with the BMS as specified in the BMS schedules and/or shown on the project drawings/schedules unless stated otherwise.

L. The MCP shall be able to be monitored and controlled from BMS/SCADA system as per the requirements. Additionally, MCP functional units shall be able to communicate through internet/cloud platforms.

M. Where busway is used as an incoming or outgoing feeder of the MCP, the MCP manufacturer shall provide all necessary accessories as recommended by the busway manufacturer such as adaptor box for the MCP to be able to accept the busway flange. The contractor is responsible for coordination between the two manufacturers.

2.6 MAGNETIC CONTROLLERS

A. Controller Units: Combination controllers.

B. Disconnects:

1. Fusible Switch:

   a. Heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate fuses.
   b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
   c. Auxiliary Contacts: **NC & NO**, arranged to activate before switch blades open.

2. MCP:

   a. With interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
   c. **NC** & **NO** alarm contact that operates only when MCP has tripped.
   d. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB:

    a. With interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
    d. **NC** & **NO** alarm contact that operates only when MCCB has tripped.

4. Molded-Case Switch:

    a. With in-line fuse block for power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
    b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
    c. **NC** & **NO** alarm contact that operates only when molded-case switch has tripped.

C. Controllers:

1. Full-Voltage Magnetic Controllers: Electrically held, full voltage, general purpose, Class A.

    a. Classification: **Non-reversing**.

2. Reduced-Voltage Magnetic Controllers: Electrically held, general purpose, Class A; **open** transition; adjustable time delay on transition. **Electrically** held.

    a. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
    b. Part-Winding Controller: Separate START and RUN contactors, with separate overload relays for starting and running sequences.
    c. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; one RUN and two START contactors.

3. Multispeed Magnetic Controllers: Electrically held, full voltage, general purpose, Class A.

        1) Two speed, with compelling relays to ensure that motor will start only at low speed.
        2) Timer Relays: Accelerating, for properly timed acceleration through speeds lower than that selected.

    b. Timer Relays: Accelerating, for properly timed acceleration through speeds lower than that selected.

D. Overload Relays:

1. Melting-Alloy Overload Relays:

a. Inverse-time-current characteristic.
b. **Class 10** tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

2. Bimetallic Overload Relays:

a. Inverse-time-current characteristic.
b. **Class 10** tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

3. Solid-State Overload Relays:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. **Class 10/20 selectable** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Ground-fault protection, with start and run delays to prevent nuisance trip on starting.
e. Analog communication module.

4. **NC & NO** isolated overload alarm contact.
5. External overload reset push button.

2.7 REDUCED-VOLTAGE SOLID-STATE CONTROLLERS

A. Controller Units: An integrated unit with disconnects, power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relays.

B. Disconnects:

1. Fusible Switch:

a. Heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate fuses.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary Contacts: **NC** & **NO**, arranged to activate before switch blades open.

2. MCP:

a. With interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. **NC** & **NO** alarm contact that operates only when MCP has tripped.
d. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB:

    a. With interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
    d. **NC** & **NO** alarm contact that operates only when MCCB has tripped.

4. Molded-Case Switch:

    a. With in-line fuse block for power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
    b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
    c. **NC** & **NO** alarm contact that operates only when molded-case switch has tripped.

C. Configuration: **Standard** duty; **nonreversible.**

D. Starting Mode: **field selectable**.

E. Stopping Mode: **field selectable**.

F. Bypass Contactor: Shall operate automatically to bypass the SCRs when the motor has reached rated speed and full voltage is applied to motor. Solid-state controller protective features shall remain active when the bypass relay is in the bypass mode.

1. Bypass Contactor: Manufacturer's standard product.

G. Acceleration Control: Adjustable, using voltage or current ramp, and adjustable starting torque control with up to **400** percent current limitation for 20 seconds.

H. SCR Bridge: At least two SCRs per phase, for stable and smooth acceleration **with** external feedback from the motor or driven equipment.

I. Keypad: Front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:

1. Adjusting motor full-load amperes, as a percentage of the controller's rating.
2. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
3. Adjusting linear acceleration and deceleration ramps, in seconds.
4. Setting initial torque, as a percentage of the nominal motor torque.
5. Adjusting torque limit, as a percentage of the nominal motor torque.
6. Adjusting maximum start time, in seconds.
7. Adjusting voltage boost, as a percentage of the nominal supply voltage.
8. Selecting stopping mode and adjusting parameters.
9. Selecting motor thermal-overload protection class between 5 and 30.
10. Activating and deactivating protection modes.
11. Selecting or activating communications modes.

J. Digital Display: Front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:

1. Controller Condition: Ready, starting, running, stopping.
2. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
3. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

K. Controller Diagnostics and Protection:

1. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.
2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency excursions to over- or under-normal. Accomplish protection by the following:

    a. Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.

L. Remote Output Features:

1. All outputs prewired to terminal blocks.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

M. Overload Relays:

1. Melting-Alloy Overload Relays:

    a. Inverse-time-current characteristic.
    b. **Class 10** tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

2. Bimetallic Overload Relays:

    a. Inverse-time-current characteristic.
    b. **Class 10** tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    d. Ambient compensated.
    e. Automatic resetting.

3. Solid-State Overload Relays:

    a. Switch or dial selectable for motor-running overload protection.
    b. Sensors in each phase.
    c. **Class 10/20 selectable** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

d. Ground-fault protection, with start and run delays to prevent nuisance trip on starting.
e. Analog communication module.

N. Optional Features:

1. Analog output for field-selectable assignment of motor operating characteristics **4- to 20-mA dc**.
2. **Two** additional field-assignable Form C contacts for alarm outputs.
3. Full-voltage/BYPASS selector switch. Power contacts shall be totally enclosed, double break, made of silver-cadmium oxide, and assembled to allow inspection and replacement without disturbing line or load wiring.

2.8 VFC

A. Controller Units: Combination controllers, consisting of variable-frequency power converter that is factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; arranged for self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

B. VFC enclosure shall be IP 54 IEC 60529 with inlet air filters. Drive shall be mounted on a floor stand.

C. VFC is to be provided for motor starting and speed control where shown on electrical or mechanical drawings.

D. VFC shall convert three-phase, 60 hertz utility power to adjustable voltage and frequency, three phase power for stepless motor speed control from 10% to 100% of the motor's 60 hertz speed. Input voltage shall be as specified on the drawing schedules.

E. VFC shall include a converter and an inverter section. The converter section shall convert fixed frequency and voltage AC utility power to DC voltage. All VFCs shall include input line reactors or an isolation transformer as required. The inverter section of the VFC shall invert the DC voltage into a quality output waveform, with adjustable voltage and frequency for stepless motor speed control. The VFC shall maintain a constant V/Hz ratio. The VFC and options shall be tested to IEC 60947-4-1.

F. Power line noise shall be limited to a voltage distortion factor and line notch as defined in IEC 61000. The total voltage distortion shall not exceed 3 percent. THDI at point of common coupling (PCC) shall not exceed IEC 61000 limits.

G. The VFC shall comply with EMC directive and standard IEC 61800 category C2 (1st environment, restricted distribution, the VFC shall include EMC filter).

H. Motor noise as a result of the VFC shall be limited to 3 dB over across the line operation measured at 1 meter from the motor's centerline.

I. VFC's full load amp rating shall meet or exceed NFPA 70, NEC Table 430-250.

J. Protective Features will include:

1. Individual motor overload protection for each motor controlled.
2. Protection against input power under-voltage (for non-emergency motors only), over-voltage, and phase loss.
3. Protection against output current overload and instantaneous over-current.
4. Protection against over-temperature within the VFC enclosure.
5. Protection against over-voltage on the DC bus.
6. Thermistor motor protection relay interface.
7. Protect VFC from sustained power of phase loss. Under-voltage trip activates automatically when line voltage drops more than 10 percent below rated input voltage.
8. Automatically reset faults due to under-voltage, over-voltage, phase loss, or over-temperature.
9. Protection against output short circuit and motor winding shorting to case faults.
10. Status lights or digital display for indication of individual fault conditions.
11. Controller capable of operating without a motor or any other equipment connected to the drive output to facilitate start-up and troubleshooting.
12. Input line reactors shall be provided to minimize harmonics introduced to the AC line and to provide additional protection to AC line transients.

K. Interface Features for the VFC will include:
1. Door mounted Hand/Off/Auto selector switch to start and stop the VFC. In the Auto position, the VFC will start/stop from the controller. In the Hand position, the VFC will run regardless of the remote contact position.
2. Manual speed control capability.
3. Local/Remote selector switch. In the Remote position, motor speed is determined by the follower signal. In the local position, motor speed is determined by the manual speed control.
4. Power/On light to indicate that the VFC has tripped on a fault condition.
5. Digital meter with selector switch to indicate percent speed and percent load.
6. A set of form-C dry contacts, to indicate when the VFC is in the Run mode.
7. A set of form-C dry contacts, to indicate when the VFC is in the Fault mode.
8. A 0 to 10 V output signal to vary in direct proportion to the controller's speed.
9. VFC to have terminal strip and N.C. safety contacts such as freezstats, smoke alarms, etc. VFC to safety shut down in drive or bypass mode when contacts open.

L. Adjustments will include the following:

1. Maximum speed, adjustable 15 to 100 percent base speed.
2. Acceleration time, adjustable 3 to 60 seconds.
3. Deceleration time, adjustable 3 to 60 seconds with override circuit to prevent nuisance trips if decal time is set too short.
4. Current limit, adjustable 0 to 105 percent.
5. Overload trip set point.
6. Offset and gain to condition the input speed signal.

M. Service conditions will cover:

1. Ambient temperature, 0 to 50 deg C.
2. 0 to 95 percent relative humidity, non-condensing.
3. Elevation to 1,000 meters without derating.
4. AC line voltage variation, -10 to +10 percent of nominal.

N. Special features will include the following features in the VFC enclosure:

1. For motor ratings up to 50HP, manual by-pass shall be provided with all the circuitry necessary to transfer the motor from the VFC to the power line or from the line to the controller. The by-pass circuitry shall be mounted in a separate section of the VFC enclosure. Motor overload protection shall be provided in both drive and by-pass modes. Alternatively, spare VFC for each group of frames is to be provided, subject to the Engineer's approval.
2. A door interlocked, pad lockable drive disconnect switch shall be provided to disconnect power from the VFC only (the disconnect shall be clearly marked as such).
3. A motor circuit protector, MCP, shall be provided as a means of disconnecting all power to both the VFC and by-pass circuits as well as providing short circuit and locked rotor protection to the motor while in the by-pass mode.
4. The disconnect and by-pass functions may be accomplished via disconnects, contactors and overloads, or with a four position Drive/Off/Line/Test switch with motor starter and by-pass fuses.

O. Disconnects:

1. Fusible Switch:

   a. Heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate fuses.
   b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
   c. Auxiliary Contacts: **NC** & **NO**, arranged to activate before switch blades open.

2. MCP:

   a. With interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
   c. **NC** & **NO** alarm contact that operates only when MCP has tripped.
   d. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB:

   a. With interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
   b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
   d. **NC** & **NO** alarm contact that operates only when MCCB has tripped.

4. Molded-Case Switch:

   a. With in-line fuse block for power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
   b. Lockable Handle: For three padlocks and interlocks with cover in closed position.

c. **NC** & **NO** alarm contact that operates only when molded-case switch has tripped.

5. Disconnect Rating: Not less than 115 percent of VFC input current rating.
6. Auxiliary Contacts: **NC & NO**, arranged to activate before switch blades open.
7. **NC** & **NO** alarm contact that operates only when circuit breaker has tripped.

P. Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus **15** percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding **5** percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: **97** percent at 50 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: **98** percent under any load or speed condition.
6. Overload Capability:

   a. For variable-torque controllers, 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
   b. For constant-torque controllers, 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

7. Starting Torque: Minimum of 100 percent of rated torque from 3 to 50 Hz.
8. Speed Regulation: Plus or minus **5** percent.
9. Output Carrier Frequency: Field selectable.
10. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
11. Internal Adjustability Capabilities:

    a. Minimum Speed: 5 to 25 percent of maximum rpm.
    b. Maximum Speed: 80 to 100 percent of maximum rpm.
    c. Acceleration: **0.1 to 999.9** seconds.
    d. Deceleration: **0.1 to 999.9** seconds.
    e. Current Limit: 30 to a minimum of 150 percent of maximum rating.

12. Self-Protection and Reliability Features:

    a. Input transient protection by means of SPDs for three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
    b. Loss of Input Signal Protection: Selectable response strategy including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
    c. Under- and overvoltage trips.
    d. Inverter overcurrent trips.
    e. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad;
    f. Critical frequency rejection, with **three** selectable, adjustable deadbands.
    g. Instantaneous line-to-line and line-to-ground overcurrent trips.
    h. Loss-of-phase protection.
    i. Reverse-phase protection.
    j. Short-circuit protection.

k. Motor overtemperature fault.

13. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
14. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

Q. Operator Station:

1. Inverter Logic: Microprocessor based, **32** bit, isolated from all power circuits.
2. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
3. Panel-mounted, manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

    a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
    b. Security Access: Electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

R. Displays:

1. Historical Logging Information and Displays:

    a. Real-time clock with current time and date.
    b. Running log of total power versus time.
    c. Total run time.
    d. Fault log, maintaining last **four** faults with time and date stamp for each.

2. Indicating Devices: Digital display **and additional readout devices as required,** mounted flush in VFC door and connected to display VFC parameters including the following:

    a. Output frequency (Hz).
    b. Motor speed (rpm).
    c. Motor status (running, stop, fault).
    d. Motor current (amperes).
    e. Motor torque (percentage).
    f. Fault or alarming status (code).
    g. PID feedback signal (percentage).
    h. DC-link voltage (V dc).
    i. Set-point frequency (Hz).
    j. Motor output voltage (V ac).

S. Bypass Systems:

1. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes, and indicator lights

indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

2. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.

3. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller[**; with input isolating switch and barrier**] arranged to isolate the power converter input and output and permit safe testing[**and troubleshooting**] of the power converter, both energized and de-energized, while motor is operating in bypass mode.

    a. Bypass Contactor: Load-break, **IEC**-rated contactor.
    b. Input and Output Isolating Contactors: Non-load-break, **IEC**-rated contactors.
    c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

4. Bypass Contactor Classification: **Full-voltage (across-the-line)** type.
5. NORMAL/BYPASS selector switch.

    a. HAND/OFF/AUTO selector switch.
    b. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
    c. Contactor Coils: Pressure-encapsulated type **with coil transient suppressors**.

        1) Operating Voltage: Depending on contactor size and line-voltage rating, manufacturer's standard matching control power or line voltage.
        2) Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

6. Overload Relays:

    a. Melting-Alloy Overload Relays:

        1) Inverse-time-current characteristic.
        2) **Class 10** tripping characteristic.
        3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

    b. Bimetallic Overload Relays:

        1) Inverse-time-current characteristic.
        2) **Class 10** tripping characteristic.
        3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
        4) Automatic resetting.

    c. Solid-State Overload Relays:

1) Switch or dial selectable for motor-running overload protection.
2) Sensors in each phase.
3) **Class 10/20 selectable** tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

d. **NC** & **NO** isolated overload alarm contact.
e. External overload reset push button.

T. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

U. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

V. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

2.9 CONTROLLER-MOUNTED AUXILIARY DEVICES

A. Control-Circuit and Pilot Devices: Factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: **Heavy**-duty.

a. Push Buttons: **Covered** types; **momentary** contact unless otherwise indicated.
b. Pilot Lights: **LED** types; **push to test**.
c. Selector Switches: **Rotary** type.

B. Elapsed-Time Meters: Heavy duty with digital readout in hours**; resettable**.

C. Auxiliary Dry Contacts: **NC** & **NO**.

D. Control Relays:

1. Time Delay: Auxiliary and adjustable **solid-state** time-delay relays.
2. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections and adjustable undervoltage, overvoltage, and time-delay settings.

2.10 ARC FLASH DETECTION AND PROTECTION SYSTEM

A. MCC’s shall be equipped with an efficient and reliable arc detection and protection system to protect it against internal arcing faults inside the switchboard.

B. Arc detection system shall consist of a central arc monitoring unit and a no. of light sensors/detectors distributed inside the switchboard to detect any light spark caused by an internal arcing inside the switchboard and transfer it to the arc monitoring unit which shall send a signal within a maximum of 1 mSec to trip the main breaker or branch breaker to disconnect the affected area of the switchboard.

C. Light sensors shall be connected to the arc monitoring unit by means of fiber optic cables to avoid electro-magnetic disturbances.

D. Light sensors shall not react for a light intensity lower than 3000 lux to avoid nuisance tripping.

E. The light intensity for tripping shall also be constant regardless the length of the light sensor/detector.

F. Optionally, an additional current sensing unit can be mounted if there is a risk of false trips caused by strong light hitting the sensors such as sunlight or camera flashes to avoid any unnecessary tripping.

G. It shall be possible to identify where and when the arcing fault has occurred inside the switchboard and configure the detectors to trip different breakers accordingly to disconnect the affected area of the switchboard.

H. The arc monitoring unit shall have communication via MODBUS RTU protocol to transfer the system data to BMS, SCADA, power monitoring, or energy management systems.

2.11 MEASUREMENT AND CONTROL DEVICES

A. Instrument Transformers:

1. PTs: 230 V, 50 Hz, **double** secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: 5 A, 50 Hz, secondary; **bar or window** type; **double** secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, for selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker and ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Listed or recognized by a nationally recognized testing laboratory.
2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
3. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.

b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
e. Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

4. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

2.12 FEEDER BREAKER UNITS

A. For specifications related to functional units such as ACB's, refer to Section 26 24 13 "Switchboard".

B. MCCBs (to 1000 A): Fixed mounted, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. With interrupting capacity to comply with available fault currents.

1. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
2. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long- and short-time time adjustments.
d. Ground-fault pickup level, time delay, and I^2t response.

3. Communication Capability: **Circuit-breaker-mounted** communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."

4. For ratings higher than 250A, solid state electronic trip units shall be used, it shall be equipped with colored touch screen display. Electronic trip units shall have long time delay settings between 0.4 and 1.0 times maximum trip rating, short time delay range of 1 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 1 to 10 times continuous rating. Earth fault protection shall be built into trip unit where specified and shall be suitable for connection to external current sensor. Push-to- trip button shall be provided on cover for testing the trip unit.

5. Advanced version of the electronic trip unit with embedded metering functions shall be available, without the need of extra CT's or meters or increasing the dimensions of the circuit breaker to have the measurements of current, voltage, frequency, power, power factor, energy, and THD.

6. All information displayed directly on the trip unit display shall be possible to be displayed on a smartphone, tablet or PC using the front port of the trip unit and the appropriate communication cable.
7. With built-in digital ammeter and a digital display, showing tripping cause.
8. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
9. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
10. Alarm Switch: One **NC** & **NO** contact that operates only when circuit breaker has tripped.
11. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
12. Zone-Selective Interlocking: Integral with **ground-fault** trip unit; for interlocking ground-fault protection function.
13. Electrical Operator: Remote control for on, off, and reset operations.

14. A special type of breaker dedicated for motor protection shall be used for motor starter feeders with adjustable instantaneous setting suitable for motor protection. This circuit breaker shall have magnetic only trip unit of conventional type to provide the short circuit protection for motor, overload protection for the motor shall be provided by a dedicated overload relay. Alternatively, MCCB with an advanced electronic type of trip unit can be used to protect the motor with special motor protection functions such as instantaneous, overload, locked rotor, instantaneous, phase loss, ground fault, and PTC protection functions built-in into electronic trip unit as per the requirements.

C. Fusible Switches (to 600 A): Fixed-mounted, manually operated, **electrically tripped,** fusible, quick-make, quick-break switch with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
2. Include fuse clips and fuses.
3. Electrically tripped switches shall include the following:

    a. Shunt trip.
    b. Ground-fault protection, with adjustable time delay and test panel.
    c. Single-phase protection, tripping the switch on loss of a source phase.
    d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

D. For specifications related to functional units such as MCB's, refer to Section 26 24 16 "Panel Board".

2.13 PANELBOARDS

A. Branch OCPDs for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; or plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

B. Contactors in Main Bus: Class A, **electrically** held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

C. Accessory Control Power Voltage: **self-powered**.

2.14 TRANSFORMERS

A. Factory-assembled and -tested, air-cooled, two-winding, low-voltage dry-type transformers; with primary circuit breaker.

B. Taps for Transformers Smaller Than 3 kVA: **One 5 percent tap above normal full capacity**.

C. Taps for Transformers 7.5 to 24 kVA: **One 5 percent tap above and one 5 percent tap below normal full capacity**.

D. Taps for Transformers 25 kVA and Larger: **Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity**.

E. Insulation Class: 220 deg C, **150** deg C rise above 40 deg C ambient temperature.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install motor control centers in accordance with BS 7671 and IEC 61439.

B. Floor Mounting: Install MCCs on 100-mm nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 450-mm centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible switch.

F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

G. Install power factor correction capacitors. Connect to the **line** side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components.
2. Install required warning signs.
3. Label MCC and each cubicle with engraved nameplate.
4. Label each enclosure-mounted control and pilot device.
5. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.

B. Operating Instructions: Frame printed operating instructions for MCCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of MCCs.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between **enclosed controllers** and remote devices.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 CONNECTIONS

A. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections **with the assistance of a factory-authorized service representative**.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multipole enclosed controller 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Submit calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. MCCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. **Perform** startup service.

1. Complete installation and startup checks.

3.8 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload relay pickup and trip ranges.

B. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes. Where these maximum settings do not allow starting of a motor, notify **Construction Manager** before increasing settings.

C. Set the taps on reduced-voltage autotransformer controllers at **65** percent.

D. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

E. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

3.9 DEMONSTRATION

A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 262419

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches and sockets.
2. Plates

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.
3. Section 260943.24 "KNX-Based Lighting Controls" for network lighting control relay devices.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Lighting Switches/push buttons for non-decorative areas.
2. Lighting switches/push buttons for non-decorative areas, weatherproof.
3. Lighting switches/push buttons for decorative areas.
4. Lighting switches/push buttons for decorative areas, weatherproof.
5. Single and duplex sockets for non-decorative areas.
6. Single and duplex sockets for non-decorative areas, weatherproof.
7. Single and duplex sockets for decorative areas.
8. Single and duplex sockets for decorative areas, weatherproof.

B. Samples:

1. One for each kind of switches, push buttons and sockets, cover plate and accessories specified, in each finish and color specified.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.4 WARRANTY FOR DEVICES

A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: Five years from date of Substantial Completion; full coverage for labor, materials, and equipment.
2. Follow-On Extended Warranty Period: Eight years from date of Substantial Completion; full coverage for materials only, free on board, freight prepaid.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. ABB
2. Legrand.
3. GIRA.
4. Jung.
5. Schneider Electric.

Or other approved equal

B. Source Limitations: Obtain devices, components and accessories from single source from single manufacturer.

2.2 GENERAL

A. All types shall be of the same manufacturer to provide consistent appearance, finish and colors. Openings may distinguish the functional use of similar fittings or units.

B. Rated voltage and ampere should be indicated on all wiring devices. Fixed screen shall be installed to separate live parts in case of multi-phase existing in one box.

C. All wiring devices must be suitable for 3-wire systems for single phase and 5- wire systems for three phase i.e. earthing terminal must be provided in sockets plugs, lighting switches, power socket, etc.

D. Separate mounting boxes are to be provided where lighting switches are grouped together and connected to different phases.

2.3 GENERAL-USE SWITCHES

A. General:

1. Quick-make, quick-break quiet type with silver alloy contacts in arc resisting moulded base, with toggle, rocker or push-button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side and/or back connection.

B. Regulatory Requirements:

C. Description:

1. Single, two-way or intermediate, single pole or double pole, as shown on the Drawings.

D. Lighting Switch - Type Technical:

1. General Characteristics:

a. Rocker-operated, grid-switch with plastic plate, for indoor installations in general, but with weatherproof enclosure IP44, unless otherwise indicated.

2. Rating:

a. 10 A 250 V ac.

3. Location:

a. Non-decorative areas.

4. Similar to, or approved equal:

a. Similar to Legrand Forix

2.4 SOCKETS

A. General:

1. Injection moulded plastic base socket outlets with self-adjusting, non-expanding contacts to prevent permanent distortion, arranged for side and/or back connection and with screw terminals accepting at least three parallel branch-circuit wires.

B. Regulatory Requirements:

C. Socket - Type Technical:

1. General Characteristics:

a. Weather Proof Receptacles: where installed in exterior locations or in areas of continual dampness, outlets shall be enclosed in surface mounted cast metal box, watertight pattern with watertight caps tightly closed with stainless steel springs

when the socket outlet is not in use and approved gaskets. It shall be weather proof with minimum IP 44.

2. Rating:

   a. 16 A 250 V ac.

3. Location:

   a. Non-decorative areas.

4. Similar to, or approved equal:

   a. Similar to Legrand Forix

2.5 PLATES

A. Plates shall be of square shape to adequately cover corresponding outlet boxes and be designed to fit the electrical devices.

B. Various samples shall be submitted for approval and/or selection by the Engineer.

C. Fixing screws shall be chromium plated, polished. Screw head shall suit the plates. Unless otherwise required by the Architect.

D. Combination (multi-gang) plates shall be provided for grouped outlets and devices as detailed on the Architectural or Electrical Drawings. Color shall be selected by the Engineer for different typical areas without any cost implication to the Contract.

E. Unless otherwise stated or specified in "Interior and Furnishing Works", heavy- molded, break-resistant material, flush-mounted plates shall be used for individually installed switches and wall socket outlets.

F. Plates for socket outlets shall match switch plates telephone and data outlets in each particular area.

2.6 BOXES

A. Boxes shall be provided with means to terminate conduits securely.

B. For heavy-molded rigid PVC boxes shall be provided with brass insert threads and fixed lugs to receive cover screws or galvanized steel with suitable marked earth terminal for exposed and outdoor use.

C. For more details on boxes and fittings, refer to Section (260533).

PART 3 - EXECUTION

3.1 INSTALLATION

A. The exact location, mounting height of outlets, equipment and switch boxes shall be as specified in the Equipment Consultant or Interior design Package and approved by the Engineer. Unless otherwise indicated on drawings.

B. Flush-mounted boxes shall be cast in concrete walls and grouted into brick walls. Metal boxes threaded to raceways in exposed installations shall be separately supported.

C. Boxes installed in concealed conduits or raceway systems shall be set flush with the finished surfaces. The location of all boxes shall be easily accessible and any interference with mechanical equipment or structural features shall be relocated as directed by the Engineer without any additional cost.

D. The receptacles shall be located and installed as shown on the Drawings. The location shall be easily accessible. Receptacles shall be so installed that the neutral pin is always on the left side when viewed facing the installation.

E. Local wall switches near doors, shall be located at free side of doors as finally hung, whether so indicated on Drawings or not A junction box shall be placed in the back of each wall mounted switch or socket outlet. If thickness of wall does not permit such an installation, adjacent position shall be accepted.

F. The switches shall be installed as shown on the approved Drawings. Where more than one switch is shown for one indoor outlet box, the switches shall be installed under one plate. Toggle switches for lighting, except for 2-way and 3- way switches shall be installed so that the contacts are closed when the handle is in the up position.

G. Switches shall be mounted with the longer dimension vertical and operating handle in an upward position when in the "ON" position.

H. Single pole switches shall switch the (phase) wire circuit. Neutral wire shall not run through switches. No switches shall be located inside toilets or shower places.

I. Device plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Device plates shall be installed vertically with an alignment tolerance of 0.16 mm.

J. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

K. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

L. Devices grounding connections shall be made by means of screw-type pressure connectors to the box's frame and receptacle ground pin in accordance with the IEC Code.

3.2 IDENTIFICATION

A. Comply with Division 260553 Section "Identification for Electrical Systems".

3.3 FIELD QUALITY CONTROL

A. Carry out visual inspection of fittings and equipment for fixing and workmanship.

B. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

3.4 PROTECTION

A. Protect installed components from damage. Replace damaged items prior to final acceptance.

END OF SECTION 262726

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to the project’s seismic classifications.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details.

2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.9 CODES AND STANDARDS

A. Compliance with Standards:

Reference	Title	Content
EN /IEC 60947-1 & 2	Low-voltage Switchgear and control-gear Part 2 : Circuit Breaker	Characteristics of circuit-breakers; - operation and behaviour in normal service; - operation and behaviour in case of overload and operation and behaviour in case of short-circuit, including co-ordination in service (discrimination and back-up protection); - dielectric properties;.
IEC 60947-2, annex B	Circuit Breaker incorporating residual current protection	
IEC 60947-2, annex F	Additional tests for circuit-breakers with electronic over-current protection	Electronic trip unit (rms current measurement, EMC)
IEC 60664-1	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	Category IV for a rated insulation voltage up to 690 V, class II insulation between the front and internal power circuits
IEC 61000-4-1	Electromagnetic compatibility (EMC) Testing and measurement techniques	EMC Immunity
IEC 61557-12	Combined performance measuring and monitoring devices for electrical parameters	Accuracy class
IEC 60068-2	Environmental testing	Climatic withstand
IEC 755	General requirements for residual current operated protective devices	Class A RCD

1.10 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Comply with relevant IEC, BS EN standards.saso

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 30 deg C and not exceeding 50 deg C.
2. Altitude: Not exceeding 700 m.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.

1.12 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES:

A. Rating: 500 V, 2, 3, 3+N or 4 Pole, load break, short-circuit make, in accordance with IEC 60408, utilization category 22 for heating and lighting loads, category 23 for motor circuits, and with ampere rating shown on the drawings.

B. Design: non-fusible, air-break switch disconnector, single throw, safety type, housed in separate metallic enclosure with arc quenching devices on each pole, making it capable of interrupting at least six times the isolator’s rated current.

C. Isolators shall effectively interrupt the power supply for all line conductors and neutral (where it exists), and simultaneously disconnect the supply for control circuits.

D. Operating mechanism: quick-make, quick-break, independent of operator, with external operating handle mechanically interlocked to prevent opening door unless switch is in open position. Switch disconnector is to have provision for by- passing interlock. Position of handle is to be positive and clearly indicated on cover.

E. Enclosure: general purpose sheet steel for indoor use IP 42, and weather-proof type cast metal or sheet steel for outdoor installations IP 65, unless otherwise required or shown on the drawings. Locking of operating handle is to be possible in open and closed positions.

2.2 MOLDED-CASE CIRCUIT BREAKERS UP TO 630A TRIP UNITS

A. Safety:

1. The power contacts shall be insulated in an enclosure made of a thermosetting. material from other functions such as the operating mechanism, the case, the trip unit and auxiliaries

2. All poles shall operate simultaneously for circuit breaker opening, closing and tripping.

3. MCCBs shall be actuated by a toggle or handle that clearly indicates the three positions: ON, OFF and TRIPPED.

4. In order to ensure suitability for isolation complying with IEC 60947-2 § 7-27.

5. The operating mechanism shall be designed such that the toggle or handle can only be in OFF position (O) if the power contacts are all actually separated, in OFF position, the toggle or handle shall indicate the isolation position.

6. Isolation shall be provided by a double break on the main circuit.

7. MCCBs shall be able to receive a device for locking in the “isolated” position, with up to 3 padlocks, Ø8 maximum.

8. MCCBs shall be designed to prevent access to live parts when the cover is removed.

9. MCCBs shall be equipped with a “push to trip” button in front to test operation and the opening of the poles.

10. MCCB rating, “push to trip” button, performances and contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.

11. For rating frame higher than 250 A MCCBs shall be fitted with metallic filters to reduce effects perceptible from the outside during current interruption.

12. In electronic trip units, protection functions shall be electronically managed independently of measurement function by a dedicated ASIC.

B. Current limitation, selectivity, durability:

1. From 100 A to 630 A rating frame, MCCBs breaking unit shall be made with a double rotary contact to greatly limit let through energy on the installation. For short-circuits, the maximum thermal stress I^2t shall be limited to: 106 A2s for ratings up to 250 A, 5 x106 A2s for ratings between 400 A and 630 A @440V.

2. MCCBs, the current ratings of which are identical with the ratings of their trip units, shall ensure discrimination for any fault current up to at least 35 kA rms, with any downstream circuit-breaker having a current rating less or equal to 0.4 times that of the upstream circuit-breaker @440V.

3. MCCB from 100A with electronic trip unit shall ensure total selectivity with Miniature Circuit breaker up to 40 A @440V.

4. MCCB's manufacturer shall provide selectivity and coordination tables with other devices such as other MCCB, MCB, switches up to 690V.

5. The electrical durability of MCCBs, as defined by IEC 60947-2 standard, shall be at least equal to 3 times the minimum required by the standard.

6. Auxiliaries and accessories:
   a. It shall be possible to equip MCCBs with a motor mechanism for electrically controlled operation. An "auto/manual" switch in front shall, when set to the "manual" position, lock out electrical control; when set to "auto", lock out the manual control; remote indication of "manual" or "auto" mode shall be possible. It shall also be possible to seal the access to the "auto" control. Closing shall take place in less than 80 ms.

7. Following tripping due to electrical faults (overload, short-circuit, earth fault), remote reset shall be inhibited. It shall however be possible if opening was initiated by a voltage release.

8. The operating mechanism shall be of the stored-energy type only.

9. The addition of a motor mechanism or a rotary handle shall in no way affect circuit breaker characteristics.

10. Only three stable tripping mechanism positions (ON, OFF and TRIPPED) shall be possible with the motor mechanism.

11. Suitability for isolation shall be provided by positive contact indication (ON and OFF) in front of the motor mechanism module.

12. MCCBs shall be designed to enable safe on-site installation of auxiliaries such as voltage releases (shunt and undervoltage releases) and indication switches as follows:
   a. Same field installable auxiliary contacts for signalling different functions, as: open/ closed position, fault signal, electrical fault (including electrical leakage) signal, all auxiliaries shall be common for the entire range.
   b. They shall be separated from power circuits.

c. All electrical auxiliaries shall be of the snap-in type and fitted with terminal blocks.
d. Auxiliary function and terminals shall be permanently engraved on the case of the circuit breaker and the auxiliary itself.
e. The addition of auxiliaries shall not increase the overall dimensions of the circuit breaker.
f. The addition of a motor mechanism module or a rotary handle, etc., shall not mask or block device settings.

C. Trip Unit

1. General:
   a. MCCBs shall comprise a device, designed to trip the circuit-breaker in the event of high-value short-circuit currents. This device shall be independent of the thermal-magnetic or electronic trip unit. The breaking will be carried out in less than 10 ms for short-circuit currents above 25In.
   b. MCCBs with ratings up to 250 A shall be equipped with fully interchangeable trip units in order to ensure the protection against overcharge and short-circuit. The trip units shall be either of:
      1) Thermal-magnetic.
      2) Electronic.
   c. MCCBs with ratings over 250 A shall be equipped with electronic trip units.
   d. The trip units shall not augment overall circuit breaker volume.
   e. Trip unit shall be easily interchangeable and easily secured to the MCCB without removing the breaker from the panel.
   f. All electronic components shall withstand temperatures up to 105 °C.
   g. Electronic and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorised access to the settings.
   h. Protection settings shall apply to all circuit breaker poles.
   i. It shall be possible to equip MCCBs with an auxiliary contact signalizing an electrical fault operated by the trip unit.

2. Thermo-magnetic trip unit from 16 to 250 A:
   These trip units shall offer:
   a. Adjustable thermal protection from 0.7 to 1.0 times the current rating.
   b. Fixed magnetic protection for current ratings up to 200 A.
   c. Adjustable (from 5 to 10 times the current rating) for current ratings greater than 200 A.
   d. Adjustable from 9 (or less) to 14 times the current rating for magnetic only motor protection.
   e. It shall be possible to ensure neutral protection. The tripping threshold shall be equal to that of the phases.

3. Electronic trip units from 16A to 630A:

MCCB shall be equipped with a trip unit that offers the appropriate level of performance to fit to the application:
   a. It shall be possible to adjust basic protections with a knob without any power supply or when the main is off.
   b. Electronic trip unit shall be fitted with thermal memory.
   c. The following monitoring functions shall be integral parts of electronic trip units:

1) 2 LED for load indication, one lights above 90% of Ir, and one lights above 105 % of Ir.
2) a test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.

d. MCCBs shall be equipped with a self-test of the connection between the electronic trip unit, the current transformers and the actuator. The self-test will be of positive logic and visible through the flashing of a green LED in case the self-test occurred correctly and the extinction of the LED in case the self-test failed.
e. It shall be possible to equip MCCBs with auxiliary contact to indicate the cause of tripping (long time, short time, instantaneous, earth fault if requested).

4. Electronic trip units for standard application or without measurement and communication.

5. These trip units shall offer:
   a. Long time protection (LT):
      1) Selectable Ir threshold settings from 36% to 100 % of the trip unit rating (by knobs).
   b. Short time protection (ST):
      1) Selectable Isd threshold settings from 1.5xIr to 10xIr (by knob).
      2) Fixed short time delay 40 ms.
   c. Instantaneous protection: fixed threshold between 11 and 15xIn, depending on the rating.

6. Electronic trip units for advanced protection or measurement and communication

Protections:
   a. Long time protection (LT):
      1) Selectable Ir threshold settings from 36% to 100 % of the trip unit rating (by knob).
      2) Selectable temporisation from 0.5s@6Ir to 16s@6Ir
   b. Short time protection (ST):
      1) Selectable Isd threshold settings from 1.5xIr to 10xIr (by knob).
      2) Selectable temporisation from 0 to 0.4s with option I2t ON or OFF.
   c. Instantaneous protection:
      1) Selectable Ii threshold settings from 1.5In to 11 or15xIn, depending on the rating.
   d. Fine adjustment shall be possible by keypad.
   e. Four-pole devices shall be equipped for neutral protection with:
      1) as standard with a 3-position setting : - neutral not protected - neutral tripping threshold equal to half the phase value - neutral threshold equal to the phase value.
      2) or LT protection for Neutral could be set separately up to 1,6xIr_phase.
   f. The following additional protections could be offered according to the MCCB application:
   g. Ground fault protection:
      1) It shall be possible to deactivate the ground fault protection.
      2) It shall be possible to adjust the ground fault protection down to 16A.
   h. Motor protection (unbalance, locked rotor, long start, under load).
   i. Generator protection.

7. Measurement:
   These trip units shall offer measurement without additional module. Measurements shall be either:
   a. Currents: Phases, Neutral, average, max, Or
   b. Currents, voltage, power, Energy, Total Voltage Harmonic distortion, Total current harmonic distortion.
   c. Accuracies of the entire measurement system, including the sensors: shall be:
      1) Current: Class 1 as per IEC 61557-12.
      2) Voltage: 0.5 %.
      3) Power and energy: Class 2 as per IEC 61557-12.
   d. Rogowski current transformers shall be used to ensure accurate measurements from low current up to high currents.
   e. For safety reason, protection functions shall be electronically managed independently of measurement function by a dedicated ASIC.
   f. The measurements shall be displayed on the breaker itself and on a remote system via Modbus communication. In addition to these solutions it shall be possible to connect a remote display.

8. Additional earth leakage protection:
   a. It shall be possible (up to 500 V) to assemble earth fault protection moulded-case circuit breakers by adding a residual current device (RCD) directly to the circuit breaker case. The resulting device shall:
      1) Comply with appendix B of IEC 60947-2 standard.
      2) Be immunised against nuisance tripping as per IEC 60255 and IEC 61000-4 standards.
      3) Be capable of working normally down to -25 °C ambient temperature.
      4) Operate without an auxiliary power supply, i.e. it shall be capable of operating normally on any 2-phase or 3-phase power network with a voltage between 200 V and 440 V, and of tripping the circuit-breaker even in the event of voltage dips down to 80 V.
   b. An option shall allow to use RCD for alarming only.
   c. RCD module shall not exclude some other module or accessories.

D. Communication

1. MCCB shall be equipped easily with MODBUS TCP/IP or MODBUS RS485 communication.
   a. Whatever the trip unit is:
      1) The following information shall be accessible:
         a) ON/OFF position (O/F) / trip indication (SD) / fault-trip indication (SDE).
      2) The following commands shall be possible:
         a) Open / close / reset.
   b. When advanced trip units are used the following information shall be accessible:
      1) Instantaneous and demand values, maximeters / minimeters, energy metering, demand current and power, power quality.
      2) Protection and alarm settings
      3) Time-stamped trip and alarm histories and event tables.
      4) Maintenance indicators.

E. Operating & Maintenance (Electronic trip units):

1. Operating assistance function:
   a. Electronic trip units with measurement and communication capability shall offer operating assistance function:
      1) Indication of fault types (LT, ST, instantaneous, ground fault) faulty phases, Interrupted current.
      2) Trips history.
      3) Alarms history.
      4) Events history (setting changes, test…)
   b. Theses functions and indicators shall be available by remote display, communication or setting PC tool.

2. Alarms:
   a. User shall be able to activate alarms based on measurement (I, U, F, P, Q, S, THD, CosPhi, PF, Idemand, Pdemand,) or counters:
      1) Alarms shall be time stamped.
      2) Alarms could activate a digital output.
      3) Theses functions and indicators shall be available by remote display, communication or setting PC tool.

3. Maintenance indicators:
   a. Electronic trip units with measurement and communication capability shall offer maintenance indicators:
      1) Operation, trip and alarm counters,.
      2) Operating hours counter.
      3) Contact wear.
      4) Load profile.
   b. Theses functions and indicators shall be available by remote display, communication or setting PC tool.

4. Auto-test – Led “Ready”:
   a. MCCB’s electronic trip unit shall be equipped with a self-test of the connection between the electronic trip unit, the current transformers and the actuator, that will not cause the circuit-breaker to trip.
   b. The self-test will be of positive logic and visible through the flashing of a green LED in case the self-test occurred correctly and the extinction of the LED in case the self-test failed.

5. Commissioning and Operating tool:
   a. A test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.
   b. A software tool available for all electronic trip unit shall be provided:
      1) To visualize and configure trip unit parameters.
      2) To create and save setting files.
      3) To display tripping curve.
      4) To set time and date.
      5) To display tripping and alarms histories.

2.3 MOLDED-CASE CIRCUIT BREAKERS 630 TO 1600A TRIP UNITS

A. Safety:

1. The power contacts shall be insulated in an enclosure made of a thermosetting. material from other functions such as the operating mechanism, the case, the trip unit and auxiliaries.

2. The molded case circuit breakers shall provide double insulation of the front face to allow on-site installation of auxiliaries without de-energising the installation. All electrical auxiliaries and accessories such as voltage releases, (shunt or undervoltage type) and auxiliary contacts shall be designed for easy on-site installation.

3. The operating mechanism of the molded case circuit breakers shall be of the fast make and fast break type. Tripping on a fault shall be mechanically independent of the operating handle. The operating mechanism shall be designed to operate all poles of the circuit breaker simultaneously for making, breaking and tripping.

4. It shall be possible to connect the MCCB either with bare cables or bars, isolated or not, without insulation accessories below 500V.

5. MCCBs shall be fitted with metallic filters to reduce effects perceptible from the outside during current interruption.

6. If required, the circuit breaker shall be equipped with a rotary handle.

7. The operating mechanism shall be designed in such a way that the position of the operating handle of the circuit breaker indicates the real position of the main contacts, even if the circuit breaker is equipped with a rotary handle.

8. In order to ensure suitability for isolation complying with IEC 60947-2 § 7-27: The operating mechanism shall be designed such that the handle can only be in OFF position (O) if the power contacts are all actually separated, in OFF position, the handle shall indicate the isolation position.

9. The circuit breaker shall be equipped with a safety interlock which keeps the circuit breaker open if the trip unit is not installed.

10. MCCBs shall be able to receive a device for locking in the “isolated” position, with up to 3 padlocks, Ø8 maximum or keylock (for rotary handle).

11. MCCBs shall be designed to prevent access to live parts when the cover is removed.

12. MCCBs shall be equipped with a “push to trip” button in front to test operation and the opening of the poles.

13. MCCB rating, “push to trip” button, performances and contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.

14. In electronic trip units, protection functions shall be electronically managed independently of measurement and communication function by a dedicated ASIC.

B. Breaking capacity, Current limitation, discrimination, durability:

1. The molded case circuit breakers (except for current-limiting circuit breakers) shall belong to category B as defined in IEC60947-2. Certificates attesting to compliance with these rules shall be established taking into account the following performance levels for the test sequences: service breaking capacity (Ics) equal to at least 50% of the rated ultimate breaking capacity (Icu) and a rated short-time withstand current (Icw) of 19,2kA / 1s (except for current-limiting circuit breakers).

2. The MCCB range will offer several level of Icu capacity up to 65kA @440V or 42kA@690V for Category B and 200kA@440V and 75kA@690V for Category A.

3. If required, current limiting circuit breakers shall be available.

4. The rated ultimate breaking capacity (Icu) of each molded case circuit breaker shall be equal to at least the value of the short-circuit current (Isc) at the point of installation on the electric circuit, unless the upstream circuit breaker makes it possible to ensure coordination (as defined in Appendix A of IEC 60947-2); in this case, the coordination between the two circuit breakers shall be confirmed by manufacturer.

5. MCCB's manufacturer shall provide selectivity and coordination tables with other devices such as other MCCBs, ACB, switches and contactors.

C. Auxiliaries and accessories:

1. The operating mechanism shall be of the stored-energy type only.

2. The addition of a motor mechanism or a rotary handle shall in no way affect circuit breaker characteristics.

3. Suitability for isolation shall be provided by positive contact indication (ON and OFF).

4. The trip units shall not increase overall circuit breaker dimensions.

5. Remote operation:
   a. Coils:
      1) Manually operated circuit breaker could be equipped with one shunt opening release or one undervoltage opening release.
      2) Electrically operated circuit breaker could be equipped with one shunt opening release or one undervoltage opening release in addition to opening and closing order.
      3) Coils shall be designed for continuous-duty.
      4) Voltage release auxiliary power supply:
         a) AC: 24 48 100/130 200/250 277 380/480 VAC.
         b) DC 12 24/30 48/60 100/130 200/250 VDC.
      5) Opening time with shunt opening release 50ms +/- 10ms.
      6) Electrical closing time 60ms +/- 10ms.
   b. Electric motor for spring charge:
      1) Motor auxiliary power supply:
         a) AC: 24 48 100/130 200/250 277 380/415 VAC.
         b) DC 12 24/30 48/60 100/130 200/250 VDC.
      2) Charging time: <=4sec.
      3) Operating frequency <=3 cycles / min.

c. Electrically operated MCCB shall be equipped with anti pumping function: If opening and closing orders occur simultaneously, the circuit breaker shall remain in the open position.

D. Trip Units

1. General:
   a. The high-current molded case circuit breakers shall be available in 3-pole or 4-pole (neutral protection) versions. On 4-pole circuit breakers, a 3-position switch shall be provided to set neutral protection to any of the following levels: unprotected neutral (4P3D), half-protected neutral (4P3D+N/2) or fully protected neutral (4P4D).
   b. The trip units shall not augment overall circuit breaker dimensions.
   c. Trip unit shall be easily interchangeable and easily secured to the MCCB without removing the breaker from the panel.
   d. All electronic components shall withstand temperatures up to 105 °C.
   e. Electronic and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorised access to the settings.
   f. Protection settings shall apply to all circuit breaker poles.
   g. It shall be possible to adjust protections with a knob without any power supply or when the main is off.
   h. Electronic trip unit shall be fitted with thermal memory.
   i. It shall be possible to equip MCCBs with an auxiliary contact signalizing an electrical fault operated by the trip unit.
   j. The following monitoring functions shall be integral parts of electronic trip units:
      1) 1 LED for load indication lighted above 105 % of Ir.
      2) a test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.

2. Trip Unit Protection Functions:
   a. Basic protection (LI) with or without energy measurement.

   These trip units shall offer:
      1) Long time protection:
         a) Adjustable Ir threshold settings from 40% to 100 % of the trip unit rating.
         b) Adjustable tr time delay.
      2) Instantaneous protection:
         a) Adjustable Isd threshold settings from 1.5xIr to 10xIr.

3. Selective protection (LSI) with or without energy measurement.

4. These trip units shall offer:
      1) Long time protection:
         a) Adjustable Ir threshold settings from 40% to 100 % of the trip unit rating.
         b) Adjustable tr time delay.
      2) Short time protection:
         a) Adjustable Isd threshold settings from 1.5xIr to 10xIr.
         b) Adjustable tsd time delay.
      3) Instantaneous protection:

a) Adjustable Ii threshold settings from 2xIn to 15xIn with an OFF position.

5. Selective protection & Ground fault or Earth leakage protection (LSIG) with or without energy measurement.

These trip units shall offer

1) Long time protection.
   a) Adjustable Ir threshold settings from 40% to 100 % of the trip unit rating.
   b) Adjustable tr time delay.
2) Short time protection:
   a) Adjustable Isd threshold settings from 1.5xIr to 10xIr.
   b) Adjustable tsd time delay.
3) Instantaneous protection:
   a) Adjustable Ii threshold settings from 2xIn to 15xIn with an OFF position.
4) Ground fault protection (GF) Or Earth leakage protection:
   a) Adjustable Ig threshold settings Adjustable IΔn threshold settings .
   b) Adjustable tg time delay Adjustable tΔn time delay.

6. Advanced protection trip unit.

In addition to the previous protection functions trip units with Under/Over Voltage, Under/Over Frequency and Reverse Power protection could be proposed.

Trip unit measurement function:

If required by the application, the trip unit shall offer measurement (including energy) without additional module whatever the protection type (LI, LSI, LSIG). Available measurements shall be:

a. Currents.
b. Demand Current, Maxim Demand Current.
c. Voltage, active power, reactive power, power factor.
d. Demand Power, Maxim Demand Power.
e. Energy.
f. Accuracies of the entire measurement system, including the sensors: shall be
   1) Current: 1,5%.
   2) Voltage: 0.5 %.
   3) Power and energy: 2%.
g. Rogowski current transformers shall be used to ensure accurate measurements from low current up to high currents.
h. For safety reason, protection functions shall be electronically managed independently of measurement function by a dedicated ASIC.
i. The measurements shall be displayed on the breaker itself and on a remote system via Modbus communication. In addition to these solutions it shall be possible to connect a remote display.

E. Communication

1. General recommandations:

The circuit breaker shall therefore be equipped with a communicating interface that makes it possible to monitor and control protection unit with information on status, to deliver maintenance information using an open protocol such as Modbus TCP/IP or Modbus RS485 serial line:

a. Energy management: energy saving & optimization.
b. Electrical Distribution network management: protection, monitoring & control.
c. Asset management: use optimization, predictive maintenance, equipment alarming.
d. Transmit data to the BMS or FTP Server.

Communicating interface of the circuit breaker shall offer Ethernet TCP/IP 10/100 Mbps ports to be connected on the building Local Area Network (LAN) and shall offer a real time access to device data by using a standard internet web browser.

2. General characteristics:

The communicating interface comprises:

a. The following information shall be accessible: in accordance with the IEC/EN 60947-5-1 standard for circuit breakers:
    1) ON/OFF position (O/F) / trip indication (SD) / fault-trip indication (SDE).
    2) Cradle management : Draw out position.
b. The following commands shall be possible in accordance with the IEC/EN 60947-5-1 standard:
    1) Open / close / reset.
c. When advanced trip units are used the following information shall be accessible:
    1) Instantaneous and demand values, maximeters / minimeters, energy metering, demand current and power, power quality.
    2) Protection and alarm settings.
    3) Time-stamped trip and alarm histories and event tables.
    4) Maintenance indicators.
d. Gathering digital and analog inputs and controlling output.
e. Energy meter in accordance with the IEC/EN – 62053-21 & 31standard.

3. Communicating Interface functions:

Data shall be collected via Ethernet TCP/IP or ModBus Serial Link networks which circuit breakers, I/O digital and analog input modules, will be connected to communicating interface.

A switchboard display shall be connected via Ethernet TCP/IP network to communicating interface and shall offer a real time direct data access to monitor and control the circuit breaker.

Ethernet Communication interface will be compatible to Device Profile Web Service (DPWS) for discovery on the local area network (LAN).

Communicating interface shall collect:

a. Data from circuit breaker with embedded measurement capability.
b. Logic state of technical devices or equipment.
c. Device alarms with time logs.
d. Temperature analog sensor value.

Communicating interface shall display via web pages:

a. Energy consumption.

b. Electrical data network monitoring.
c. Alarms and events.
d. Energy quality monitoring.
e. Circuit breaker status (open, close, tripped, NA) and indication of fault types (LT, ST, instantaneous, ground fault) faulty phases, Interrupted current.
f. Operation and predictive maintenance monitoring.

Communicating interface shall integrate simple control functions via web pages.

4. Communicating Interface features:

The communicating interface enables an intelligent modular unit (IMU), for circuit breaker to be connected to an Ethernet network or enables gateway to Modbus serial line connection.

An intelligent modular unit is a mechanical and electrical assembly containing one or more products to perform a function in a switchboard (incoming protection, motor command, and control). The modular units are easily installed in the switchboard.

The features of communicating interface are:
a. Dual Ethernet port for simple daisy chain connection.
b. Device Profile Web Service (DPWS) for discovery on the local area network (LAN).
c. Dual Universal Logic Plug (ULP) compliant for advanced connection with Air or Molded Case circuit breaker.
d. Gateway for Modbus-SL connected devices.
e. Embedded set-up web pages.
f. Embedded monitoring web pages.
g. Embedded control web pages.
h. Built-in e-mail alarm notification.
i. The interface mounts on a DIN rail.
j. A stacking accessory enables the user to connect several Modbus interface for Air or Molded Case circuit breaker without additional wiring.
k. The interface must be always supplied with 24 Vdc using an UL listed and recognized limited voltage/limited current or a class 2 power supply with 3 A maximum.
l. The interface provides DC supply to the Modbus interfaces for Air or Molded Case circuit breaker and it is not necessary to supply them separately.
m. The interface indicates the status of the interface, the Ethernet communication dual color ports, ULP and Modbus connections by using LED on the front panel.
n. A locking pad on the front panel of the interface enables or disables to send the remote control commands over the Ethernet network to the interface, and to the other modules of the connected IMU.
o. Pre-defined application adds new functions to the IMU in a simple way:
    1) selection by the application rotary switch on the I/O application module, defining the application with pre-defined input/output assignment and wiring diagram.
    2) No additional setting with the customer engineering tool required. The resources not assigned to the pre-defined application are free for additional user-defined applications: cradle management, breaker operation, cradle management and Energy Reduction Maintenance Setting (ERMS) light and

load control and other custom for protection / control / energy management / monitoring.

p. The firmware can be updated using FTP connection or customer engineering tool.

5. Switchboard display:

Switchboard display will be connected to communicating interface via Ethernet TCP/IP network to offer:

a. Real time display monitoring of devices.
b. Simple control of devices and load.

Switchboard display shall integrate functions to monitor:

a. Energy consumption.
b. Electrical network data.
c. Alarms and events.
d. Energy quality.
e. Equipment or devices status (open, close, tripped, NA) and indication of fault types (LT, ST, instantaneous, ground fault) faulty phases, Interrupted current.
f. Predictive maintenance monitoring in the case of feeder up to 120 Amps.

Switchboard display will integrate functions of simple control of load and devices.

6. Operating and installation principles

a. Positioning, installation and connection of communicating interface.
When the application requires the usage of a communicating interface:
1) The interface enabling communication with the monitoring system (outside the switchboard) could be using a Modbus TCP/IP.
2) The communicating interface shall be positioned in DIN rail for quick viewing of the network set up and status.
3) The communicating interface shall be equipped with plug-in type input/output application module.
4) The communicating interface wire link shall preferably be of the prefabricated type with RJ45 connectors that allow the circuit breaker to be connected to the interface in a single operation and with no risk of error.

b. Operation of the communicating interface:
1) The communicating interface shall be capable of being easily integrated into the installation’s communication network thanks to automatic adaptation of their communication parameters to match those of the network.
2) The Communicating interface shall provide data to the supervisor in Modbus tables, at fixed addresses that require no configuration.
3) The data shall be of the following type described in chapter 3.2.
4) The communication interface shall be capable of having the orders executed by the control device, after having taken into account the device real position.
5) The communicating interface should enable to monitor an analog temperature sensor.

c. Testing of the circuit breaker communication system.
1) The manufacturer shall supply a (software) tool for overall testing of the circuit breaker communication system.

2) The test tool shall supply a report describing the configuration of the circuit breaker communication system with indication of communication parameters.

F. Operation and maintenance:

1. Circuit breaker measurement and communication capability shall offer operating assistance function:
   a. Status of circuit breaker operations: Open/Close/Tripped/NA.
   b. Indication of fault types (LT, ST, instantaneous, ground fault) faulty phases, Interrupted current.
   c. Trips history.
   d. Alarms history.
   e. Events history (setting changes, test…).
   f. These functions and indicators shall be available by remote display, communication or Engineering tool.

2. The communicating interface web pages and switchboard display allow the authorize group to :
   a. Execute one or more reset commands.
   b. Control the following applications remotely:
      1) circuit breaker operations: Open/Close/Tripped/NA
      2) Reset input counters, Reset output counters, Light control, Load control, User-defined output control.
   c. To provide maintenance log information:
      1) Date and time the entry was made, and the name of the user who made it.
      2) Maintenance counter information for the selected device : circuit breaker operation counters, trip and alarm counters, load profile, contact wear counters, and the cradle counters.
   d. To send and display alarms:
      1) User shall be able to activate alarms based on measurement (I, U, F, P, Q, S, THD, CosPhi, FP, Idemand, Pdemand,) or counters.
      2) Alarms shall be time stamped.
      3) Alarms could activate a digital output for local indication.
      4) These functions and indicators shall be available by remote display, communication or Engineering tool.

G. Operating & Maintenance (Electronic trip units):

1. Operating assistance function:
   a. Electronic trip units with measurement and communication capability shall offer operating assistance function:
      1) Indication of fault types (LT, ST, instantaneous, ground fault) faulty phases, Interrupted current.
      2) Trips history.
      3) Alarms history.
      4) Events history (setting changes, test…)
   b. Theses functions and indicators shall be available by remote display, communication or setting PC tool.

2. Alarms:

a. User shall be able to activate alarms based on measurement (I, U, F, P, Q, S, THD, CosPhi, PF, Idemand, Pdemand,) or counters.
b. Alarms shall be time stamped.
c. Alarms could activate a digital output.
d. Theses functions and indicators shall be available by remote display, communication or setting PC tool.

3. Maintenance indicators:
   a. Electronic trip units with measurement and communication capability shall offer maintenance indicators:
      1) Operation, trip and alarm counters.
      2) Operating hours counter.
      3) Contact wear.
      4) Load profile.
   b. Theses functions and indicators shall be available by remote display, communication or setting PC tool.

4. Auto-test – Led “Ready”:
   a. MCCB’s electronic trip unit shall be equipped with a self-test of the connection between the electronic trip unit, the current transformers and the actuator, that will not cause the circuit-breaker to trip.
   b. The self-test will be of positive logic and visible through the flashing of a green LED in case the self-test occurred correctly and the extinction of the LED in case the self-test failed.

5. Commissioning and Operating tool
   a. A test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.
   b. A software tool available for all electronic trip unit shall be provided:
      1) To visualize and configure trip unit parameters.
      2) To create and save setting files.
      3) To display tripping curve.
      4) To set time and date.
      5) To display tripping and alarms histories.

2.4 MOLDED-CASE SWITCHES

A. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

B. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with IEC standards.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION 262816

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. UPS systems.
2. Surge suppression.
3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GTO: Gate turn-off thyristor.

C. IGBT: Isolated gate bipolar transistor.

D. LCD: Liquid-crystal display.

E. LED: Light-emitting diode.

F. NiCd: Nickel cadmium.

G. PC: Personal computer.

H. SPD: Surge protection device.

I. THD: Total harmonic distortion.

J. UPS: Uninterruptible power supply.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of UPS.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring. Detail internal and interconnecting wiring; and power, signal, and control wiring. Differentiate between field-installed and factory-installed wiring and components.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For power quality specialist.

B. Seismic Qualification Certificates: For UPS equipment, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each product, from manufacturer.

D. Factory Test Reports: Comply with specified requirements.

E. Product Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

F. Field quality-control reports.

G. Sample Warranties: For manufacturer's special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than 2 of each.
2. Cabinet Ventilation Filters: three complete sets.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of UPS manufacturer for both installation and maintenance of units required for this Project.

B. Manufacturer Qualifications: A firm who maintains a service center capable of providing training, parts, and emergency maintenance and repairs for equipment at Project site with eight hours' maximum response time.

C. Source Limitations: Obtain the UPS and associated components specified in this Section from a single manufacturer with responsibility for entire UPS installation.

D. Electrical Components, Devices, and Accessories:

1. UPS Units: IEC 62040-1-1.

1.9 WARRANTY

A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Sealed, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 25 deg C.

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	1 minute	1.67	120 cycles

B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. APC by Schneider Electric.
2. Liebert by Emerson.
3. Eaton.

2.2 REQUIREMENTS

A. Automatic operation includes the following:

1. Double Conversion, Standard Efficiency:

a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
c. Power Failure: If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
d. Provide a modular UPS installations, complete with transient voltage surge suppression, rectifier-charger, battery, battery disconnect device, inverter, static bypass transfer switch, remote UPS monitoring provisions.

2. When power is restored at the normal supply terminals of the system, controls shall automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger shall supply power to the load through the inverter and simultaneously recharge the battery.
3. If the battery becomes discharged and normal supply is available, the rectifier-charger shall charge the battery. The rectifier-charger shall automatically shift to float-charge mode on reaching full charge.
4. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch shall switch the load to the normal ac supply circuit without disturbance or interruption.
5. The output power converters shall produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter shall sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
6. The inverter shall be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.

7. Should overloads persist past the time limitations, the automatic static transfer switch shall switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch shall return the load to the UPS system.
8. If the battery is disconnected, the UPS shall supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance:

1. Ambient Temperature for Electronic Components: 0 to 32 deg C.
2. Ambient Temperature for Battery: 5 to 35 deg C.
3. Relative Humidity: Zero to 95 percent, noncondensing.
4. Altitude: Sea level to 1220 m.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to applicable specifications section.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.

B. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
3. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
4. Load is 30 percent unbalanced continuously.

C. Minimum Duration of Supply: : If battery is sole energy source supplying UPS-rated 100% output load current at 100 percent power factor, duration is as shown on drawings.

D. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10 percent and minus 10 percent from nominal voltage.

E. Overall UPS Efficiency: Equal to or greater than 95 percent at 100 percent load, 96 percent at 50 percent load, and 95 percent at 25 percent load.

F. Maximum Acoustical Noise: 50 "A" weighting, emanating from any UPS component under any condition of normal operation, measured at 1000 mm from nearest surface of component enclosure.

G. Maximum Energizing Inrush Current: Six times the full-load current with a Soft start linear input current rise to 100 percent over a 1- to 40-second period, factory set at 10 seconds.

H. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.

I. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.

J. Output Frequency: 50 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.

K. Limitation of harmonic distortion of input current to the UPS shall be as follows:

1. Description:

a. Rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.

L. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current, with a load crest factor of 3.0.

M. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.

N. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain

within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:

1. 50 Percent: Plus or minus 3 percent.
2. 100 Percent: Plus or minus 5 percent.
3. Loss of AC Input Power: Plus or minus 1 percent.
4. Restoration of AC Input Power: Plus or minus 1 percent.

O. Input Power Factor: A minimum of 0.90 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.

P. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

2.4 UPS SYSTEMS

A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.

B. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

C. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

D. Configuration: Multicabinet modular style units.

E. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

F. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

I. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

J. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

K. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.5 SURGE SUPPRESSION

A. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 400-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

2.6 RECTIFIER-CHARGER

A. Description: Voltage source converter, 12-pulse IGBT rectifier.

B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

E. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger shall be matched to the battery type supplied.

2.7 INVERTER

A. Description:

1. Pulse-width modulated, IGBT with sinusoidal output.
2. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.8 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: Plain-language messages on a digital LCD.

1. Quantitative indications shall include the following:

a. Input voltage, each phase, line to line.
b. Input current, each phase, line to line.
c. Bypass input voltage, each phase, line to line.
d. Bypass input frequency.
e. System output voltage, each phase, line to line.
f. System output current, each phase.
g. System output frequency.
h. DC bus voltage.
i. Battery current and direction (charge/discharge).
j. Elapsed time discharging battery.

2. Basic status condition indications shall include the following:

a. Normal operation.
b. Load-on bypass.
c. Load-on battery.
d. Inverter off.
e. Alarm condition.

3. Alarm indications shall include the following:

a. Bypass ac input overvoltage or undervoltage.
b. Bypass ac input overfrequency or underfrequency.
c. Bypass ac input and inverter out of synchronization.
d. Bypass ac input wrong-phase rotation.
e. Bypass ac input single-phase condition.
f. Bypass ac input filter fuse blown.
g. Internal frequency standard in use.
h. Battery system alarm.
i. Control power failure.
j. Fan failure.
k. UPS overload.
l. Battery-charging control faulty.
m. Input overvoltage or undervoltage.
n. Input transformer overtemperature.
o. Input circuit breaker tripped.
p. Input wrong-phase rotation.
q. Input single-phase condition.
r. Approaching end of battery operation.
s. Battery undervoltage shutdown.
t. Maximum battery voltage.
u. Inverter fuse blown.
v. Inverter transformer overtemperature.

w. Inverter overtemperature.
x. Static bypass transfer switch overtemperature.
y. Inverter power supply fault.
z. Inverter transistors out of saturation.
aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.9 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.

C. Input SPD: 80 kA.

2.10 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

3. Switch shall electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but shall allow primary power to the UPS for testing.

B. Mounting Provisions: Internal to system cabinet.

C. Retain paragraph below for externally mounted switch or where static transfer switch must be closed prior to closing the maintenance bypass switch.

D. Key interlock with key that is released only when the rectifier-charger and inverter are bypassed by the static bypass transfer switch. Key shall be required to unlock maintenance bypass/isolation switch before switching from open (normal) position to closed position. Lock shall be designed specifically for mechanical and electrical component interlocking.

2.11 OUTPUT DISTRIBUTION SECTION

A. Panelboards: Comply with Section 262416 "Panelboards," except provide assembly integral to UPS cabinet.

2.12 REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicating five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.13 REMOTE MONITORING

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units for data transmission via RS-485, Ethernet, or web-based link.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
3. Software and Hardware: Compatible with that specified in Section 260913 "Electrical Power Monitoring and Control."
4. Remote monitoring with SNMP and web interface.

2.14 BUILDING MANAGEMENT SYSTEM (BMS)

A. BMS gateway is part of the UPS lot, it shall be provided in order to have a full interface of the UPS with the approved BMS. The adapted gateway shall be as per the approved BMS system (Lonworks, BACnet or others).

2.15 SOURCE QUALITY CONTROL

A. Factory test complete UPS, including battery, before shipment. Include the following tests:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.
6. Efficiency test at 50, 75, and 100 percent of rated full-load current at rated power factor.
7. Efficiency shall be 96% at 50% load and 95% at 100% load.

B. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

2.16 BATTERY

A. Description: VRLA Sealed, Lead-Acid units 10 years life time, factory assembled in an isolated compartment of UPS cabinet, and complete with battery disconnect switch.

1. Arrange for drawout removal of battery assembly from cabinet for test and inspection.

a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

2.17 BASIC BATTERY MONITORING

A. Description: Continuous, real-time capture of battery performance data.

B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

C. Battery compartment high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

D. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

E. Annunciation of Alarms: At UPS control panel and remotely.

2.18 ADDITIONAL BATTERY MONITORING

A. Monitoring features and components shall include the following:

1. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
2. Connections for data transmission via RS-485 link, and network interface and] external signal wiring to computer.
3. External signal wiring and computer are not specified in this Section.
4. USB ports for printer and accessories.
5. PC-based software designed to store and analyze battery data, compile reports on individual-cell parameters and total battery performance trends, and provide data for scheduling and prioritizing battery maintenance.

B. Performance: Automatically measure and electronically record the following parameters on a routine schedule and during battery discharge events. During discharge events, record measurements timed to nearest second; including measurements of the following parameters:

1. Total battery voltage and ambient temperature.
2. Individual-cell voltage, impedance, and temperature, and string current. During battery-discharging events such as utility outages, measures battery and cell voltages, battery string current and records values versus time to nearest second.
3. Individual-cell electrolyte levels.

2.19 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measure and record each discharge event, classify it according to duration category and total discharges according to warranty criteria, and display remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminal. Initiate an alarm for excursions outside the proper float-voltage level.
2. Monitoring: Ambient temperature at battery; initiate an alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provide access to monitored data using front panel display.
4. Alarm Contacts: Arrange to initiate local and remote alarm for battery discharge events, abnormal temperature, abnormal battery voltage or temperature.
5. Memory: Store recorded data in nonvolatile electronic memory.

6. Ethernet Port: Permits downloading of data to a PC.

2.20 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use the same type of batteries that are part of final installation. Include the following:

1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.

C. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection if required for coordination with UPS overcurrent protective device requirements.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
4. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 450-mm centers around the full perimeter of concrete base 150 mm from the outer edge of the base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

F. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

3.3 GROUNDING

A. Separately Derived Systems:

1. If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
2. If part of a listed power supply for a data-processing room, comply with manufacturer's written instructions that include grounding requirements in excess of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify each battery cell individually.

3.5 BATTERY EQUALIZATION

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.6 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:

1. Owner will engage qualified testing agency to administer and perform tests and inspections.
2. Engage qualified testing agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Tests and Inspections:

1. Inspect interiors of enclosures, including the following:

    a. Inspect anchorage, alignment, grounding, and required clearances.
    b. Component type and labeling verification.
    c. Ratings of installed components.

2. Test static transfer from inverter to bypass and back. Use normal load, if possible.
3. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
4. Verify synchronizing indicators for static switch and bypass switches.

    a. Verify correct operation and timing of the following functions:

        1) Normal source voltage-sensing and frequency-sensing relays.
        2) Time delay on transfer.
        3) Alternative source voltage-sensing and frequency-sensing relays.
        4) Automatic transfer operation.
        5) Interlocks and limit switch function.
        6) Time delay and retransfer on normal power restoration.

5. Test direct current system's batteries.

    a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
    b. Verify electrolyte level. Measure electrolyte level, specific gravity, and temperature.
    c. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
    d. Verify all charger functions and alarms.

e. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
f. Perform a load test according to manufacturer's published data or IEEE 450.
g. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
h. Test values.

1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Charger float and equalize voltage levels shall be according to battery manufacturer's published data.
3) The results of charger functions and alarms shall be according to manufacturer's published data.
4) Cell voltages shall be within 0.05 V of each other or according to manufacturer's published data.
5) Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
6) Results of load tests shall be according to manufacturer's published data or IEEE 450.

6. Test communication of status and alarms to remote monitoring equipment.

a. Simulate malfunctions to verify protective device operation.
b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
d. Test output voltage under specified transient-load conditions.
e. Test efficiency at 50, 75, and 100 percent of rated loads.
f. Test remote status and alarm panel functions.
g. Test battery-monitoring system functions.

C. Seismic-restraint tests and inspections shall include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
2. Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

D. The UPS system will be considered defective if it does not pass tests and inspections.

E. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

F. Prepare test and inspection reports.

3.7 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated for each UPS system.

B. Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period

1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

1. Current: Each phase and neutral and grounding conductors.
2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.
5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.
10. Battery cell temperature during charging.
11. Ambient temperature.

D. Monitoring and Testing Procedures:

1. Exploratory Period: For the first two] days of the scheduled monitoring and testing period, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

    a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
    b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.

c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
d. Using loads and devices available as part of the facility's installed systems and equipment, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
e. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing; repeat appropriate monitoring and testing to verify success of corrective action.

E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in the report:

1. Descriptions of corrective actions performed during monitoring and survey work and their results.

2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendations for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes lightning protection system for ordinary structures.

B. Section includes lightning protection system for the following:

1. Ordinary structures.
2. Roof top canopy

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by IEC62305 for bonding of metal bodies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

   a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations.
   b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by IEC 62305.

2. Shop Drawings: Submit the following drawings:
   - Scale drawings showing the nature, dimensions, materials and protection of all component parts of the lightning protection system.
   - Any special earthing arrangements.
   - Type and position of the earth electrodes.
   - Details of earthing pits.
   - As built drawings.

1.6 QUALITY ASSURANCE

A. The Contractor is responsible for the quality of all its purchased items and as such, must develop and submit a supplier quality inspection plan to review. The inspection plan is to cover those items intended for shop inspection and the procedures for carrying out same.

B. Manufacturer: Components of lightning protection system shall be the standard products of a manufacturer regularly engaged in manufacture of components of types and sizes required and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.

C. Codes and Standards: Comply with requirements of the following codes and standards except as herein modified:

1. IEC - International Electrotechnical Commission

2. IEC 62305 Protection of Structures Against Lightning.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Dehn
2. Erico
3. Furse
4. GEC
5. Kingsmill
6. Wallis
7. OBO Bettermann

B. Source Limitations: Obtain components and accessories from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. EN62305 Lightning Protection Standard: Comply with EN62305 requirements for a Class (As per existing) lightning protection system.

2.3 MATERIALS

A. Air Terminals:

1. Horizontal conductors shall be of copper strip tape having a cross section of 25x3mm, or solid round copper conductor of 70 mm2, or as shown on drawings.

2. Base supports shall be of copper bronze or bronze with outside thread for terminal mounting and a bolted type two-piece cable clamp, provided with lead anchors (2 at least) and screws.

3. Materials used in connection with the installation of the lightning protection system shall be approved for lightning protection systems. No combination of materials shall be used that form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture, unless moisture is permanently excluded from the junction of such metals. Bimetallic fittings shall be used unless otherwise impractical or impossible.

4. Where unusual conditions exist which would cause deterioration or corrosion of conductors, conductors with suitable protective coatings or oversize shall be used. If a mechanical hazard is involved, the conductor size shall be increased to compensate therefore or suitable protection shall be provided. The conductors may be protected by covering them with molding or tubing preferably made of wood or nonmagnetic material. If metal tubing is used, the conductor shall be electrically connected to it at its upper part.

B. Ground Loop Conductor: Stranded copper, as shown on drawings,

C. Ground Rods:

1. Material: Solid copper

2. The earth electrode shall be copperweld rod of 16 mm diameter and of an extensive type. It shall have a spike at one end and driving head at the other. The sectional rods shall be coupled with strong bronze couplers. The coupler shall be threaded to fit the rod section. For driving the rod into the ground threaded steel stud shall be used. A brass clamp of suitable size shall be provided for clamping the earth conductor to the earth rod where accessible, cad weld shall be applied elsewhere. The top of earth electrode shall be enclosed in a concrete or brick lined pit with removable concrete or metal cover, where applicable. Earth electrode shall be connected to its associated earth conductor through a link, which will be mounted above ground in an accessible position and as close as possible to the earth electrode. Each link shall comprise a bolted copper link studs, nuts and washers to take earth conductor and bolted lug for the cable connection to the electrode. The length of the electrode shall not be less than 3 m.

3. Where multi-rods are used they shall be separated by a distance of not less than the driven length.

4. The earthing system shall be earthed by sets of earth electrodes. The earth resistance of each electrode shall be measured separately and shall be less than the product by 5 times the number of electrodes to be provided.

5. Earth electrodes shall be linked to earth loop as shown on drawings.

6. Bare copper tape buried at a minimum depth of 600mm shall be used for interconnection of rods.

7. Where soil conditions make the use of rod type electrode impracticable a grid configuration may be used comprising horizontally buried copper tape of dimensions 25mm x 4mm minimum. Tape shall be buried at a minimum depth of 600mm.

D. TEST POINTS

1. Test-linked shall be double bolted copper links of equivalent section as down conductors.

2. Each down conductor shall be provided with a test link.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to IEC62305.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and (203 mm) in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

Install in accordance with manufacturer's instructions.

E. Installation of Lightning System: The lightning protection system shall consist of air terminations, roof cables, down conductors, earth connections and earth terminations securely and electrically interconnected to form the shortest distance practicable to earth without passing through any non-conducting parts of the structure.

F. Air Terminations:

1. Air terminations shall be securely connected to, and made electrically continuous with, the horizontal conductors by means of bolted pressure joints of malleable metal in tee form, connected to the air terminal by a screw coupling. Air terminators shall be secured against overturning by means of suitable brace permanently and rigidly attached to the building.

2. Any metal projections or metal parts that may be struck by the lightning, shall be securely bonded to the conductor of the same unit weight per length as the main conductor.

3. Where metal AC equipment,fans are installed air terminations shall be mounted thereon, where practicable. These air terminations shall be bonded to the ventilator near the top and bottom thereof.

G. Interconnection of Metal Bodies:

1. A metal body situated wholly in the interior of a building, such as a tank, piping system, and stationary machinery, that at any point comes within 1800 mm of a lightning conductor or metal connected thereto, shall be electrically connected with it.

2. For bonding, interconnecting and independent grounding for metallic masses, the conductor used shall be at least a 50 mm square copper wire.

H. Horizontal Conductors:

1. Horizontal conductors shall be fixed directly to the roof. Sharp bends or turns in conductors shall be avoided. Necessary turns shall have a radius of not less than 200 mm. Conductors shall be securely fastened to the roof every 1200 mm.

2. All connections shall be electrically continuous. Roof conductors shall be connected to form a closed loop.

3. Down Conductors: Down conductors shall be electrically continuous from air terminals to earth connection. Down conductors shall preferably be coursed over extreme outer portions of the structure, due consideration being given to the best places for making earth connections and the location of air termination. Down conductors shall be symmetrically spaced about the perimeter of the structure, and shall be protected where necessary, to prevent mechanical injury to the conductor.

4. Interconnection of Metallic Parts: All metal parts such as gutters etc. shall be connected by not smaller than 50 mm square copper wire, directly to earth or to a down conductor.

5. Earth Connection: Earth connections comprising continuations of down conductors from the structure to the earth loop shall be securely connected to the down conductor and ground in a manner to insure electrical continuity between the two. All connections shall be of the clamp type except inaccessible where cad welding shall be applied. There shall be an earth connection for each down conductor. Earth connections shall be protected from mechanical injury. Earth connections shall be provided for all metal pipes entering the building below finished grade at a point immediately outside the foundation wall be means of substantial clamp to which the conductor can be bolted.

6. Earth loops: Down conductors connected shall be earth looped through the earthing loop specified under section “Earthing”. Earth loops shall be set not less than 900 mm and not more than 1500 mm from the structure. The complete installation shall have a total resistance to earth of not more than 5 ohms.

7. Test Links: Test links shall be installed in every down conductor to be located above ground at convenient height to allow testing of the ground terminal system.

8. Inspection by Engineer: The lightning protection system shall be inspected by the engineer to determine conformance with the requirements of this specification. No part or the lightning protection system shall be concealed before inspection by the Engineer.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors or exothermic weld.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Perform inspections to obtain an LPI certification.
   2. On the completion of the installation the following measurements and/or checks shall be made and the results recorded in a lightning protection system log book:
      - The resistance to earth of the earth termination network and of each earth electrode.
      - The results of a visual check of all conductors, bonds and joints or their measured electrical continuity.
   3. If the resistance to earth of a lightning protection system exceeds 5 ohms, the value should be reduced.

END OF SECTION 264113

SECTION 264313 - SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type 1 surge protective devices.
2. Type 2 surge protective devices.
3. Type 3 surge protective devices.
4. Type 4 surge protective devices.
5. Type 5 surge protective devices.
6. Enclosures.
7. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
3. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.
4. Section 262726 "Wiring Devices" for integral SPDs installed by receptacle manufacturer.

1.2 DEFINITIONS

A. I_n: Nominal discharge current (8/20µs).

B. I_{imp}: Impulse current (10/350µs).

C. Imax: Maximum discharge current.

D. Uc: Maximum continuous operating voltage.

E. Up: Voltage protection level.

F. Uoc: Open circuit voltage.

G. U_T: Temporary overvoltage test value.

H. Maximum Continuous Operating Voltage (MCOV): The maximum designated RMS value of the power frequency voltage that may be continuously applied to the mode of protection of an SPD.

I. Metal-Oxide Varistor (MOV): An electronic component with a significant bidirectional, nonlinear current-voltage characteristic.

J. Mode(s), Modes of Protection, or Protection Modes: Electrical paths where the SPD offers defense against transient overvoltages. Examples include: line to neutral (L-N), line to ground (L-G), line to line (L-L), and neutral to ground (N-G).

K. SCCR: Short-circuit current rating.

L. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

M. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

N. Type 3 SPDs: Point of utilization SPDs.

O. Type 4 SPDs: Component SPDs, including discrete components, as well as assemblies.

P. Type 5 SPDs: Discrete component surge suppressors, such as MOVs that may be mounted on a printed wiring board, connected by its leads or provided within an enclosure with mounting means and wiring terminations.

1.3 ACTION SUBMITTALS

A. Product Data: Include manufacturer’s name & SPD model numbers, detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), impulse current (Iimp), nominal discharge current (In), maximum discharge current (Imax), voltage protection level (Up), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.

B. Shop Drawings: Include wiring diagrams showing all factory and field connections with wire and circuit breaker/fuse sizes.

C. Certificates: Manufacturer's documentation of compliance with the following standards:

D. BS EN / IEC 61643.

E. BS EN / IEC 62305.

F. Field Quality Control Test Reports.

G. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

H. The Specialist Lightning Protection manufacturer shall submit details of all surge protection required throughout the project and ensure appropriate surge protectors are provided to offer full safety to the equipment and operators.

I. Operation and Maintenance Data: Include information on status indicators and recommended maintenance procedures and intervals.

J. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

K. Project Record Documents: Record actual connections and locations of surge protective devices.

1.4 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's special warranty.

1.5 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that SPDs perform in accordance with specified requirements and agrees to provide repair or replacement of SPDs that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: Five year(s) from date of Substantial Completion, for labor, materials, and equipment.
2. Follow-On Extended Warranty Period: 10 year(s) from date of Substantial Completion, for materials only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. ABB
2. Eaton
3. Phoenix Contacts
4. Schneider Electric
5. Siemens

B. Source Limitations: Obtain SPDs, overcurrent protective devices, components, and accessories from single source from single manufacturer.

2.2 GENERAL REQUIREMENTS

A. Description: Factory-assembled surge protective devices (SPDs) for 50Hz service; Certified, classified, and labelled as suitable for the purpose intended; system voltage as indicated on the drawings. Subject to compliance with requirements, provide products from the approved vendor list.

2.3 SURGE PROTECTIVE DEVICES FOR LV DISTRIBUTION BOARDS

A. Unless otherwise indicated, provide switchboard internally mounted SPDs.

B. Maximum continuous operating voltage (Uc) of the SPD shall be equal to 110% of the nominal system voltage as a minimum or the next higher rating to ensure the ability to withstand temporary swell over voltages. SPD shall be suitable for a supply mains frequency 50/60 Hz.

C. All installed SPDs shall be connected in common mode to eliminate overvoltage between each phase & earth and between neutral & earth, unless otherwise specified. Correct selection and installation of SPDs is critical for effective protection and this shall be ensured by the supplier. SPDs shall fully comply with BS EN / IEC 61643 product standard series.

D. Choose Type 1 (Test class I) or combined Type 1 + 2 (Test class I+II) SPD when installed at the service entrance (MDB/EMDB/ATS level fed directly from the transformer) and Type 2 (Test class II) when connected on load side of service entrance (SMDB/MCC/MCP level) to reduce the discharge energy. And Type 3 (Test class III) SPDs shall be installed at terminal equipments or in final distribution boards feeding sensitive equipment.

E. Distribution locations of SPDs include MDBs, SMDB's, Motor Control Centers, MCB DBs etc.

F. Type 1 or Type 1 +2 or Test Class I+II SPDs shall utilize MOV or GDT technologies.

G. Provide SPDs utilizing field-replaceable modular protection units.

H. Surge Current Rating: Value of impulse current (Iimp) shall not be less than 12.5kA for each mode of protection as per IEC 60364-5-53. Response time shall not be more than 25ns.

I. Preferred value for the maximum discharge current (Imax) for Type 1 test SPD shall be 50kA and 40kA for Type 2 SPD.

J. Nominal Discharge Current (In): 25 kA for Type 1 + 2 SPD and 20kA for Type 2 SPD.

K. Up Voltage protection level of the SPD shall not be higher than the level of overvoltage category II 2.5kV as per IEC 60364-4 and shall not be higher than 1.5kV if sensitive electronic equipment are to be protected.

L. Diagnostics: SPDs shall have LED/mechanical flag /pop-out indicator to indicate breakdown / end of service life. Volt free auxiliary contact shall be provided for connecting to BMS/PLC for remote monitoring.

M. Length of connecting conductors from the lines to the SPD added to the cable conductor from the SPD to main earth terminal shall be less than 0.5m as per IEC 60364-5-53 or by the manufacturer’s guidelines whichever is more stringent. Cross-section shall not be less than 4 sq.mm for Type 2 SPD and not less than 16 sq.mm for Type 1 SPD.

N. OCPD shall provide protection against SPD short-circuits. Rating of over current protection device (OCPD) provided at the line side of SPDs shall be exactly as per manufacturer’s recommendations.

O. Short Circuit Current Rating (SCCR): Not less than the short circuit current rating of the equipment the SPD is connected to, including any series ratings.

P. End of service life for SPDs shall be given through mechanical flag indication and electrical signaling contacts.

Q. As an alternative, SPDs in compliance with UL 1449 may be considered subject to Engineer’s approval.

2.4 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide OCPD and disconnect for installation of SPD in accordance with manufacturer's instructions.

B. Perform work in a neat and workman like manner in accordance with BS 7671 and local authorities under jurisdiction.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and BS 7671.

D. Provide conductors with minimum ampacity not less than manufacturer's recommended minimum conductor size.

E. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
2. Do not exceed manufacturer's recommended lead length.
3. Do not bond neutral and ground.
4. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 0526 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.

F. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's installation requirements.
4. Inspect and test in accordance with BS 7671 and respective IEC/EN standards.
5. Disconnect SPD prior to performing any high voltage testing on the switchboards.

C. Procure services of a qualified manufacturer's representative to observe installation and assist in inspection, testing, and adjusting. Include manufacturer's reports with field quality control submittals.

D. Nonconforming Work:

1. SPDs that do not pass tests and inspections will be considered defective.
2. Remove and replace defective units and retest.

E. Prepare test and inspection reports.

F. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION 264313

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cylinder.
2. Downlight.
3. Highbay, linear.
4. Highbay, nonlinear.
5. Linear industrial.
6. Lowbay.
7. Recessed, linear.
8. Strip light.
9. Surface mount, linear.
10. Surface mount, nonlinear.
11. Suspended, linear.
12. Suspended, nonlinear.
13. Materials.
14. Luminaire support.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

D. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

E. Product Schedule: For luminaires and lamps.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 300 mm of the plane of the luminaires.
4. Structural members to which equipment and or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Ceiling-mounted projectors.

7. Moldings.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each type of luminaire.

D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Provide luminaires from a single manufacturer for each luminaire type.

B. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

C. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance:

1. Luminaires shall withstand the effects of earthquake motions determined in accordance with the project’s seismic classification.
2. Luminaires and lamps shall be labeled vibration and shock resistant.
3. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

B. Ambient Temperature: 5 to 50 deg C.

1. Relative Humidity: Zero to 95 percent.

C. Altitude: Sea level to 700m.

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories:

1. Listed and labeled by a qualified testing agency, and marked for intended location and application.
2. Comply with the requirements of SASO.

B. Factory-Applied Labels: Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI.

2.3 CYLINDER.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 250 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.4 DOWNLIGHT.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 250 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.5 HIGHBAY, LINEAR.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 250 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.6 HIGHBAY, NONLINEAR.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 250 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.7 LINEAR INDUSTRIAL.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 5,000 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Housing and Rating:
1. IP 54, unless otherwise indicated in the Lighting Fixtures Schedule.
2. IP 66, unless otherwise indicated in the Lighting Fixtures Schedule.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Refer to Lighting Fixtures Schedule.

G. With integral mounting provisions.

H. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.

2.8 LOWBAY

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 5000 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are

designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
   1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

   1. ENERGY STAR certified.
   2. RoHS compliant.
   3. UL Listing: Listed for damp location.

2.9 RECESSED, LINEAR.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

   1. Minimum 1500 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
   2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
   3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable from 100 percent to zero percent of maximum light output.
   6. Internal driver.

C. Housings:
   1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
   1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

   1. ENERGY STAR certified.
   2. RoHS compliant.
   3. UL Listing: Listed for damp location.

2.10 STRIP LIGHT.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 1000 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.11 SURFACE MOUNT, LINEAR.

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 1000 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
   1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

   1. ENERGY STAR certified.
   2. RoHS compliant.
   3. UL Listing: Listed for damp location.

2.12 SURFACE MOUNT, NONLINEAR

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

   1. Minimum 1000 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
   2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
   3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable from 100 percent to zero percent of maximum light output.
   6. Internal driver.

C. Housings:
   1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
   1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

   1. ENERGY STAR certified.
   2. RoHS compliant.
   3. UL Listing: Listed for damp location.

2.13 SUSPENDED, LINEAR

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 1500 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.14 SUSPENDED, NONLINEAR

A. Nominal Operating Voltage: 230 V ac.

B. Lamp:

1. Minimum 1500 lm, unless otherwise indicated in the Lighting Fixtures Schedule.
2. Minimum allowable efficacy of 80 lm/W, unless otherwise indicated in the Lighting Fixtures Schedule.
3. CRI of 80. CCT: as indicated in the Lighting Fixtures Schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

C. Housings:
1. Refer to Lighting Fixtures Schedule.
2. Universal mounting bracket.
3. Integral junction box with conduit fittings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:
   1. Refer to Lighting Fixtures Schedule.

F. With integral mounting provisions.

G. Standards:

   1. ENERGY STAR certified.
   2. RoHS compliant.

2.15 MATERIALS

A. Metal Parts:

   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

   Unless otherwise indicated in the Lighting Fixtures Schedule.

B. Steel:

   1. ASTM A36/A36M for carbon structural steel.
   2. ASTM A568/A568M for sheet steel.

   Unless otherwise indicated in the Lighting Fixtures Schedule.

C. Stainless Steel:

   1. Manufacturer's standard grade.
   2. Manufacturer's standard type, ASTM A240/240M.

   Unless otherwise indicated in the Lighting Fixtures Schedule.

D. Galvanized Steel: ASTM A653/A653M. Unless otherwise indicated in the Lighting Fixtures Schedule.

E. Aluminum: ASTM B209. Unless otherwise indicated in the Lighting Fixtures Schedule.

2.16 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.17 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 13-mm steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Rod Hangers: 5-mm minimum diameter, cadmium-plated, threaded steel rod.

D. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

B. Install lamps in each luminaire.

C. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

D. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

E. Wall-Mounted Luminaires:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaires:

1. Ceiling Mount:

   a. Two 4-mm diameter aircraft cable supports adjustable to 3 m in length.
   b. Pendant mount with 4-mm diameter aircraft cable supports adjustable to 3 m in length.
   c. Hook mount.

2. Pendants and Rods: Where longer than 1200 mm, brace to limit swinging.
3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

H. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.24 "KNX-Based Lighting Controls."

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 265213 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency lighting.
2. Exit signs.
3. Materials.
4. Luminaire support components.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. Correlated Color Temperature (CCT): The absolute temperature, measured in kelvins, of a blackbody whose chromaticity most nearly resembles that of the light source.

B. Color Rendering Index (CRI): Measure of the degree of color shift that objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Lumen (lm): The SI derived unit of luminous flux equal to the luminous flux emitted within a unit solid angle by a unit point source (1 lm = 1 cd-sr).

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of emergency lighting unit, exit sign, and emergency lighting support.

a. Include data on features, accessories, and finishes.
b. Include physical description of unit and dimensions.
c. Battery and charger for light units.
d. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.

e. Include photometric data and adjustment factors based on laboratory tests by, or under supervision of, qualified luminaire photometric testing laboratory, for each luminaire type.

B. Shop Drawings:

1. For nonstandard or custom luminaires.

a. Include plans, elevations, sections, and mounting and attachment details.
b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
c. Include diagrams for power, signal, and control wiring.

C. Samples: For each product and for each color and texture specified.

D. Samples for Initial Selection: For each type of luminaire with factory-applied finishes.

E. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of luminaire.

B. Product Test Reports: For each luminaire for tests performed by, or under supervision of, qualified luminaire photometric testing laboratory.

C. Sample Warranty: For manufacturer’s special warranty.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 20 of each type and rating installed. Furnish at least one of each type.
2. Luminaire-mounted, emergency battery pack: One for every emergency lighting units.
3. Diffusers and Lenses: 20 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: 20 of each type and rating installed. Furnish at least one of each type.

1.6 QUALITY ASSURANCE

A. FM Global Compliance: Luminaires for hazardous locations must be listed and labeled for indicated class and division of hazard by FM Global.

B. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.8 WARRANTY

A. Special Installer Extended Warranty for Emergency and Exit Lighting: Installer warrants that fabricated and installed emergency luminaires and exit signs, including batteries, perform in accordance with specified requirements and agrees to repair or replace components and assemblies that fail to perform as specified within extended warranty period.

1. Extended Warranty Period: Two year(s) from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty for Batteries for Emergency and Exit Lighting: Manufacturer warrants that batteries for emergency luminaires and exit signs perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended warranty period.

1. Extended Warranty Period: Five year(s) from date of Substantial Completion;

PART 2 - PRODUCTS

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 and UL 924 or as approved by local authority having jurisdiction/civil defense, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with:

1. NFPA 101.
2. EN 60598-1 (Luminaires: General requirements and tests).
3. EN 60598-2-22 (Luminaires: Particular requirements. Luminaires for emergency lighting).
4. EN 1838 (Lighting applications: Emergency lighting).
5. ISO 3864 / ISO 7010 (Graphical symbols - Safety colors and safety signs).

6. IEC / EN 61347-2-3 (Particular requirements for a.c. and/or d.c. supplied electronic control gear for fluorescent lamps (Annex J).
7. IEC / EN 61347-2-13 (Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules).
8. IEC / EN 62384 (DC or AC supplied electronic control gear for LED modules – Performance requirements.
9. IEC / EN 62034 (Automatic test systems for battery powered emergency escape lighting).

C. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.

1. Emergency Connection: Operate lamp(s) continuously at full lumens output each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

D. External Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.

1. Emergency Connection: Operate LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Battery: Sealed, maintenance-free, nickel-cadmium type.
4. Charger: Fully automatic, solid-state, constant-current type.

5. Housing: Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly must be located no less than half of distance recommended by emergency power unit manufacturer, whichever is less.
6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.2 EMERGENCY LIGHTING

A. General Characteristics: Self-contained units.

B. Emergency Luminaire
1. Options:
   a. Operating at nominal voltage of 230 V(ac).
   b. Coordinate requirements below with "Emergency Power Units" Article.
   c. Internal emergency power unit for a duration as indicated on drawings.
   d. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.

2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. AWEX
   b. CEAG Cooper / Eaton Company
   c. Emergilite
   d. Sure-Lite
   e. Lithonia

2.3 EXIT SIGNS

A. General Characteristics: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction/civil defense.

B.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. AWEX

b. CEAG Cooper / Eaton Company
c. Emergilite
d. Sure-Lite
e. Lithonia

2. Options:

a. Operating at nominal voltage of 230 V(ac).
b. Lamps for AC Operation:
1) LEDs; 50,000 hours minimum rated lamp life.

c. Self-Powered Exit Signs (Battery Type): Internal emergency power unit for a duration as indicated on layouts.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components must be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Glass: Annealed crystal glass unless otherwise indicated.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 3.175 mm minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing unless otherwise indicated on drawings.
2. Powder coated finish.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, (2.69 mm)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Architect and engineer on site.

B. Tests and Inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

C. Nonconforming Work:

1. Luminaire will be considered defective if it does not pass operation tests and inspections.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support and supervise field tests and inspections.

3.5 SYSTEM STARTUP

A. Perform startup service:

1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect luminaires. Replace lamps, emergency power units, batteries, exit signs, and luminaires that are defective.

a. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

3.7 PROTECTION

A. Remove and replace luminaires and exit signs that are damaged or caused to be unfit for use by construction activities.

END OF SECTION 265213

DIVISION 27

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Underground-line warning tape.
2. Signs.
3. Bands and tubes.
4. Cable ties.
5. Miscellaneous identification products.
6. Labels.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 70 and TIA 606-B.

B. Comply with ANSI Z535.4 for safety signs and labels.

C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 67 deg C, for ambient temperature; and 100 deg C, for material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Equipment Identification Labels:

1. Black letters on a white field.
2. Labelling to be provided for all equipment, racks, boxes, devices…

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Optronics.
   - Opterna
   - Leviton Telecom
   - R& M

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Optronics.
   - Opterna
   - Leviton Telecom
   - R& M

C. Self-Adhesive Wraparound Labels: Preprinted 0.08-mm-thick, polyester flexible labels with acrylic pressure-sensitive adhesive.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - Optronics.
    - Opterna
    - Leviton Telecom
    - R& M
2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
3. Marker for Labels:
    a. Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 0.08-mm- thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - Optronics.
    - Opterna
    - Leviton Telecom
    - R& M
2. Minimum Nominal Size:

    a. 37 by 150 mm for raceway and conductors.
    b. 76 by 127 mm for equipment.
    c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 50 mm long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE".

C. Tag, Nonconducting Polyolefin: Type I:

1. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Width: 75 mm.
3. Thickness: 0.1 mm.
4. Weight: 9.0 kg/100 sq. m.
5. Tensile according to ASTM D882: 133.4 N and 17.2 MPa.

D. Tag, Nonconducting Multilayer Laminate: Type II:

1. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Width: 75 mm.
3. Thickness: 0.3 mm.
4. Weight: 17.6 kg/100 sq. m.
5. Tensile according to ASTM D882: 1780 N and 79.2 MPa.

E. Tag, Detectable: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, [continuous-printed on one side with the inscription of the utility,]compounded for direct-burial service.
2. Width: 75 mm.
3. Overall Thickness: 0.125 mm.
4. Foil Core Thickness: 0.00889 mm.
5. Weight: 13.7 kg/100 sq. m.
6. Tensile according to ASTM D882: 311.3 N and 31.7 MPa.

F. Tag, Detectable, Reinforced: Type IID:

1. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, [continuous-printed on one side with the inscription of the utility,]compounded for direct-burial service.
2. Width: 75 mm.
3. Overall Thickness: 0.2 mm.
4. Foil Core Thickness: 0.00889 mm.
5. Weight: 16.6 kg/100 sq. m.
6. Tensile according to ASTM D882: 1334 N and 86.1 MPa.

2.6 SIGNS

A. Baked-Enamel Signs:
   1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
   2. 6.4-mm grommets in corners for mounting.
   3. Nominal Size: 180 by 250 mm.

B. Metal-Backed Butyrate Signs:
   1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 1-mm galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
   2. 6.4-mm grommets in corners for mounting.
   3. Nominal Size: 250 by 360 mm.

C. Laminated-Acrylic or Melamine-Plastic Signs:
   1. Engraved legend.
   2. Thickness:
      a. For signs up to 129 sq. cm, minimum 1.6 mm thick.
      b. For signs larger than 129 sq. cm, 3.2 mm thick.
      c. Engraved legend with black letters on white face.
      d. Punched or drilled for mechanical fasteners with 6.4-mm grommets in corners for mounting.
      e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

   1. Minimum Width: 5 mm.
   2. Tensile Strength at 23 deg C according to ASTM D638: 82.7 MPa.
   3. Temperature Range: Minus 40 to plus 85 deg C.
   4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

   1. Minimum Width: 5 mm.
   2. Tensile Strength at 23 deg C according to ASTM D638: 82.7 MPa.
   3. Temperature Range: Minus 40 to plus 85 deg C.
   4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

   1. Minimum Width: 5 mm.
   2. Tensile Strength at 23 deg C according to ASTM D638: 48.2 MPa.
   3. UL 94 Flame Rating: 94V-0.

4. Temperature Range: Minus 46 to plus 140 deg C.
5. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.

G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

H. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

3. Provide label 150 mm from cable end.

I. Snap-Around Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 150 mm from cable end.

J. Self-Adhesive Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 150 mm from cable end.

K. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 13-mm- high letters on 38-mm- high label; where two lines of text are required, use labels 50 mm high.

L. Snap-Around, Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

M. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 150 to 200 mm below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 400 mm overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

N. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.

C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.

1. System legends shall be as follows:

a. Telecommunications.

D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation[, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:

1. Wiring closet designation.
2. Colon.
3. Faceplate number.

E. Equipment Room Labeling:

1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing telecom AV, and security equipment designation.
2. Patch Panels: Label individual rows in each rack, starting at top and working down, with self-adhesive labels.
3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:

    a. Room number being served.
    b. Colon.
    c. Faceplate number.

F. Backbone Cables: Label each cable with a vinyl-wraparound label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.

G. Horizontal Cables: Label each cable with a vinyl-wraparound label indicating the following, in the order listed:

1. Room number.
2. Colon.
3. Faceplate number.

H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.

I. Instructional Signs: Self-adhesive labels.

J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels.

1. Apply to exterior of door, cover, or other access.

K. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label.
2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign 100 mm high.
3. Equipment to Be Labeled:

    a. Communications cabinets.
    b. Uninterruptible power supplies.
    c. Computer room air conditioners.
    d. Fire-alarm and suppression equipment.

e. Egress points.
f. Power distribution components.

END OF SECTION 270553

SECTION 271323 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM3).
4. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
5. Optical fiber cable connecting hardware, patch panels, and cross-connects.
6. Cabling identification products.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. RCDD: Registered Communications Distribution Designer.

1.4 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. Cabling administration drawings and printouts.
3. Wiring diagrams to show typical wiring schematics including the following:

    a. Telecommunications rooms plans and elevations.
    b. Telecommunications pathways.
    c. Telecommunications system access points.
    d. Telecommunications grounding system.
    e. Cross-connects.
    f. Patch panels.
    g. Patch cords.

4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Optical fiber cable testing plan.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Product Certificates: For each type of product.

D. Field quality-control reports.

E. Shop Drawings:
1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. Cabling administration drawings and printouts.
3. Wiring diagrams to show typical wiring schematics, including the following:
4. Cross-connects.
5. Patch panels.
6. Patch cords.
7. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
8. Samples: For workstation outlets, jacks, jack assemblies, cables, patch panels, and patch cords.
1. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Patch-Panel Units: 10 of each type.
2. Plugs: 10 of each type.
3. Jacks: 10 of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, and field testing program development
2. Installation Supervision: Installation shall be under the direct supervision of technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI to supervise on-site testing.
2. Maintenance Proximity: Not more than 2 hours' normal travel time from Installer's place of business to Project site.
3. The installer should provide evidence of its establishment in KSA for more than 10 years.
4. The installer should have the highest partnership level with the manufacturer. The partnership should be in place for at least 5 years.
4. The installer should have at least two certified technical persons on each of the proposed manufacturer’s solution.
5. The installer should provide manufacturer’s certified maintenance contracts for each proposed solution(s). These certifications will bound the installer/manufacturer to provide the required hardware replacement/software updates/etc. for each proposed item and for the requested period of one year after date of substantial.
6. The installer should provide evidence of his capability to install such a solution by providing references to similar installations in similar environment minimum of 10 references required, without subcontracting.
7. The installer should demonstrate the capability of local implementation and support by providing the following:
   - CVs of the technical engineers who will be in charge of the implementation of the requested works (minimum two engineers).
   - These engineers should have valid manufacturer’s Certifications that demonstrate their ability to install and troubleshoot the proposed solution.
   - The CVs must provide evidence of their experience in installing the proposed solution in other institutions.
   - Availability of a Project Management team and a minimum experience of 8 years in large scale projects.
   - All personnel involved in the project should have been employed for at least 3 year in the installer company.
8. The installer should have a dedicated Support team. The team capabilities and certifications should be submitted. In addition, they should provide their internal escalation procedure.
9. Spare part list to be detailed with the ability for the client to inspect without prior notice.
10. Spare part list to be detailed with the ability for the client to inspect without prior notice.

11. The installer should submit a Manufacturer authorization letter to supply and install the proposed solution for the client.
12. The installer should be responsible for integration and support coordination for all of the project's hardware and software included in the Bid. Moreover, the installer will be responsible for all required installation, operation and acceptance testing of delivered equipment
13. The installer should provide an implementation plan that includes detailed schedule of events, duration and phases

B. Supplier Qualifications: Supplier shall have minimum 10 years of experience in this field, with at least 2 similar installations in KSA and the gulf. Supplier shall submit a detailed reference list of its projects, along with detailed contact list for each project. Engineer and/or owner shall have the right to call or visit any of the referenced projects and inspect the installation and system operation without notifying the supplier.

C. Source Limitations: Obtain all Structured Cabling equipment (cables, patch panels, patch guides, cabinets, and all related accessories) from single source and from single manufacturer.

B. Source Limitations: Obtain all active components and software from single source from single manufacturer.

1.10 WARRANTY AND SERVICES DURING THE WARRANTY PERIOD

A. The Warranty Period for all components of the Communications Cabling System and their installation shall be a minimum of twenty five (25) years from the date of practical completion and final handover. The date of substantial completion shall be the date when all components have been certified by the Consultant and accepted by the Owner to be complete in accordance with the definition of handover completion.

B. All components and their installations shall be free from defects. Any defective material or workmanship and any resulting damage to work of other trades shall be replaced or repaired as directed during the Warranty Period. Comply with General Conditions, agreeing to repair or replace any components of the Communications Cabling System that have failed within the warranty period.

C. Schedule repair work with the Owner's representative to prevent interference with normal building activities.

D. The Base Bid price shall include the cost of all replacement parts during the warranty period and all of the associated installation costs and all of the costs associated with the repair of components during the warranty period but shall not include the cost of labor for routine maintenance during the warranty period. The cost of labor for routine maintenance during the warranty period shall be provided separately as an Alternate Price as detailed below.

E. Replace or repair all supplied defective installations. Respond and be on site within four hours of the Owner placing a system trouble call for items of an immediate nature (eg: failed component, non-functioning controller, etc.). Response to Warranty call out by the Owner shall be within 24 hours for items not requiring immediate attention. Work to trouble shoot and identify the cause of the Communications Cabling System or component failure shall begin immediately and shall continue until repaired to the satisfaction of the Owner.

F. Any software modifications or upgrades that become standard product offerings from the Communications Cabling System Contractor and/or Communications Cabling System equipment vendors during the warranty period shall be brought to the attention of the Owner and, if the Owner wishes, shall be provided at no additional cost to the Owner.

G. The Communications Cabling System Contractor shall maintain an inventory of common components in the local office for the replacement of failed components.

H. Provide replacement components within the specified time periods for the following components. The subcontractor shall guarantee to the Owner that the delivery of replacement components will be provided within the specified time periods.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

1.12 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.13 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.14 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cable:
   a. AMP Netconnect, USA
   b. Belden
   c. Systimax, USA
   d. Siemon, USA
   e. Leviton, USA.
   f. West Penn, USA

   Or approved equal

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

D. Grounding: Comply with TIA-607-B.

E. The 50/125 micrometer fiber channel shall support single-channel serial transmission, in both the building riser and campus backbones, to 10 gigabits per second (Gb/s) for a distance of 550 meters with 2 LC connections.

F. The 50/125 micrometer fiber channel shall be backward compatible with legacy applications such as: Ethernet, Token Ring, FDDI, Fast Ethernet and ATM for in-building network distances) ensuring a smooth migration path from 10Mb/s to 10 Gb/s using achievable technology.

G. The channel shall support 10 Gb/s short wavelength (850 nm) emerging technology applications using vertical cavity surface emitting lasers (VCSELs) and low bit rate LED applications for legacy systems.

H. The 50 micrometer fiber shall be optimized to control differential mode delay (DMD) so that “pulse splitting” at 10 Gb/s is eliminated.

I. A single manufacturer shall manufacture the 50 micrometer fiber cable, 50 micrometer fiber connectors, 50 micrometer patch cords and apparatus, which comprise the channel.

J. The 50 micrometer fiber shall meet or exceed the following standards, as applicable, for OSP or Plenum cables: ICEA S-83-596, ISO/IEC-794, GR-409, TIA/EIA455, TIA/EIA492,

K. TIA/EIA568-B, ANSI-FDDI, IEEE 802, UL 910, OFNP classification as described in the National Electric Code (NEC2), OFN-LS Low Smoke Cables, CSA Certified (OFN FT4/FT6) and approved component industry standards.

L. The manufacturer shall warrant the 10 Gb/s channel's cable, components, and applications for a period of 25 years.

M. The 25-year warranty shall be a transferable warranty and include all labor to replace any defective components as well as the component replacement.

2.3 62.5/125-MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM1)

A. Description: Multimode, 62.5/125-micrometer, 6 or 12 core fiber as shown on drawings, nonconductive, tight buffer, optical fiber cable.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAA for detailed specifications.

C. Conductive cable shall be steel armored type.

D. Maximum3 Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-Length Product: 200 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Jacket:

1. Jacket Color: Orange
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 1000 mm.

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
1. Plenum Rated, Nonconductive: Type OFNP complying with NFPA 262 and listed for plenum communications raceway.
1. Riser Rated, Nonconductive: Type OFNP, in listed riser or plenum communications raceway.

2.4 50/125 MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM2)

A. Description: Multimode, 62.5/125-micrometer, 6 or 12 core fiber as shown on drawings, nonconductive, tight buffer, optical fiber cable.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAB for detailed specifications.

C. Conductive cable shall be steel armored type.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Jacket:

1. Jacket Color: Orange.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 1000 mm.

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
1. Plenum Rated, Nonconductive: Type OFNP complying with NFPA 262 and listed for plenum communications raceway.
2. Riser Rated, Nonconductive: Type OFNP, in listed riser or plenum communications raceway.

2.5 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM3)

A. Description: Multimode, 62.5/125-micrometer, 6 or 12 core fiber as shown on drawings, nonconductive, tight buffer, optical fiber cable.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAC for detailed specifications.

C. Conductive cable shall be steel armored type.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 1500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Minimum Effective Modal Bandwidth-length Product: 2000 MHz-km at 850 nm.

G. Jacket:

1. Jacket Color: Aqua.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 1000 mm.

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
1. Plenum Rated, Nonconductive: Type OFNP complying with NFPA 262 and listed for plenum communications raceway.
3. Riser Rated, Nonconductive: Type OFNP, in listed riser or plenum communications raceway.

2.6 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM4)

A. Description: Multimode, 62.5/125-micrometer, 6 or 12 core fiber as shown on drawings, nonconductive, tight buffer, optical fiber cable.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAD for detailed specifications.

C. Conductive cable shall be steel armored type.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 3500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Minimum Effective Modal Bandwidth-length Product: 4700 MHz-km at 850 nm.

G. Jacket:

1. Jacket Color: Aqua.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 1000 mm.

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
1. Plenum Rated, Nonconductive: Type OFNP complying with NFPA 262 and listed for plenum communications raceway.
4. Riser Rated, Nonconductive: Type OFNP, in listed riser or plenum communications raceway.

2.7 OPTICAL FIBER CABLE HARDWARE

A. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 900-mm lengths.

D. Connector Type: Type SC complying with TIA-604-3, connectors.

E. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 dB.
3. Marked to indicate transmission performance.

F. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 dB.
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate.

G. Optical Fibre Patch Cords

1. Optical fibre patch cords shall be available in simplex or duplex configurations.
2. 50 micron Multimode fibre patch cords will be provided with OM4 fibre only
3. Fibre patch cords will utilise indoor rated cordage with either LSZH or plenum rating.
5. The following connector types must be available:
    a. LC/UPC (SM and MM), LC/APC (SM) compliant with IEC 61754-20 and TIA 604-10-A
    b. SC/UPC (SM and MM), SC/APC (SM) compliant with IEC 61754-4, IEC 60784- 14 and TIA 604-3

H. Optical Fibre Patch Panels

1. Suitable for mounting in 19” frames within termination closets. Fixed using securing bolts and captive nuts at either side.
2. With sufficient finger space around connectors to allow patch cables to be connected and disconnected and to allow individual connectors to be mounted and dismounted without disturbing other adjacent connectors.

3. In the case of panels housing terminations with maintenance access to rear, using sliding, tilting or other mechanism that does not strain the terminated cables or terminations.
4. Multiple Pre-Stamped Cable Entry points
5. Includes 24 splice bridge, 2 x cable entry glands, Cable tie bridges in base of draw.
6. Patch panel options shall be available with capability of accommodating SC Simplex & Duplex, LC Duplex connectors

I. Optical Fibre Adapters

1. Fibre adapters must be available for single mode or multimode fibre
2. The following fibre adapters must be available in simplex, duplex and ganged adapter configurations as part of distribution modules and panels:
    a. LC adapter compliant with IEC 61754-20 and TIA 604-10-A
    b. SC adapter compliant with IEC 61754-4, IEC 60784-14 and TIA 604-3

J. Optical Fibre Pigtails

1. Optical fibre pigtails shall be available in standard 900 micron tight buffered or ruggedised with additional strength elements.
2. The following connector types must be available:
    a. LC/UPC (SM and MM), LC/APC (SM) compliant with IEC 61754-20
    b. SC/UPC (SM and MM), SC/APC (SM) compliant with IEC 61754-4, IEC 60784-14 and TIA 604-3

K. Optical Fibre Splice Trays

1. Splice trays must be available for the 1U, 2U and 4U shelves to secure fusion splices.
2. Splice trays must be stackable and must accommodate up to 24 single fusion splices in a single tray.

2.8 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.9 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.10 SOURCE QUALITY CONTROL

A. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Comply with NECA 1, NECA 301, and NECA/BICSI 568.

B. General Requirements for Optical Fiber Cabling Installation:

1. Comply with TIA-568-C.1 and TIA-568-C.3.
2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 760 mm and not more than 150 mm from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

9. In the communications equipment room, provide a 3-m- long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 1800 mm long not less than 300 mm in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

3.4 FIRESTOPPING

A. Comply with requirements in Section 078400 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.5 GROUNDING

A. Install grounding according to BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 50-mm clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: Class 3.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 3 level of administration including optional identification requirements of this standard.

C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

E. Cable and Wire Identification:

1. Label each cable within 100 mm of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 4.5 m.
4. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-

coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.

2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

F. End-to-end cabling will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 271323

SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Category 6a twisted pair cable.
   2. Twisted pair cable hardware, including plugs and jacks, patch panels, patch cords, equipment cabinets/racks, power distribution units, connectors, cable managers.
   3. Cabling identification products.
   4. Grounding provisions for twisted pair cable.
   5. Source quality control requirements for twisted pair cable.

1.3 DEFINITIONS

A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

B. EMI: Electromagnetic interference.

C. FTP: Shielded twisted pair.

D. F/FTP: Overall foil screened cable with foil screened twisted pair.

E. F/UTP: Overall foil screened cable with unscreened twisted pair.

F. IDC: Insulation displacement connector.

G. LAN: Local area network.

H. Jack: Also commonly called an "outlet," it is the fixed, female connector.

I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

J. RCDD: Registered Communications Distribution Designer.

K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

L. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

M. S/FTP: Overall braid screened cable with foil screened twisted pair.

N. S/UTP: Overall braid screened cable with unscreened twisted pairs.

O. UTP: Unscreened (unshielded) twisted pair.

1.4 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable cabling system shall provide interconnections between IDF (intermediate distribution frames), and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 9.3 sq. m, and includes the components that extend from the equipment outlets to the station equipment.

C. The maximum allowable horizontal cable length is 90 m. This maximum allowable length does not include an allowance for the length of 4.9 m to the workstation equipment or in the horizontal cross-connect.

D. The Communications Cabling System Contractor shall provide a complete end to end Communications Cabling solution including all equipment racks, fans, shelves, drawers, special power wiring, earth connections, surge suppression, patch panels, copper patch cords, fibre patch cords, cables, connectors and adapters of any kind necessary to accommodate the system installation, operation, testing, or maintenance. Contractor shall provide the appropriate factory or custom rack mount adapters for all equipment installed in the equipment rack, whether specifically itemized or not. Contractor shall cover unused slots using blank panels.

E. Communications Cabling System Contractor shall be responsible for reviewing the containment provisions and confirming their suitability and capacity for the proposed Communications Cabling System.

F. Communications Cabling System Contractor shall provide coordination with the Engineer, Architect, Main Contractor and MEP Contractor as required.

G. Furnish all materials, labor and any engineering services to provide complete and professionally installed Communications Cabling systems in working order as described herein. Labor furnished shall be specialized and experienced in Communications Cabling System installation.

H. The Communications Cabling System telecommunications technicians employed shall be fully trained and qualified by the manufacturer on the installation and testing of the equipment to be installed. Evidence that the vendor is a current, certified installer of the manufacturer must be provided in writing prior to commencing work on the Communications Cabling for the building.

I. The system shall utilize a network of fiber optic, and unshielded twisted pair, riser, tie and station cables. Cables and terminations shall be provided and located as shown and in the quantities indicated within the compiled design documentation.

J. Fiber cables shall terminate on fiber patch panels and/or modular patch panels located in all demarcation and termination points shown on the drawings.

K. All cables and terminations shall be identified at all locations.

L. All cables shall terminate in an alphanumeric sequence at all termination locations.

M. All balanced twisted pair cable terminations shall comply with, and be tested to TIA/EIA568- C standards for Category 6A installations.

N. Design calculations -The Consultant reserves the right to request and review the calculations carried out by the Communications Cabling System Contractor in order to ensure compliance with the specification and standards. As a minimum these calculations shall include, but shall not be limited to, the following:

- Cable sizing
- Schedules of equipment power requirements
- Fibre Loss Budget

1. All calculations shall be submitted in legible formats and in duplicate, clearly set out, cross-referenced to the relevant services section and to any applicable drawings. The calculation shall be dated, checked and signed off by an appropriate and qualified engineer.

2. Calculations shall clearly identify any assumptions made and any departures from the requirements of the specification. Summary sheets shall be attached to calculations, where necessary.

3. The Communications Cabling System Contractor shall allow sufficient time for review of the calculations and further time shall be allowed in the programme for any re- submissions and reviews in the event that the calculations are rejected.

4. The Communications Cabling System Contractor shall produce a full set of documentation and design drawings.

O. The Communications Cabling System Contractor is responsible for verifying the completeness of parts lists, the correctness of the type numbers and the overall suitability of the equipment to meet the main purpose of the specifications. The Contractor, even if not specifically mentioned herein or on drawings, shall supply any additional equipment needed in order to meet the requirements stated above, without claim for additional payment. The Communications Cabling System Contractor must obtain in writing explicit approval from both the Engineer and Consultant for any changes or substitutions to the specification.

P. Furnish and install all equipment items and associated hardware.

Q. Furnish shop drawings and receive consultant approval, prior to fabrication and installation.

R. Furnish and install local Patch Cords and make final connection to Telecommunications Outlets.

S. Furnish Provide calibrated test reports for complete systems.

T. Perform initial adjustments and verification tests. Submit verification test report.

U. Participate in acceptance tests and perform final adjustments.

V. Provide system documentation including copies of all relevant drawings and equipment manuals.

W. Provide maintenance services for the specified period from the date of acceptance.

X. Guarantee all equipment and components for the specified period from the date of acceptance.

Y. Coordination with the Electrical Contractor is required to assure correct containment and conduit, back box locations, and power circuit locations are provided in the correct locations.

1.5 REFERENCES

A. Reference to Standards listed in this section shall include the latest issue, and any amendments thereto, and any Standard in substitution therefore, issued up to 3 months before the closing date for tenders.

B. The design of the Communications Cabling System shall comply with relevant requirements and recommendations of the following ISO and Telecommunications Industry Association (TIA) standards and references:

1. Structured cabling vendors must have 3rd party independent testing verification and approval on a 4 connector cable system approved to ISO/IEC 11801 Ed 2.2.

2. Structured cabling vendors must have 3rd party independent testing verification and approval on the keystone/outlet to a minimum of ISO/IEC 11801 to component level.

3. Structured cabling vendors must have 3rd party independent testing verification and approval on patch cords to a minimum of ISO/IEC 11801 to component level.

4. Current local service provider Standards and Guidelines

5. ISO/IEC 11801 Ed2.2 Information technology – Generic cabling for customer premises

6. IEC 60603-7-51:2010 Connectors for electronic equipment detail specification for 8- way, shielded, free and fixed connectors, for data transmissions with frequencies up to 500 MHz

7. IEC 61156 (all parts), Multicore and symmetrical pair/quad cables for digital communications

8. ISO/IEC TR 14763-1, Information technology – Implementation and operation of customer premises cabling – Part 1: Administration

9. ISO/IEC TR 14763-2, Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation

10. ISO/IEC TR 14763-3, Information technology – Implementation and operation of customer premises cabling – Part 3: Testing of optical fibre cabling

C. The Communications Cabling System Contractor design of the Communications Cabling System shall comply with relevant requirements and recommendations of the following standards and references ANSI/TIA-568-C.0, ANSI/TIA-568-C.1, ANSI/TIA-568-C.2, ANSI/TIA-568-C.3, ANSI/TIA-569-C, ANSI/TIA-606-B, ANSI/TIA-607-B, ANSI/TIA-862-A, ANSI/TIA-942-A, ANSI/TIA-1005, ANSI/TIA-1179, ISO/IEC 11801, ISO/IEC 11801 Class EA, IEEE 802.3af, IEEE 802.3at, IEEE 802.3an, IEEE 802.3ba and IEEE 802.11 standards.

1. ANSI X3T9.5, Requirements for UTP at 100 Mbps.

2. TIA/EIA TSB-125, Guidelines for Maintaining Optical Fiber Polarity Through Reverse-Pair Positioning, 2001.

3. TIA/EIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems (pending).

4. ANSI/TIA-568-C.0, "Generic Telecommunications Cabling for Customer Premises", published 2009 ANSI/TIA-568-C.0, Edition. C Amended. 2, 08-2012

   - Annex A: Centralized Optical Fiber Cabling
   - Annex B: Optical Fiber Polarity
   - Annex C: Multi-Tenant Cabling
   - Annex D: Application Information
   - Annex E: Optical Fiber Field Test Guidelines
   - Annex F: Environmental Classifications

5. ANSI/TIA-568-C.1,"Commercial Building Telecommunications Cabling Standard", published 2009 Edition. C Amended. 2, 05-2012

   - Annex A: Entrance Facilities
   - Annex B: Equipment Rooms
   - Annex C: Telecommunications Rooms and Enclosures
   - Annex D: Backbone Cabling
   - Annex E: Horizontal Cabling
   - Annex F: Work Area

6. ANSI/TIA-568-C.2, "Balanced Twisted-Pair Telecommunication Cabling and Components Standard", published 2009 Edition. C Amended. 04-2014
   - Annex A: Connector Reliability
   - Annex B: Measurement Requirement
   - Annex C: Test Procedures
   - Annex D: Connector Transfer & Impedance Test Method
   - Annex E: Connector Test fixtures
   - Annex F: Multiport Measurement Considerations
   - Annex G: Installation in Higher Temperature
   - Annex H: Propagation Delay Derivations
   - Annex I: Return Loss Limit Derivation
   - Annex J: Modeling Configurations
   - Annex K: NEXT Loss Limit Considerations
   - Annex L: PSAACRF and AFEXT Loss Normalization
   - Annex M: Category x* (x* = 5, 5e, 6, 6a, and 6e) Channel Parameters

7. ANSI/TIA-568-C.3, "Optical Fiber Cabling Components Standard", published 2008, errata issued in October, 2008 Edition. C Amended. 1, 10-2011

   - Annex A: Connector performance specifications, Optical Fiber Cable Connecting hardware adapters and Patch Cords and Fiber Transitions

8. ANSI/TIA-607-B -1 Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises- Addendum 1 for Building electrodes. 2013 January.

9. ANSI/TIA-569-C-1 Telecommunications Pathways and Spaces Addendum 1- Revised Temperature and Humidity Requirements for Telecommunications Space. 2013 February

10. ANSI/TIA-569-C Telecommunications Pathways and Spaces 2012 May.

11. ANSI/TIA-570-C Residential Telecommunications Infrastructure Standard. 2012 August. ANSI/TIA-568-C.0-2 Generic Telecommunications Cabling for Customer Premises Addendum 2, General Updates. 2012 August.

12. ANSI/TIA-1183 Measurement methods and test fixtures for balun-less measurements of balanced components and systems. 2012 August.

13. ANSI/TIA-568-C.1-1 Commercial Building Telecommunications Cabling Standard, Addendum 1 Pathway and Spaces. 2012 May.

14. ANSI/TIA-568-C.0-1 Generic Telecommunications Cabling for Customer Premises-Addendum 1, Updated Reference for Balanced Twisted-Pair Cabling. 2012 April.

15. ANSI/TIA-607-B Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises. 2012 April.

16. ANSI/TIA-606-B Administration Standard for Telecommunications Infrastructure. 2012 June.

17. ANSI/TIA-758-B Customer-Owned Outside Plant Telecommunications Infrastructure Standard. 2012 April

18. ANSI/TIA-1005-A Telecommunications Infrastructure Standard for Industrial Premises. 2012 June.

19. ANSI/TIA-568-C.1-2 Commercial Building Telecommunications Cabling Standard, Addendum 2 General Updates. 2011 November

20. ANSI/TIA-862-A Building Automation Systems Cabling Standard. 2011 April ANSI/TIA-1179, Facility Telecommunications Infrastructure Standard. 2010 July

21. ANSI TSB-155, Guidelines for the Assessment and Mitigation of Installed Category 6A Cabling to Support 10GBASE-T. 2010 March

22. ANSI/TIA-568-C.2 Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted- Pair Cabling Components. 2009 March.

23. ANSI/TIA-568-C.0 Generic Telecommunications Cabling for Customer Premises. 2009 March.

24. ANSI TSB-184, Guidelines for Supporting Power Delivery over Balanced Twisted-Pair Cabling. 2009 July.

25. ANSI TSB-185, Environmental Classification (MICE). 2009 December. ANSI/TIA-568-C.3 Optical Fiber Cabling Components Standard. 2008 June.

26. ANSI TSB-162, Telecommunications Cabling Guidelines for Wireless Access Point. 2006 March.

27. ISO 11801 Class EA Cables

28. Institute of Electrical & Electronics Engineers Seventeenth Edition IEEE 802.1 - LAN/MAN Bridging and Management.

29. IEEE 802.3 - CSMA/CD Access Methods.

30. IEEE 802.3af, Power over Ethernet (PoE) Standard IEEE 802.3at, Power over Ethernet+ (Plus) Standard

31. IEEE 802.3an, Physical Layer and Management Parameters for 10 Gbps Operation, Type 10G BASE-T

32. IEEE 802.3ba Media Access Control Parameters, Physical Layers and Management Parameters for 40 Gbps and 100 Gbps Operation

33. IEEE 802.11, Wireless Standard IEEE 802.11 - Wireless LAN's.

In addition to the standards listed above, all applicable local building code, safety, environmental and other requirements shall be met.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration Drawings and printouts.
4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:

    a. Telecommunications rooms plans and elevations.
    b. Telecommunications pathways.
    c. Telecommunications system access points.
    d. Telecommunications grounding system.
    e. Telecommunications conductor drop locations.
    f. Typical telecommunications details.
    g. Mechanical, electrical, and plumbing systems.

C. Twisted pair cable testing plan.

D. Samples: For telecommunications jacks and plugs, **in specified finish, one for each type and configuration and faceplates for color selection and evaluation of technical features**. Faceplates are as specified in Section 262726 "Wiring Devices."

E. Before proceeding with any manufacturing or ordering the Contractor shall submit shop drawings for approval in complete bound sets indexed by specification number to the Client in accordance with the Contractors program of works. A description of all items submitted shall be included. Manufacturer's specification or data sheets shall be clearly marked to delineate the options or styles to be furnished.

F. Plans and elevations of the Structured Cabling Systems equipment racks quantifying all equipment to be mounted therein and including notes detailing their fabrication. All materials, methods for construction and finishes shall be fully detailed and coordinated with all other service disciplines.

G. Elevations of equipment racks identifying each item of equipment to be installed within the rack in the exact positioning.

H. Interconnection diagrams showing a detail of each device and interconnect wiring between devices. Block diagrams involving cross-referencing to catalogue specification sheets will not be acceptable.

I. Catalogue literature with performance specifications, which indicate compliance to the specifications herein.

J. Complete instruction manuals, service manuals, parts lists, and current list of local manufacturer approved service centers.

K. System provider/installer shall provide all additional information or demonstrations required by the Owner and Engineer to demonstrate conformance with the specifications herein.

L. Itemized list of all equipment and materials to be used in assembling the system

M. Schematic diagrams including all wiring labels. All diagrams shall be detailed not schematic defining the interconnection of all inputs and outputs for all equipment. Diagrams shall indicate exact equipment counts.

N. Drawings of all items that are to be custom fabricated or modified. Drawings shall be of scale suitable for use in fabrication. They shall show materials, finishes and panel/control markings.

O. The above listed drawings shall be produced on CAD or other computer graphics workstation, or by a professional draftsperson. Photocopies or other reproductions of the specifications or drawings are not acceptable.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **Installer,** installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

D. Field quality-control reports.

E. Submit the following according to Conditions of the Main Contract.

F. Provide manufacturer’s catalog information showing dimensions, colors, and configurations.

G. The contractor shall submit the below along with other relevant documents to obtain approval, prior to commencing work on-site.

a. Current Independent 3rd Party Component Compliance Certification, indicating manufacture and component reference, for all copper items to be installed and supplied.

b. 4 Connector Channel certification for the end to end Cat6A UTP system

c. Site Inspection Report Template - from the Manufacturer

d. Manufactures' literature for products installed.

e. Physical Infrastructure warranty (25-Years) Template from Manufacturer.

f. Template of warranty against defective parts or workmanship for a minimum of 1 year after Practical Completion.

H. Submittals shall include all items called for in PART 2 – PRODUCTS of this document and the manufacturers cut sheets for the following:

a. All fiber optic and balanced twisted pair cable: to include patch cords, cross connect wire and cross connect cordage.

b. All connectors and required tooling.

c. All termination system components for each cable type.

d. All grounding and surge suppression system components.

e. All test equipment to be used for fiber and balanced twisted pair channels

f. A Performance Specification showing manufacturer's Guaranteed Channel Performance over the full swept frequency range.

g. Technical data sheets shall include the physical specifications as well as the following electrical and transmission characteristics for balanced twisted pair channels:

- Mutual Capacitance
- Characteristic Impedance
- DC Resistance
- Insertion Loss (IL)
- Pair-to-Pair Near End Crosstalk (NEXT)
- Power Sum Near End Crosstalk (PSNEXT)
- ACR-F (previously known as ELFEXT)
- Power Sum ACR-F (PSACR-F)
- Alien NEXT (ANEXT)
- Power Sum Alien NEXT (PSANEXT)
- Alien ACR-F (AACR-F)
- Power Sum Alien ACR-F (PSAACR-F)
- Return Loss (RL)
- Propagation delay
- Delay Skew

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Project Record Drawings: Prepare and submit four copies of manuals containing:

C. Warranties, guarantees, and manufacturer's directions on equipment and material provided. Replacement parts lists of major items of equipment. Equipment brochures, wiring diagrams, control diagrams and control programming including cable numbers and signal levels. Approved shop drawings including details of fabricated items.

D. Operation Instructions and description of system components and their relationship to the system function (bound separately).

E. All “as-built” drawings to be provided both in electronic form (ACAD R2015 or later, DWG or DXF) and five sets in hard copy.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Connecting Blocks: 10 of each type.
2. Faceplates: 10 of each type.
3. Jacks: **Ten** of each type.
4. Multiuser Telecommunications Outlet Assemblies: **One** of each type.
5. Patch-Panel Units: **One** of each type.
6. Plugs: **Ten** of each type.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings **and Cabling Administration Drawings, and field testing program development shall be under direct supervision of engineer.**
2. Installation Supervision: Installation shall be under the direct supervision of **technician**, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI to supervise on-site testing.
1. Maintenance Proximity: Not more than 2 hours' normal travel time from Installer's place of business to Project site.
2. The installer should provide evidence of its establishment in KSA for more than 10 years.
4. The installer should have the highest partnership level with the manufacturer. The partnership should be in place for at least 5 years.
3. The installer should have at least two certified technical persons on each of the proposed manufacturer’s solution.
4. The installer should provide manufacturer’s certified maintenance contracts for each proposed solution(s). These certifications will bound the installer/manufacturer to provide the required hardware replacement/software updates/etc. for each proposed item and for the requested period of one year after date of substantial.
5. The installer should provide evidence of his capability to install such a solution by providing references to similar installations in similar environment minimum of 10 references required, without subcontracting.
6. The installer should demonstrate the capability of local implementation and support by providing the following:
   - CVs of the technical engineers who will be in charge of the implementation of the requested works (minimum two engineers).
   - These engineers should have valid manufacturer’s Certifications that demonstrate their ability to install and troubleshoot the proposed solution.
   - The CVs must provide evidence of their experience in installing the proposed solution in other institutions.
   - Availability of a Project Management team and a minimum experience of 8 years in large scale projects.
   - All personnel involved in the project should have been employed for at least 3 year in the installer company.

7. The installer should have a dedicated Support team. The team capabilities and certifications should be submitted. In addition, they should provide their internal escalation procedure.
8. Spare part list to be detailed with the ability for the client to inspect without prior notice.
9. Spare part list to be detailed with the ability for the client to inspect without prior notice.
10. The installer should submit a Manufacturer authorization letter to supply and install the proposed solution for the client.
11. The installer should be responsible for integration and support coordination for all of the project's hardware and software included in the Bid. Moreover, the installer will be responsible for all required installation, operation and acceptance testing of delivered equipment
12. The installer should provide an implementation plan that includes detailed schedule of events, duration and phases

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an **RCDD**.

C. Supplier Qualifications: Supplier shall have minimum 10 years of experience in this field, with at least 2 similar installations in KSA and the gulf. Supplier shall submit a detailed reference list of its projects, along with detailed contact list for each project. Engineer and/or owner shall have the right to call or visit any of the referenced projects and inspect the installation and system operation without notifying the supplier.

D. Source Limitations: Obtain all Structured Cabling equipment (cables, patch panels, patch guides, cabinets, and all related accessories) from single source and from single manufacturer.

B. Source Limitations: Obtain all active components and software from single source from single manufacturer.

1.11 WARRANTY AND SERVICES DURING THE WARRANTY PERIOD

E. The Warranty Period for all components of the Communications Cabling System and their installation shall be a minimum of twenty five (25) years from the date of practical completion and final handover. The date of substantial completion shall be the date when all components have been certified by the Consultant and accepted by the Owner to be complete in accordance with the definition of handover completion.

F. All components and their installations shall be free from defects. Any defective material or workmanship and any resulting damage to work of other trades shall be replaced or repaired as directed during the Warranty Period. Comply with General Conditions, agreeing to repair or replace any components of the Communications Cabling System that have failed within the warranty period.

G. Schedule repair work with the Owner's representative to prevent interference with normal building activities.

H. The Base Bid price shall include the cost of all replacement parts during the warranty period and all of the associated installation costs and all of the costs associated with the repair of components during the warranty period but shall not include the cost of labor for routine maintenance during the warranty period. The cost of labor for routine maintenance during the warranty period shall be provided separately as an Alternate Price as detailed below.

I. Replace or repair all supplied defective installations. Respond and be on site within four hours of the Owner placing a system trouble call for items of an immediate nature (eg: failed component,

non-functioning controller, etc.). Response to Warranty call out by the Owner shall be within 24 hours for items not requiring immediate attention. Work to trouble shoot and identify the cause of the Communications Cabling System or component failure shall begin immediately and shall continue until repaired to the satisfaction of the Owner.

J. Any software modifications or upgrades that become standard product offerings from the Communications Cabling System Contractor and/or Communications Cabling System equipment vendors during the warranty period shall be brought to the attention of the Owner and, if the Owner wishes, shall be provided at no additional cost to the Owner.

K. The Communications Cabling System Contractor shall maintain an inventory of common components in the local office for the replacement of failed components.

L. Provide replacement components within the specified time periods for the following components. The subcontractor shall guarantee to the Owner that the delivery of replacement components will be provided within the specified time periods.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

1.13 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.14 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.15 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for **two** years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within **two** years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide **30** days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. 1- Cable:

   a. AMP Netconnect, USA
   b. Belden
   c. Systimax, USA
   d. Siemon, USA
   e. Leviton, USA.
   f. West Penn, USA

   Or approved equal

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.3 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685 **or Type CMP in listed plenum communications raceway**.
2. Communications, Non-plenum: Type CMR complying with UL 1666 **and ICEA S-103-701**.

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: **25** or less.
2. Smoke-Developed Index: **50** or less.

C. RoHS compliant.

2.4 CATEGORY 6a TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, **with internal spline,** certified to meet transmission characteristics of Category 6a cable at frequencies up to 500MHz.

B. Standard: Comply with TIA-568-C.2 for Category 6a cables.

C. Conductors: 100-ohm, 23 AWG solid copper.

D. Cable Rating: **Plenum**.

E. Jacket: **White** thermoplastic.

F. The solution must consist of a complete end-to-end UTP Channel from a single manufacturer including horizontal cable, patch cords and RJ45 Plugs and Modules.

G. Horizontal cables shall each consist of eight 23 AWG insulated, solid conductors, formed into four individually twisted pairs. Outer sheath shall be of a material that does not give off toxic fumes in case of fire and with flame propagation retardant property (LSZH).

H. Cable proposed shall meet IEC 60332-1 Fire performance standard, IEC 61034 Smoke Emission standard and IEC 60754 Acid Emission standards.

I. The performance of the SCS Contractors Horizontal structured system being provided shall meet ISO 11801: Ed2.2, ISO 60603-7-5, ISO 61156-5, EN 50173-1, EN50310

J. Standards operating at frequencies up to 500Mhz, supporting Voice, Data & Video applications at data rates of up to 10Gbit/s to full 100m channel requirements.

K. The Category 6A Class EA UTP Structured Cabling System (SCS) shall comply with the following requirements:

- ISO/IEC 11801:2010
- EN 50173-1:2011
- EN 50173-2:2010
- ANSI/TIA-568-C e. IEC 60603-7-4
- IEEE 802.3 applications
- Local/National Codes and Regulation

L. All Category 6A high performance cables shall the following specification: Conductor 23AWG, Solid Plain Copper

Insulation	Foamed Polyethylene
Outer Sheath	Flame resistant, Low Smoke Zero Halogen
Outer Diameter	6.90 mm +/- 0.2mm
Installation Temperature	Temperature Range 0°C to +60°C
Operating Temperature Range	Temperature Range -20°C to +60°C
Minimum Bend Radius	60mm (during installation)
Minimum Bend Radius	31mm (during operation)
Flame Retardance	IEC 60332-1
Smoke Emission	IEC 61034
Average weight per metre	0.06 Kg/m
NVP	76%
Construction	IEC 61156-5 ed2.0 Augmented Category

M. The Category 6A/ Class EA UTP SCS shall be capable of supporting, at minimum, the following IEEE Ethernet applications:

- 802.3e 1BASE5

- 802.3i 10BASE-T 10 Mbit/s over twisted pair
- 802.3u 100BASE-TX, 100BASE-T4, Fast Ethernet at 100 Mbit/s w/auto negotiation
- 802.3y 100BASE-T2 100 Mbit/s (12.5 MB/s) over low quality twisted pair
- 802.3z 1000BASE-X Gbit/s Ethernet over Fibre-Optic at 1 Gbit/s
- 802.3ab 1000BASE-T Gbit/s Ethernet over twisted pair at 1 Gbit/s
- 802.3af Power over Ethernet (12.95 W)
- 802.3an10GBASE-T 10 Gbit/s Ethernet over unshielded twisted pair
- 802.3at Power over Ethernet enhancements (25.5 W)
- 802.3az Energy Efficient Ethernet

N. The SCS must consist of individual components provided by the same manufacturer. “Mix and Match” products are not allowed as there is no guarantee that the overall channel will meet Category 6A or Class EA Channel requirements if constructed with components from different vendors.

O. The components provided shall consist of:

- Horizontal cable
- Information Outlets
- Patch Panels
- Patch-cords
- Zone cords (outlet-to-plug)

P. When configured in worst-case 100 metre channels with full cross-connects and consolidation points with the other products proposed, the cable shall be capable of delivering the minimum guaranteed channel performance specified in above section

Q. The length of each individual run of horizontal cable from the telecommunications closet on each floor to the telecommunications outlet shall not exceed 90 metres, and shall be continuous without any joints or splices.

R. Contractor shall observe the bending radius and pulling strength requirements of the 4 pair UTP cable during handling and installation.

S. The cable and cordage shall be available in Plenum, Non-Plenum and Low-Smoke, Zero Halogen (LSZH) and Outside Plant compatibility.

T. The LSZH version must comply with the following Fire Safety standards:

- ISO/IEC 60332-1-22: Vertical Flame Spread
- ISO/IEC 60754-2: Acidity
- ISO/IEC 61034-2: Smoke Density

U. 3rd Party verification of the Fire Safety/ Environmental tests listed above must be provided as part of the bid response.

V. The print string will indicate amount of cable remaining on the reel.

2.5 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements of **Category 6a**
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

C. Source Limitations: **Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source.**

D. Connecting Blocks:

1. 110-style IDC for Category 5e.
2. 66-style IDC for Category 5e.
3. 110-style IDC for Category 6.
4. 110-style IDC for Category 6a.
5. Provide blocks for the number of cables terminated on the block, plus **25** percent spare, integral with connector bodies, including plugs and jacks where indicated.

6. Number of Terminals per Field: **One** for each conductor in assigned cables.

E. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

   a. Universal T568A and T568B wiring labels.
   b. Labeling areas adjacent to conductors.
   c. Replaceable connectors.
   d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 483 mm equipment racks.
3. Number of Jacks per Field: One for each four-pair **cable indicated, plus spares and blank positions adequate to suit specified expansion criteria**.
4. The Panels shall be available in Modular, IDC Based & Pre-Terminated Options
5. Angled side-by-side Presentation of Chrome Finish
6. Front connectors to be angled RJ45 style
7. Front presentation of Jack outlet to be angled at 45 degrees
8. Rear cable presentation to be 180 degrees shall be compatible with mounting on 19” based hardware per IEC 60297 and EIA-310-D.
9. The patch panel type shall be compliant with IEC 60603-7-4.
10.
11. 3rd Party Verification test certificates shall be provided to show compliance to ISO/IEC 11801 testing for Category 6A components.
12.
13. When configured in worst-case 100 metre channels with full cross-connects and consolidation points with the other products proposed in this tender, the panel shall be capable of delivering the minimum guaranteed channel performance specified.

F. Patch Cords: Factory-made, four-pair cables in **1200-mm** lengths; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.

2. Cords shall be equipped with 8-pin modular plugs on each end.

3. All cords shall be round, and consist of copper conductors, tightly twisted into individual pairs.

4. Plugs shall be designed with an anti-snag latch to facilitate easy removal during move, add and change processes.

5. The cordage must be available in the following options:

   a. 8 solid 23 AWG copper conductors.
   b. 8 stranded AWG copper conductors
   c. Copper clad aluminum is not permitted.

6. The cordage shall be Low-Smoke, Zero Halogen (LSZH) outer jacket.

7. The LSZH version must comply with the following Fire Safety standards:

   a. ISO/IEC 60332-1-22: Vertical Flame Spread
   b. ISO/IEC 60754-2: Acidity
   c. ISO/IEC 61034-2: Smoke Density

8. 3rd Party verification of the Fire Safety/ Environmental tests listed above must be provided as part of the bid response.

9. 3rd Party Verification test certificates shall be provided to show compliance to ISO/IEC 11801 for Category 6A components.

10. The patch cords will have insertion life of 750 cycles minimum.

11. When configured in worst-case 100 metre channels with full cross-connects and consolidation points with the other products proposed in this tender, the patch cords shall be capable of delivering the minimum guaranteed channel performance specified in section 2.1.

G. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.
3. Marked to indicate transmission performance.

H. Field Terminatable Connectors

1. Field terminatable tool free connectors from the vendor shall be available and covered as part of the 25 Year Warranty program.
2. The male connectors proposed shall have 3rd party certification to ISO/IEC 11801 Ed 2.2.

I. Zone Cords:

1. The Category 6A/Class EA SCS shall provide an option for factory-terminated zone cabling
2. The cordage used in the zone cords shall meet all requirements specified.
3. Zone cord connector types shall be an unshielded modular 8-pin connector compliant with IEC 60603-7-4.
4. Zone cables shall consist of solid 23 AWG or stranded copper cabling with factory terminated plug on one end and a factory terminated information outlet on the other end.

J. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.
5. Unless otherwise noted on the floor plans or within this document, all voice, data and video wall outlets shall be as follows:

    a. 8-position/ 8-conductor modular outlets
    b. Insulation displacement
    c. Support Universal applications in a multivendor environment, accepting modular RJ-45 plugs.
    d. Provided with blank module inserts for all unused module locations. Jack module arrangement is shown on the drawings. Provide color coded inserts at each outlet, termination block and at patch panels as shown on the drawings.
    e. Mounted in one, two or three gang utility outlet boxes.
    f. Equipped with EIA/TIA-T568A and EIA/TIA-T568B universal wiring labels.
    g. All Category 6A outlets shall meet or exceed Category 6A/ Class EA transmission requirements when installed in a complete channel, as specified in draft TIA/EIA 568-C.2: 2009 Commercial Building Telecommunications Cabling Standard and ISO/IEC 11801 Ed2.2. The Category 6A outlets shall be backward compatible with Category 6, 5e, 5 and 3 cords and cables.
    h. The Category 6A outlets shall be of a universal design supporting T568A & B wiring.
    i. The Keystone/outlet shall have current independent third-party approval status to a minimum of ISO/IEC 11801 component level.
    j. The Category 6A outlets shall be capable of being in a modular patching situation or as a modular telecommunication outlet (TO) supporting current 10BASE-T, Token Ring, 100 Mbps TP-PMD, 155 Mbps ATM, 622 Mbps ATM using parallel transmission schemes and evolving high-speed, high-bandwidth applications, including Ethernet, 1000BASE-T and 10GBASE-T.
    k. The Category 6A outlets shall be capable of being installed at either a 450 or a 900 angle in any M-series modular faceplate, frame, or surface-mounted box avoiding the need for special faceplates.
    l. The Category 6A outlets shall have improved pair splitters and wider channel for enhanced conductor placement. The outlet shall also have a low-profile wire cap, which protects against contamination and secures the connection. Multicolored identification labels shall be available to assure accurate installation.
    m. Support Universal applications in a multivendor environment, accepting modular RJ-Telecommunication outlet modules shall be compatible with modular faceplates.

K. Faceplate:

1. **Two**/**Four** ports, vertical single gang faceplates designed to mount to single gang wall boxes.
2. **Six/Eight** ports, vertical double gang faceplates designed to mount to double gang wall boxes.
3. Plastic Faceplate: as specified in Section 262726 "Wiring Devices."
4. Metal Faceplate: **Stainless steel**, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

    a. Flush mounting jacks, positioning the cord at a 45-degree angle.

L. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

M. Equipment Cabinets (IDF/telecom racks)

1. The Contractor shall supply & install free-standing equipment cabinets for the telecom rooms.
2. Freestanding equipment cabinet shall provide front and rear support for 19” W (482.6 mm) EIA rack-mount equipment and shelves.
3. The required minimum dimensions are: (42U) x 800mm x 800 mm (HxWxD)
4. Equipment mounting rails, two pairs
5. The cabinet shall meet the following functionality requirements:
    a. Welded steel and bolted aluminium four-post frame
    b. Equipment mounting rails, two pairs
    c. Levelling feet and casters
    d. Floor attachment brackets
    e. PDU brackets, one pair, for mounting two horizontal PDUs
    f. Double Perforated front door 78% open per secure section
    g. Double perforated rear door 78% open per secure section
    h. Front door shall open to 120° when bayed, 145° when not bayed
    i. Rear door shall open to 180° when bayed or not bayed
    j. Doors shall attach to cabinet frame using hinge pins to allow easy removal during maintenance
    k. Doors shall be reversible to open from the right or left and interchangeable front or rear and feature a swing handle with Access controlled, auditable lock
    l. Doors shall include a tamper alarm, such that any entry into a cabinet section create a recorded alarm.
    m. Side panels shall have cable brush port openings to allow rack to rack patching
    n. Side panels shall be split to accommodate each secure section of the rack
    o. Top panel shall be a one-piece solid panel with four large brush grommets over cable openings, one per corner
    p. Unsealed openings dimension shall be 114 mm x 228 mm
    q. A Finger Cable Manager that attaches to the equipment mounting rail creating a pathway for cables next to the rail and includes plastic T-shaped cable guides (fingers) that organize cables by rack-mount space (U) shall be provided.
    r. In server equipment racks, one cable manager shall be installed at the rear right of the cabinet
    s. In Network and cabling racks, two cable managers shall be provided at the front of the cabinet

6. Equipment support:
    a. Two pairs of mounting rails in the cabinet
    b. Adjustable depth, rails slide front-to-back; marks on frame for easy vertical alignment
    c. 44.45 mm U spacing, marked and numbered on all rails
    d. 19” W, EIA-310-E Universal 15.9 mm – 15.9 mm – 12.7 mm) vertical hole spacing
    e. Square-punched holes to accept cage nuts
7. Load capacity (per UL2416):
    a. 1360 kg, static load on levelling feet
    b. 1020 kg, rolling load on casters
8. Grounding/Bonding:
    a. Mounting rails, top panel, side panels and doors are to be electrically bonded to the cabinet frame
    b. A factory prepared location for ground lug attachment shall be provided at the top and bottom of the cabinet frame
9. Certifications:
    a. EIA-310-E compliant
    b. UL Listed 2416, NWIN

N. Equipment Cabinets (Main telecom racks)

1. The Contractor shall supply & install gang able equipment cabinets for the Server Room.
2. Freestanding equipment cabinet provides front and rear support for 19” W (482.6 mm) EIA rack-mount equipment and shelves.
3. The required minimum dimensions are: (42U) x 800mm x 1000mm (HxWxD)
4. The cabinet shall meet the following functionality requirements:
    a. Welded steel and bolted aluminum four-post frame
    b. Equipment mounting rails, two pairs
    c. Levelling feet and casters
    d. Floor attachment brackets
    e. PDU brackets, one pair, for mounting two vertical PDUs
    f. Perforated front door 78% open
    g. Solid rear door with perimeter seal
    h. Front door shall open to 120° when bayed, 145° when not bayed
    i. Rear door shall open to 180° when bayed or not bayed
    j. Doors shall attach to the cabinet frame using hinge pins allow easy removal during maintenance
    k. Doors shall be reversible to open from the right or left and shall feature a swing handle with Access controlled, auditable lock
    l. Side panels shall have cable brush port openings to allow rack to rack patching
    Top panel shall incorporate a Vertical Exhaust Duct which includes the duct. The Exhaust duct will interface (connect) directly to the return air plenum. The exhaust duct dimensions, should be such that they accommodate the necessary air flow and heat load requirements anticipated for the cabinets.

m. Exhaust duct will be positioned at the hot side of the cabinet and necessary internal dampers and infill panels should be included. Infill panels and dampeners should be adaptable to different active equipment manufacturers.
n. Exhaust ducts should be the same manufacturer as the cabinet, no self-fabricated solutions will be acceptable.
o. Exhaust ducts should neatly interface with return air plenum and should include a surround to hide any tile / ceiling cuts.
p. The front section of the panel should include a minimum, two cable openings and large brush grommets, one per side.
q. Unsealed openings shall be 114 mm x 228 mm.

5. Equipment support:

a. Two pairs of mounting rails in the cabinet
b. Adjustable depth, rails slide front-to-back; marks on frame for easy vertical alignment
c. 1-3/4”H (44.45 mm) U spacing, marked and numbered on all rails
d. 19” W, EIA-310-E Universal 15.9 mm – 15.9 mm – 12.7 mm) vertical hole spacing
e. Square-punched holes to accept cage nuts

6. Load capacity (per UL2416):

a. 1360 kg, static load on levelling feet
b. 1020 kg, rolling load on casters

O. Cabinet Power Distribution Units

1. The Contractor shall supply, furnish and install power distribution strips for the cabinets.
2. The power strips shall meet the following specifications and functionality:
3. Energy Efficient Latching relays – require less energy to switch, produce less heat and can be configured to return to pre-outage state or leverage outlet sequencing technology to minimize inrush current and circuit breaker trips.
4. Power cords shall be compatible with SecureLock and shall be available in different colours to identify power source.
5. The Intelligent Controller shall be hot swap field replaceable and flush mounted with industrial grade reliability, configurable firmware, disaster recovery support.
6. The power strip shall be available in multiple colours.
7. The power strip feature low profile flush mount circuit breakers
8. The power strip shall be rated for temperatures up to 60°
9. Power distribution unit (PDU) with a minimum 12 outlet receptacles of type IEC320 C13 rated for 230 VAC, 16 Amps and input power plug type IEC60309 16A
10. As shown on drawings, when an equipment rack (IDF) will house equipment for both SSN and DTN networks, two PDU units shall be provided, one for each section.

11. The power strip shall have the following outputs (subject to final equipment configuration):

a. (20) IEC 60320 C13 2-pole, 3-wire; 10A
b. (4) IEC 60320 C19 2-pole, 3-wire; 16A

P. Cable Managers

1. Front vertical cable manager at both left and right side of the cabinet
   a. 250mm vertical cable trays installed on both sides of the equipment rack (inside) to organize the incoming horizontal and backbone communication cables within the rack.
   b. Rear cable management hardware with all copper patch panels to facilitate a neat and orderly approach for terminating the UTP cables.
   c. 1 U horizontal cable management hardware for patch cord management.
   d. As shown on drawings, when an equipment rack (IDF) will house equipment for both SSN and DTN networks i.e. with physical separation separating the two sections, the SSN cables shall enter the IDF from below and the DTN cables from the upper side.

2.6 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.7 GROUNDING

A. Install grounding according to BICSI TDMM, “Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 50-mm clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor

2.8 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568-C.1.

C. Factory test twisted pair cables according to TIA-568-C.2.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 12 mm from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. MUTOA shall not be used as a cross-connect point.
7. Consolidation points may be used only for making a direct connection to equipment outlets:

    a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
    b. Locate consolidation points for twisted-pair cables at least 15 m from communications equipment room.

8. Cables may not be spliced. Secure and support cables at intervals not exceeding 760 mm and not more than 150 mm from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
9. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
10. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information

Transport Systems Installation Methods Manual , Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.

11. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
12. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
13. In the communications equipment room, install a 3-m- long service loop on each end of cable.
14. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 200 mm above ceilings by cable supports not more than **1524 mm** apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable **1800 mm** long not less than **300 mm** in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 127 mm.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 300 mm.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 600 mm.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 64 mm.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 150 mm.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 300 mm.

4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 76 mm.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 150 mm.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 1200 mm.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 127 mm.

3.3 FIRESTOPPING

A. Comply with requirements in Section 078400 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.4 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 50-mm clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: **Class 3.**
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B for **Class 3** level of administration**, including optional identification requirements of this standard**.

C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

E. Cable and Wire Identification:

1. Label each cable within 100 mm of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 4.5 m.
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    b. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections **with the assistance of a factory-authorized service representative**.

D. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

E. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

F. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

G. End-to-end cabling will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.7 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for **two** years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within **two** years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide **30** days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

END OF SECTION 271513

SECTION 272100 – DATA COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Core and Edge Server, Firewall and Switch Components, Internet router, Wireless access points, Wireless controller, IP telephony PABX.

B. Related Requirements:
1. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
2. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.

1.3 DEFINITIONS

A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.

B. BICSI: Building Industry Consulting Service International.

C. RCDD: Registered communications distribution designer.

D. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

E. TGB: Telecommunications grounding bus bar.

F. TMGB: Telecommunications main grounding bus bar.

G. IP: Internet protocol.

H. IDC: Insulation displacement connector.

I. LAN: Local area network.

J. VOIP: Voice over IP.

K. STP: Shielded twisted pair.

L. IGMP: Internet Group Management Protocol

M. VTP: Virtual Terminal Protocol

N. WAN: Wide area network

O. ADSL: Asymmetric Digital Subscriber Line

P. ISDN: Integrated Services Digital Network

Q. UPS: Uninterrupted Power Supply

R. EMI: Electromagnetic interference.

S. LAN: Local area network.

T. UTP: Unshielded twisted pair.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.
4. Schematic diagrams including all wiring labels
5. Mechanical drawings of all equipment racks.
6. The above listed drawings shall be produced on CAD or another computer graphics workstation, or by a professional draftsperson. Photocopies or other reproductions of the specifications or drawings are not acceptable.

C. Provide manufacturer’s catalogue information showing dimensions, colors, and configurations.

D. Submittals shall include all items called for in PART 2 – PRODUCTS of this document and the manufacturers cut sheets for the following: All Core and Edge Server, Firewall and Switch Components

E. Manufacturer’s Instructions

1. Indicate complete details and dimensions of work to be performed and indicate types and locations of equipment, fabricated equipment, and other details to completely describe work to be performed. Provide three sets of drawings for review. Do not begin installation or fabrication without the approval of the Engineer.

F. Contract Closeout Submittals
1. Project Record Drawings: Prepare and submit four copies of manuals containing:
2. Warranties, guarantees, and manufacturer's directions on equipment and material provided. Replacement parts lists of major items of equipment. Equipment brochures, wiring diagrams, control diagrams and control programming including cable numbers and signal levels. Approved shop drawings including details of fabricated items.
3. Operation Instructions and description of system components and their relationship to the system function (bound separately).
4. All "as-built" drawings to be provided both in electronic form (ACAD R2018 or later, DWG or DXF) and five sets in hard copy.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **Installer,** qualified layout technician, installation supervisor, and field inspector.

B. Seismic Qualification Data: Certificates, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings **and Cabling Administration Drawings, and field testing program development shall be under direct supervision of engineer.**
2. Installation Supervision: Installation shall be under the direct supervision of **technician**, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI to supervise on-site testing.
1. Maintenance Proximity: Not more than 2 hours' normal travel time from Installer's place of business to Project site.
2. The installer should provide evidence of its establishment in KSA for more than 10 years.
4. The installer should have the highest partnership level with the manufacturer. The partnership should be in place for at least 5 years.
3. The installer should have at least two certified technical persons on each of the proposed manufacturer's solution.
4. The installer should provide manufacturer's certified maintenance contracts for each proposed solution(s). These certifications will bound the installer/manufacturer to provide the required hardware replacement/software updates/etc. for each proposed item and for the requested period of one year after date of substantial.
5. The installer should provide evidence of his capability to install such a solution by providing references to similar installations in similar environment minimum of 10 references required, without subcontracting.

6. The installer should demonstrate the capability of local implementation and support by providing the following:
   - CVs of the technical engineers who will be in charge of the implementation of the requested works (minimum two engineers).
   - These engineers should have valid manufacturer's Certifications that demonstrate their ability to install and troubleshoot the proposed solution.
   - The CVs must provide evidence of their experience in installing the proposed solution in other institutions.
   - Availability of a Project Management team and a minimum experience of 8 years in large scale projects.
   - All personnel involved in the project should have been employed for at least 3 year in the installer company.
7. The installer should have a dedicated Support team. The team capabilities and certifications should be submitted. In addition, they should provide their internal escalation procedure.
8. Spare part list to be detailed with the ability for the client to inspect without prior notice.
9. Spare part list to be detailed with the ability for the client to inspect without prior notice.
10. The installer should submit a Manufacturer authorization letter to supply and install the proposed solution for the client.
11. The installer should be responsible for integration and support coordination for all of the project's hardware and software included in the Bid. Moreover, the installer will be responsible for all required installation, operation and acceptance testing of delivered equipment
12. The installer should provide an implementation plan that includes detailed schedule of events, duration and phases

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

   1. Testing Agency's Field Supervisor: Currently certified by BICSI as an **RCDD**.

C. Supplier Qualifications: Supplier shall have minimum 10 years of experience in this field, with at least 2 similar installations in KSA and the gulf. Supplier shall submit a detailed reference list of its projects, along with detailed contact list for each project. Engineer and/or owner shall have the right to call or visit any of the referenced projects and inspect the installation and system operation without notifying the supplier.

D. Source Limitations: Obtain all Structured Cabling equipment (cables, patch panels, patch guides, cabinets, and all related accessories) from single source and from single manufacturer.

B. Source Limitations: Obtain all active components and software from single source from single manufacturer.

1.7 REFERENCES

A. Reference to Standards listed in this section shall include the latest issue, and any amendments thereto, and any Standard in substitution therefore, issued up to 3 months before the closing date for tenders.

B. The design of the Data Communications Systems shall comply with relevant requirements and recommendations of the following ISO and Telecommunications Industry Association (TIA) standards and references.

C. The Data Communications Systems Contractor design of the Data Communications Systems shall comply with relevant requirements and recommendations of the following standards and references:

1. KSA Local Authority Guidelines.

2. ANSI/TIA-568-C.0, ANSI/TIA-568-C.1, ANSI/TIA-568-C.2, ANSI/TIA-568-C.3, ANSI/TIA-569-C, ANSI/TIA-606-B, ANSI/TIA-607-B, ANSI/TIA-862-A, ANSI/TIA-942- A, ANSI/TIA-1005, ANSI/TIA-1179, ISO/IEC 11801, ISO/IEC 11801 Class EA, IEEE

3. 802.3af, IEEE 802.3at, IEEE 802.3an, IEEE 802.3ba and IEEE 802.11 standards.

4. ANSI X3T9.5, Requirements for UTP at 100 Mbps.

5. Institute of Electrical & Electronics Engineers Seventeenth Edition

6. IEEE 802.1 - LAN/MAN Bridging and Management.

7. IEEE 802.3 - CSMA/CD Access Methods.

8. IEEE 802.3af, Power over Ethernet (PoE) Standard

9. IEEE 802.3at, Power over Ethernet+ (Plus) Standard

10. IEEE 802.3an, Physical Layer and Management Parameters for 10 Gbps Operation, Type 10G BASE-T

11. IEEE 802.3ba Media Access Control Parameters, Physical Layers and Management Parameters for 40 Gbps and 100 Gbps Operation

12. IEEE 802.11, Wireless Standard

13. IEEE 802.11 - Wireless LAN's.

In addition to the standards listed above, all applicable local building code, safety, environmental and other requirements shall be met in addition to the local service provider's standards, guidelines and requirements.

1.8 WARRANTY AND SERVICES DURING THE WARRANTY PERIOD

A. The Warranty Period for all components of the Data Communications System and their installation shall be a minimum of two (2) years from the date of substantial completion. The date of substantial completion shall be the date when all components have been certified by the Consultant and accepted by the Owner to be complete in accordance with the definition of substantial completion.

B. All components of the Data Network shall have a life span of at least 10 years.

C. All components and their installations shall be free from defects. Any defective material or workmanship and any resulting damage to work of other trades shall be replaced or repaired as directed during the Warranty Period. Comply with General Conditions, agreeing to repair or replace any components of the Data Communications System that have failed within the warranty period.

D. Schedule repair work with the Owner's representative to prevent interference with normal building activities.

E. The Base Bid price shall include the cost of all replacement parts during the warranty period and all of the associated installation costs and all of the costs associated with the repair of components during the warranty period but shall not include the cost of labour for routine maintenance during the warranty period. The cost of labour for routine maintenance during the warranty period shall be provided separately as an Alternate Price as detailed below.

F. Replace or repair all supplied defective installations. Respond and be on site within four hours of the Owner placing a system trouble call for items of an immediate nature (e.g.: failed component, non-functioning controller, etc.). Response to Warranty call out by the Owner shall be within 24 hours for items not requiring immediate attention. Work to trouble shoot and identify the cause of the Data Communications System or component failure shall begin immediately and shall continue until repaired to the satisfaction of the Owner.

G. Any software modifications or upgrades that become standard product offerings from the Data Communications System subcontractor and/or Data Communications System equipment vendors during the warranty period shall be brought to the attention of the Owner and, if the Owner wishes, shall be provided at no additional cost to the Owner.

H. The Data Communications System subcontractor shall maintain an inventory of common components in the local office for the replacement of failed components.

I. Provide replacement components within the specified time periods for the following components. The subcontractor shall guarantee to the Owner that the delivery of replacement components will be provided within the specified time periods.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Environmental Limitations: Do not deliver or install cables, devices and equipment until all the wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining the required ambient temperature and humidity conditions until the end of the construction period.

B. The system components must be handled with care to prevent damage, breaking and scoring. Do not install damaged equipment or components, to be replaced with new.

C. The system components to be stored in clean dry place. To protect them from weather, dirt, fumes, water, construction debris, and any physical damage.

D. Inspection shall be performed in two stages, first time upon receiving the equipment, devices and cables on site before storing and second time after installation according to the installation phases.

1.10 DELEGATED DESIGN RESPONSIBILITY:

A. Notwithstanding the drawings and other information provided to the Contractor, the Contractor shall be fully responsible for the design, detailing of the works described herein, including (without limitation) the comprehensive engineering analysis by a qualified professional engineer, and shall provide a complete, and secure installation, which shall meet the specified performance and design requirements indicated and which shall be fit for their intended purpose. The Contractor indemnifies the Employer and Design Consultant from any and all

claims, costs and expenses arising from any loss or damage in connection with any error in or failure of the Contractor's designed portion of the Works.

PART 2 - PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Network Equipment (Hardware/Software):

- CISCO
- HP
- AVAYA

or approved equal

2.2 SYSTEM DESCRIPTION AND SCOPE OF WORK

A. This specification covers Active Wired and Wireless Data Communications and Firewall Network Equipment and Systems.

B. Furnish all materials, labour and any engineering services to provide complete and professionally installed Data Communications System for all areas within the project.

C. The scope of work includes for the supply, delivery, installation, programming and testing of the following: -End to end wired data switching networking and firewall equipment including all modules, accessories, uplinks, software and software licenses.

D. Labour furnished shall be specialized and experienced in Data Communications System installation.

E. Contractor shall provide coordination with the Engineer, Architect, Interior Designer, Main Contractor and MEP Contractor as required.

F. Contractor shall provide a complete Data Communications System solution including all items of any kind necessary to accommodate the system installation, operation, testing, or maintenance. Contractor shall provide the appropriate factory or custom rack mount adapters for all equipment installed in the equipment rack, whether specifically itemized or not. Contractor shall cover unused slots using blank panels.

G. The contractor shall be responsible for coordination with the Local Service Provider (STC) to ensure that the requirements of the service provider are met and all local service provider guidelines and recommendations are adhered to.

H. Furnish all materials, labour and any engineering services to provide complete and professionally installed Data Network systems in working order as described herein. Labour furnished shall be specialized and experienced in Data Communications System installation.

I. The network technicians employed shall be fully trained and qualified by the manufacturer on the installation and testing of the equipment to be installed. Evidence that the vendor is a current, certified installer of the manufacturer must be provided in writing prior to commencing work.

J. The Contractor is responsible for verifying the completeness of parts lists, the correctness of the type numbers and the overall suitability of the equipment to meet the main purpose of the specifications. The Contractor, even if not specifically mentioned herein or on drawings, shall supply any additional equipment needed in order to meet the requirements stated above, without claim for additional payment. The Contractor must obtain in writing explicit approval from the Engineer for any changes or substitutions to the specification.

K. Furnish and install all equipment items and associated hardware.

L. Furnish shop drawings and receive approval, prior to fabrication and installation.

M. Furnish Provide calibrated test reports for complete systems.

N. Perform initial adjustments and verification tests. Submit verification test report.

O. Participate in acceptance tests and perform final adjustments.

P. Provide system documentation including copies of all relevant drawings and equipment manuals.

Q. Provide maintenance services for the specified period from the date of acceptance.

R. Guarantee all equipment and components for the specified period from the date of acceptance.

S. Independent Networks for the pavilions and CCTV equipment shall be provided.

T. The network architecture shall be based on a two-tier topology using centralized core, and access layers.

U. Core Switches will be connected to the optical fiber backbone. The backbone will deliver data to the access layer switches located in the Intermediate Distribution Frame `

V. The uplink requirement is as follows:

From Device	To Device	No. of Uplinks	Capacity Per Link in Gb
Core Switch Primary	Core Switch Secondary	2	10G
Core Switch Secondary	Core Switch Primary	2	10G
Core Switch Primary	Server Farm Switch Primary	1	10G
Core Switch Primary	Server Farm Switch Secondary	1	10G
Core Switch Secondary	Server Farm Switch Primary	1	10G
Core Switch Secondary	Server Farm Switch Secondary	1	10G
Core Switch Primary	Edge Switch Primary	1	10G
Core Switch Secondary	Edge Farm Switch Secondary	1	10G

W. The active network equipment shall support high-speed standards based 10/100/1000 Mbps switched, multi-protocol, Ethernet network, providing converged IP services based on ANSI/TIA/EIA and ISO standards.

X. The active data network shall support the following services and applications:
   1. POS
   2. VOIP
   3. Wi-Fi WLAN
   4. CCTV
   5. Access Control
   6. Digital Signage
   7. Background Music System
   8. Audio-visual System
   9. BMS

Y. Network services for the development will originate at Core Switches located in the main telecom room.

Z. The data network design is based on a collapsed core topology.

AA. It should be noted that the structured cabling systems that will support the active data network are detailed within Section 27 15 13 Communication Copper Horizontal Cabling.

BB. Core Switches will be interconnected to the Optical Fiber backbone. The Backbone will deliver data and voice to and terminate at the Edge Switches located in the (IDF/TR).

CC. The active network equipment shall support high-speed standards based 10/100/1000 Mbps switched, multi-protocol, Ethernet network, providing converged IP services based on ANSI/TIA/EIA and ISO standards.

DD. The building LAN cabling configuration shall be a hierarchical star topology utilizing a Centralized Core and distributed Access to individual edge level devices located throughout the premises in designated areas.

EE. The building backbone cabling system shall support 10 Gbps Ethernet based converged networking. The infrastructure cabling shall be installed to ANSI, TIA and EIA standards with all network endpoints designed to support 10/100/1000 Mbps.

FF. Incoming Telecom and Internet services shall be provided by the appointed ISP provider.

2.3 PERFORMANCE REQUIREMENTS

A. The ICT network is utilized to provide the following services as a minimum in line with any other specific operation and configuration dependencies:
   1. POS
   2. VOIP
   3. Wi-Fi WLAN
   4. Digital Signage
   5. Background Music System
   6. Audio-visual System
   7. BMS

B. There shall be hardware redundancy and uplink redundancy between the Primary and Secondary Core Switches

C. There shall be uplink redundancy between the Core and Access Layers

D. Network Core Primary and Secondary Switches

The network core switched shall be provided with dual management modules in an active - active configuration.

The network core switched shall be provided with 2 no. power supplies.

E. The network core switches must meet the following minimum specifications:

1. Switch should be cloud manageable
2. I/O Ports: the switch should be capable to accommodate a Minimum of 24 10-GbE ports And must support SR and LR transceivers
3. Routing/switching capacity: Minimum of 500Gbps
4. Throughput: Minimum of 400 Mpps
5. Routing table size: Minimum 6000 entries
6. MAC table size: Minimum 16000entries
7. PSU: Redundant and hot swappable power supplies.
8. The network core switch shall support layer 2 to 4 intelligence edge features.
9. The switches shall support aggregation of links using IEEE 802.3ad (LACP).
10. The switches need to be able to support POE modules.
11. The switches need to have support for external additional POE supply if required.
12. The switches must support SNTP.
13. The switches must support jumbo frames.

F. The network core switches must meet the following advanced specifications:

Layer 2 Switching

1. VLAN support and tagging support for the IEEE 802.1Q standard.
2. 2048 simultaneous VLANs.
3. IEEE 802.1v protocol VLANs.
4. GARP VLAN Registration Protocol (GVRP).
5. Support for the following spanning tree versions: 802.1D (STP), 802.1w (RSTP), 802.1s (MSTP).
6. Support for STP Root Guard, BPDU filtering, BPDU Protection.

Layer 3 Routing

1. Support for loopback interface address, and support for loopback address by RIP and OSPF.
2. Support for static IP routing to provide manually configured routing for both IPv4 and IPv6 networks.
3. Support for Routing Information Protocol (RIP) to provide RIPv1 and RIPv2 routing.
4. Support for OSPFv2 and OSPFv3 dynamic routing protocol.
5. Support for Equal cost multipath protocol (ECMP).

6. Support for User Datagram Protocol (UDP) helper function providing UDP broadcasts to be directed across router interfaces to specific IP unicast or subnet broadcast addresses and preventing server spoofing for UDP services such as DHCP.
7. Support for route mapping to provide more control during route redistribution; allow filtering and altering of route metrics.
8. Support for Virtual Router Redundancy Protocol (VRRP).

Security

1. Support for TACACS+
2. Support for RADIUS
3. Support for SSH v1 and v2
4. Support for Web-based and MAC-based authentication.
5. Support for SSL
6. Support for Port security, MAC-lockout and MAC-lockdown.
7. Support for static and dynamic IP lockdown.
8. Support for Dynamic ARP protection.
9. Support for ICMP throttling
10. Support for Access Control lists (ACL)
11. Support for Source port filtering
12. Support for Port-based access control (802.1x).
13. Support for concurrent 802.1x and web authentication.
14. Support for concurrent 802.1x and MAC authentication.
15. Support for multiple 802.1x clients per port
16. Support for RADIUS and 802.1x accounting
17. Support for RADIUS assigned ACLs
18. Support for secure-management access.

Network Management

1. Support for SNMP v1, v2, v3
2. Support for RMON and extended RMON
3. Support for flow control 802.3X
4. Support for SFlow
5. Support for LLDP (802.1ab) and LLDP-MED
6. Support for dual flash images.
7. Support for multiple configuration files.
8. Support for configuration file backup to TFTP server via CLI and SNMP.
9. Support for port mirroring, mirror port VLAN tag, remote mirroring, MAC based remote mirroring.
10. Quality of Service (QoS)
11. Support for Traffic Prioritisation (802.1p).
12. Support for Traffic prioritization and traffic classification into eight priority levels mapped to eight queues
13. Support for Class of Service (CoS)IEEE 802.1p priority tag setting based on IP address, IP Type of Service (ToS), Layer 3 protocol, TCP/UDP port number, source port, and DiffServ.
14. Support for rate limiting policies on a per-port or per-VLAN basis with ingress/egress enforced maximum bandwidth.
15. Support for ICMP rate limiting.
16. Support for advanced classifier-based QoS based on Layer 2, 3, and 4 information.
17. Support for Layer 4 prioritization based on TCP/UDP port numbers
18. Classifier-based rate limiting using access control list (ACL) to enforce maximum bandwidth for ingress traffic on each port

19. Guaranteed minimum bandwidth providing per-port, per-queue egress-based guaranteed minimum bandwidth
20. Support for inbound rate-limiting for broadcast and multicast traffic.

G. Network Server Farm Switches

The uplinks between the Server Farm Switches and the Cores must provide redundant connections into the core environment and must be a minimum of 10Gbps into each core.

The uplinks between the servers and the server farm switches must provide redundancy and the uplink speed must match that of the servers (i.e. 10Gbps).

The server farm switches shall be provided with dual power supplies.

H. The server farm switches must meet the following minimum specifications for 10Gb switches:

1. I/O Ports: 48 x auto-sensing 10/100/1000 Mbps ports. 4 x dual-personality ports capable of either 10/100/1000 RJ45 or SFP slot to be used with SFP GBIC. Support for a maximum of 4 x 10 Gb ports.
2. I/ I/O Ports must be able to support for 10Gb.
3. Throughput: Minimum of 80 Mpps
4. Switching capacity: Minimum 100 Gbps
5. Routing table size: Minimum 6000 entries
6. MAC table size: Minimum 16000 entries
7. Client management: command-line interface; Web browser; configuration menu; out-of-band management.
8. PSU: Capable of supporting redundant power supply.
9. It is essential that the server farm switches fully support multicast traffic for TVoIP, Digital Signage and multimedia applications. The switches must be capable of IGMP v1, v2, v3, IGMP Fast Leave / Fast Join, IP Multicast snooping (Data Driven IGMP) protocols.
10. The switches shall support aggregation of links using IEEE 802.3ad (LACP).
11. The switches must support SNTP.
12. The switches must support jumbo frames.

I. The server farm switches must meet the following advanced specifications:

Layer 2 switching support

1. VLAN support and tagging support for the IEEE 802.1Q standard.
2. 256 simultaneous VLANs.
3. IEEE 802.1v protocol VLANs.
4. GARP VLAN Registration Protocol (GVRP).
5. Support for the following spanning tree versions: 802.1D (STP), 802.1w (RSTP), 802.1s (MSTP).
6. Support for STP Root Guard, BPDU filtering, BPDU Protection.

Layer 3 routing

1. Support for loopback interface address, and support for loopback address by RIP and OSPF.
2. Support for static IP routing to provide manually configured routing for both IPv4 and IPv6 networks.
3. Support for Routing Information Protocol (RIP) to provide RIPv1 and RIPv2 routing.
4. Support for Equal cost multipath protocol (ECMP).

Security

1. Support for TACACS+
2. Support for RADIUS
3. Support for SSH v1 and v2
4. Support for Web-based and MAC-based authentication.
5. Support for SSL
6. Support for Port security, MAC-lockout.
7. Support for Dynamic ARP protection.
8. Support for Access Control lists (ACL)
9. Support for Source port filtering
10. Support for Port-based access control (802.1x).
11. Support for concurrent 802.1x and web authentication.
12. Support for concurrent 802.1x and MAC authentication.
13. Support for multiple 802.1x clients per port
14. Support for RADIUS and 802.1x accounting
15. Support for RADIUS assigned ACLs
16. Support for secure-management access.

Network Management

1. Support for SNMP v1, v2, v3
2. Support for flow control 802.3X
3. Support for SFlow
4. Support for LLDP (802.1ab) and LLDP-MED
5. Support for port mirroring.

Quality of Service (QoS)

1. Support for Traffic Prioritisation (802.1p).
2. Support for Traffic prioritization and traffic classification into eight priority levels mapped to eight queues
3. Support for Class of Service (CoS)IEEE 802.1p priority tag setting based on IP address, IP Type of Service (ToS), Layer 3 protocol, TCP/UDP port number, source port, and DiffServ.
4. Support for rate limiting policies on a per-port basis with ingress enforced maximum bandwidth.
5. Support for Layer 4 prioritization based on TCP/UDP port numbers.

J. Network DMZ Switches

The uplinks between the DMZ Switches and the core must provide redundant connections into the core environment and must be a minimum of 10Gbps into each core.

The uplinks between the servers and the DMZ Switches must provide redundancy and the uplink speed must match that of the servers (10Gbps).

The DMZ Switches shall be provided with dual power supplies.

K. The DMZ Switches shall meet the following minimum specifications for 10 Gb switches:

1. I/O Ports: 48 x auto-sensing 10/100/1000 Mbps ports. 4 x dual-personality ports capable of either 10/100/1000 RJ45 or SFP slot to be used with SFP GBIC. Support for a maximum of 4 x 10 Gb ports.
2. I/ I/O Ports must be able to support for 10Gb and 1Gb links.
3. Throughput: Minimum of 131 Mpps
4. Switching capacity: 176 Gbps
5. Routing table size: Minimum 10000 entries
6. MAC table size: Minimum 64000 entries
7. Client management: command-line interface; Web browser; configuration menu; out-of-band management.
8. PSU: Capable of supporting redundant power supply.
9. It is essential that the server farm switches fully support multicast traffic for TVoIP, Digital Signage and multimedia applications. The switches must be capable of IGMP v1, v2, v3, IGMP Fast Leave / Fast Join, IP Multicast snooping (Data Driven IGMP) protocols.
10. The switches shall support aggregation of links using IEEE 802.3ad (LACP).
11. The switches must support SNTP.
12. The switches must support jumbo frames.

L. The DMZ Switches shall meet the following advanced specifications:

Layer 2 switching support

1. VLAN support and tagging support for the IEEE 802.1Q standard.
2. 256 simultaneous VLANs.
3. IEEE 802.1v protocol VLANs.
4. GARP VLAN Registration Protocol (GVRP).
5. Support for the following spanning tree versions: 802.1D (STP), 802.1w (RSTP), 802.1s (MSTP).
6. Support for STP Root Guard, BPDU filtering, BPDU Protection.

Layer 3 routing

1. Support for loopback interface address, and support for loopback address by RIP and OSPF.
2. Support for static IP routing to provide manually configured routing for both IPv4 and IPv6 networks.
3. Support for Routing Information Protocol (RIP) to provide RIPv1 and RIPv2 routing.
4. Support for Equal cost multipath protocol (ECMP).

Security

1. Support for TACACS+
2. Support for RADIUS
3. Support for SSH v1 and v2
4. Support for Web-based and MAC-based authentication.
5. Support for SSL
6. Support for Port security, MAC-lockout.
7. Support for Dynamic ARP protection.
8. Support for Access Control lists (ACL)
9. Support for Source port filtering
10. Support for Port-based access control (802.1x).
11. Support for concurrent 802.1x and web authentication.
12. Support for concurrent 802.1x and MAC authentication.
13. Support for multiple 802.1x clients per port
14. Support for RADIUS and 802.1x accounting
15. Support for RADIUS assigned ACLs
16. Support for secure-management access.

Network Management

1. Support for SNMP v1, v2, v3
2. Support for RMON and extended RMON
3. Support for flow control 802.3X
4. Support for SFlow
5. Support for LLDP (802.1ab) and LLDP-MED
6. Support for dual flash images.
7. Support for multiple configuration files.
8. Support for configuration file backup to TFTP server via CLI and SNMP.
9. Support for port mirroring.

Quality of Service (QoS)

1. Support for Traffic Prioritisation (802.1p).
2. Support for Traffic prioritization and traffic classification into eight priority levels mapped to eight queues
3. Support for Class of Service (CoS)IEEE 802.1p priority tag setting based on IP address, IP Type of Service (ToS), Layer 3 protocol, TCP/UDP port number, source port, and DiffServ.
4. Support for rate limiting policies on a per-port basis with ingress enforced maximum bandwidth.
5. Support for Layer 4 prioritization based on TCP/UDP port numbers.

M. Network Firewall

The specification of the firewall shall be as follows:

1. Application awareness – Shall enforce access policy based on more than 1200 commonly used applications and 150,000 micro applications; provides access control based on "behaviour" (for example, a file upload or a post on a social networking site) to further control user activity related to applications; controls port- and protocol-hopping applications that can evade classic security controls.

2. Identity-based firewalling – Shall provide differentiated access control based on user and user role; supports common identity mechanisms such as Windows Active Directory agent, LDAP, Kerberos, and Windows NT LAN Manager.
3. Device-type-based enforcement – Shall use clients to identify the types of devices (such as iPads, iPhone, and Android devices) that are accessing the network, and controls which devices will be permitted or denied.
4. URL filtering – Shall enables precise control of Internet traffic with an enterprise-class, full-featured URL filtering solution.
5. Intrusion prevention – Shall detect and block Internet-born threats that target end users and their personal devices. Next-Generation Firewalls with IPS protect the Internet edge and reduce complexity through simplified policies integrated with Next-Generation Firewall Services.
6. Stateful firewall capabilities - In addition to enabling Layer 7 context-aware rules, shall provide extensive support for Layer 3 and Layer 4 stateful firewall features, including access control, network address translation, and stateful inspection.

Performance

1.	Throughput:	Min 650 Mbps
2.	Maximum concurrent ses-	Min 750,000
3.	Connections per second:	Min 30,000
4.	Supported applications:	More than 1200
5.	Supported micro-	More than 150,000
6.	URL categories:	Min 78
7.	Number of URLs catego-	More than 20 million
8.	Languages for URL filtering:	More than 60

N. Network Access Switches (DATA and Telephony)

Network access switches shall be in the telecom rooms racks as indicated in the layout drawings. The access layer switches can be 48 ports or 24 ports depending on the required number of connected devices in order to optimize port density.

The uplinks between the access layer switches and the core must be provided via redundant connections and must be a minimum of 10Gb +10Gb.

The access layer switches shall provide POE+ power on all ports.

The access layer switches can be 48 ports or 24 ports depending on the required number of connected devices.

The network access layer switches shall meet the following minimum specifications:

I/O Ports

1. 48 Port Switch

- 48 POE+ Ports (IEEE 802.3at)
- 48 x auto-sensing 10/100/1000 Mbps ports.
- 4 x dual-personality ports capable of either 10/100/1000 RJ45 or SFP slot to be used with SFP GBIC.
- Support for a maximum of 4 x 10Gb ports.

2. 24 Port Switch

    - 24 POE+ Ports (IEEE 802.3at)
    - 24 x auto-sensing 10/100/1000 Mbps ports.
    - 4 x dual-personality ports capable of either 10/100/1000 RJ45 or SFP slot to be used with SFP GBIC.
    - Support for a maximum of 4 x 10Gb ports.

3. I/O Ports must be able to support for 10Gb SR and LR transceivers, and for 1Gb SX and LX transceivers.
4. Throughput:

    - 24 ports: Minimum of 95 Mpps
    - 48 ports: Minimum of 131 Mpps

5. Switching capacity:

    - 24 ports: Min 128 Gbps
    - 48 ports: Min 176 Gbps

6. Routing table size: Minimum 10000 entries
7. MAC table size: Minimum 64000 entries
8. Client management: command-line interface; Web browser; configuration menu; out-of-band management.
9. The switches shall support aggregation of links using IEEE 802.3ad (LACP).
10. The switches must support SNTP.
11. The switches must support jumbo frames.
12. The switches must have a manufacturer warranty for a minimum of 10 years. If this is at extra costs then the costs must be shown.
13. The switch warranty must include switch operating system upgrades for a minimum of 10 years. If this is at extra costs then the costs must be shown.
14. The switch warranty must include parts replacement shipping fees for a minimum of 10 years. If this is at extra costs then the costs must be shown.

O. The network access layer switches must meet the following advanced specifications:

Layer 2 switching support

1. VLAN support and tagging support for the IEEE 802.1Q standard.
2. 256 simultaneous VLANs.
3. IEEE 802.1v protocol VLANs.
4. GARP VLAN Registration Protocol (GVRP).
5. Support for the following spanning tree versions: 802.1D (STP), 802.1w (RSTP), 802.1s (MSTP).
6. Support for STP Root Guard, BPDU filtering, BPDU Protection.

Basic Layer 3 routing

1. Support for static IP routing to provide manually configured routing for both IPv4 and IPv6 networks.
2. Support for Routing Information Protocol (RIP) to provide RIPv1 and RIPv2 routing.

Security Features.

1. Support for TACACS+

2. Support for RADIUS
3. Support for SSH v1 and v2
4. Support for Web-based and MAC-based authentication.
5. Support for SSL
6. Support for Port security, MAC-lockout.
7. Support for Dynamic ARP protection.
8. Support for Access Control lists (ACL)
9. Support for Source port filtering
10. Support for Port-based access control (802.1x).
11. Support for concurrent 802.1x and web authentication.
12. Support for concurrent 802.1x and MAC authentication.
13. Support for multiple 802.1x clients per port
14. Support for RADIUS and 802.1x accounting
15. Support for RADIUS assigned ACLs
16. Support for secure-management access.

Network management features.

1. Support for SNMP v1, v2, v3
2. Support for RMON and extended RMON
3. Support for flow control 802.3X
4. Support for SFlow
5. Support for LLDP (802.1ab) and LLDP-MED
6. Support for dual flash images.
7. Support for multiple configuration files.
8. Support for configuration file backup to TFTP server via CLI and SNMP.
9. Support for port mirroring.

Quality of Service (QoS)

1. Support for Traffic Prioritisation (802.1p).
2. Support for Traffic prioritization and traffic classification into eight priority levels mapped to eight queues
3. Support for Class of Service (CoS)IEEE 802.1p priority tag setting based on IP address, IP Type of Service (ToS), Layer 3 protocol, TCP/UDP port number, source port, and DiffServ.

2.4 IP telephony

A. The IP PABX system shall be a hybrid system capable of integrating with TDM equipment and enable any mix between IP, Analog, Digital, TDM and Wired or Wireless phones

B. The system shall provide migration of its architecture from a centralized Hybrid PBX type to an architecture distributed on both Analog Gateways and IP.

C. The system shall interface to a GSM gateway.

D. The system shall be server based in providing centralized call processing running on a standards based Linux (or similar) operating system.

E. The system shall provide gateways including CCITT-defined Basic Rate Interface (BRI), the European Telecommunications Standards Association (ETSI) ISDN-PRI, E1 over QSIG and IP over QSIG incoming and outbound calling, analogue ports for emergency and in

house use, PSTN and ISDN. (Note: BRI must support two 64K clear bearer (B) channels and one 16K signaling (D) channel).

F. The Voice System shall be based on a Linux or other open standard operating system and shall support industry standards including H.323, H.450, H.248, 802.1p, 802.1q, MGCP, TAPI, TSAPI, DAPI, ASAI, LDAP, JTAPI and SIP.

G. The centralized call processor shall support distributed communications system (DCS) and Q-Signaling (QSIG) protocols over ATM, or IP networks to provide centralized voice mail, attendant operations, and customer relationship management capabilities.

H. The IP telephony system (IP PABX) shall be designed to provide 99.999% availability.

I. The system shall offer this availability with the switchover of a CPU or communication server without any interruption nor reloading of the system.

J. Telephony servers shall be provided in a dual redundant configuration. Each server shall be able to handle the total system traffic.

K. The system shall support the following:
- Digital terminals
- Analog terminals
- Wireless services, or Voice over WiFi, or Voice over WLAN
- Analog public network (PSTN) trunking
- ISDN type and T1/T2/T0 public network trunking (as required)
- PBX-PBX IP, Digital and/or analog tie lines (as required)
- Leased lines: complete or fractional T1/T2 ISDN

L. The system must be able to support the following connectivity interfaces:
- Public Switched Telephone Networks
- WAN Voice
- WAN Data
- Terminal connectivity
- Application connectivity

M. The system must support the following features: Integrated Voice Messaging; Hospitality Server Functionality not limited to DOD, speed dialing, unanswered calls, call forwarding, Do Not Disturb (DND), Voice mail services, Mailbox, multiple languages

N. The proposed shall leverage the Telecomm Network Infrastructure to run an IP based telephone system, allowing:
- Service delivery automation, easier deployment, management, use and support
- Unrivaled scalability
- Integrated security
- Integrated resilience
- Open standards and innovation
- Lowest total cost of ownership and investment protection

O. Using IP Communications in an Intelligent Network shall deliver significantly higher levels of automation to streamline the automation deployment, management, and ease of using communications services. These benefits extend to all applications working together as a system to provide improved resilience, security, and higher quality of service:
- Resilient:

- High Availability N+1 clustering, SRST
- Secure servers, gateways, endpoints
- Scalability and modularity
- Enhanced IP routing, HSRP, MGCP capabilities
- Integrated
- VLANs for security, management, wireless
- Auto VLAN provisioning
- E-911 management
- IP Phones to apps integration
- Adaptive
- Plug and play IP Phone and device configuration
- Auto software update
- In-line power
- Extension mobility
- Integrated video telephony adaptation

P. VOICE GATEWAY

1. Supports SIP, SCCP, H323 and MGCP Protocols
2. Voice Server and Voice gateway for IP Telephony
3. Supports Integration with Microsoft Exchange, Voice Mail, Extension Mobility, Paging and Audio conference
4. 3 x GE Ports
5. 1 x E1 Card
6. 4 x FXO Ports
7. Packet Voice DSP Module

Q. IP TELEPHONE SETS

1. IP Phones support POE or AC Adapter options
2. Extension mobility, Conference, Do not disturb and Voice mail features
3. Entry level IP Phone:

    - 10/100 Base-T Ethernet Switch (LAN/PC Interfaces)
    - Minimum 3-inch screen
    - 1 Line
    - PoE
    - Speaker phone
    - Black & White Display

4. Mid-range IP Phone:

    - Gigabit Ethernet (10/100/1000) (LAN/PC Interfaces)
    - Minimum 5-inch screen
    - Colored Display
    - 5 Lines

5. High end IP Phone:

    - Gigabit Ethernet (10/100/1000) (LAN/PC Interfaces)
    - Minimum 5-inch screen

- Colored Display
- 5 Lines
- Includes Video
- Supports Bluetooth

6. Operator Phone:

- 10/100 Base-T Ethernet Switch
- Minimum 3-inch screen
- 16 line keys

Analog Telephone Adapter:

- UC 2 Port Analog Telephone Adapter

2.5 INTERNET ROUTER

A. Integrated Services router has options to support Firewall/Security, Voice Telephony gateway and internet

B. Value Added Modules to support E1, WAN, ADSL, ISDN and Leased Line

C. Enhanced investment protection through increased modularity

D. Supports up to 800 VPN tunnels with the AIM Module

E. Throughput of 100Mbps upgradable through license up to 300Mbps with security enabled

F. 3GE Ports

2.6 WIRELESS ACCESS POINTS

A. Contractor shall provide a complete end to end Wireless Network system solution including all equipment, modules, software, accessories and adapters of any kind necessary to accommodate the system installation, operation, testing, or maintenance.

B. The Contractor is to prepare wireless heatmaps and site survey based on the AP proposed that demonstrate that the coverage and throughput criteria are being met in all areas of the development.

C. Furnish all materials, labour and any engineering services to provide complete and professionally installed Wireless Network system in working order as described herein. Labour furnished shall be specialized and experienced in Wireless Network System installation.

D. The technicians employed shall be fully trained and certified by the manufacturer on the installation and testing of the equipment to be installed. Evidence that the vendor is a current, certified installer of the manufacturer must be provided in writing prior to commencing work on the Wireless Network System for the building.

E. The Contractor is responsible for verifying the completeness of parts lists, the correctness of the type numbers and the overall suitability of the equipment to meet the main purpose of the specifications. The Contractor, even if not specifically mentioned herein or on drawings, shall supply any additional equipment needed in order to meet the requirements stated above, without claim for additional payment. The Contractor must obtain in writing explicit approval from the Engineer for any changes or substitutions to the specification.

F. The minimum criteria for the WiFi deployment is as follows: -

- Minimum -65dB coverage.
- Minimum of 10mbps throughput on all devices including mobile handsets and tablets.
- Minimum signal to noise ratio (SNR) of 30dB.

G. WLAN coverage shall be provided via 802.11ac/802.11n wireless access point (WAP) devices operating over both the 2.4GHz and 5GHz frequency bands so as to provide complete and seamless coverage of all areas of the development.

H. Wireless controllers shall be independent hardware controllers, switch modules will not be accepted.

I. The proposed network must have full coverage for all areas and must be validated with supporting "heat-map" documentation.

J. The indoor network wireless access points shall be suitable for indoor use and mounting above ceilings.

K. The external wireless access points shall be suitable for external use and shall meet the specified IP and NEMA ratings

L. Type1 Access point

Item	Specification
802.11n version 2.0 (and related) capabilities	● 4x4 MIMO with four spatial streams ● Maximal Ratio Combining (MRC) ● 802.11n and 802.11a/g beamforming ● 20- and 40-MHz channels ● PHY data rates up to 890 Mbps (40 MHz with 5 GHz and 20 MHz with 2.4 GHz) ● Packet aggregation: A-MPDU (transmit and receive), A-MSDU (transmit and receive) ● 802.11 Dynamic Frequency Selection (DFS) ● Cyclic Shift Diversity (CSD) support
802.11ac	● 4x4 downlink MU-MIMO with four spatial streams ● MRC ● 802.11ac beamforming ● 20-, 40-, 80-, and 160-MHz channels

	● PHY data rates up to 3.47 Gbps (160 MHz with 5 GHz) ● Packet aggregation: A-MPDU (transmit and receive), A-MSDU (transmit and receive) ● 802.11 DFS ● CSD support
802.11ax	● 4x4 downlink MU-MIMO with four spatial streams ● Uplink/downlink OFDMA ● TWT ● BSS coloring ● MRC ● 802.11ax beamforming ● 20-, 40-, 80-, and 160-MHz channels ● PHY data rates up to 5.38 Gbps (160 MHz with 5 GHz and 20 MHz with 2.4 GHz) ● Packet aggregation: A-MPDU (transmit and receive), A-MSDU (transmit and receive) ● 802.11 DFS ● CSD support
Integrated antenna	Flexible radio (either on 2.4GHz or on 5GHz) ● 2.4 GHz, peak gain 4 dBi, internal antenna, omnidirectional in azimuth ● 5 GHz, peak gain 5 dBi, internal antenna, omnidirectional in azimuth Dedicated 5GHz radio ● 5 GHz, peak gain 4 dBi, internal antenna, omnidirectional in azimuth
Interfaces	● 1x 100, 1000, 2500 Multigigabit Ethernet (RJ-45) – IEEE 802.3bz ● Management console port (RJ-45) ● USB 2.0 @ 3.75W (enabled via future software)
Indicators	● Status LED indicates boot loader status, association status, operating status, boot loader warnings, and boot loader errors

M. Type 2 Access Point

Item	**Specification**
802.11n version 2.0 (and related) capabilities	● 4x4 MIMO with four spatial streams ● Maximal Ratio Combining (MRC) ● 802.11n and 802.11a/g

	● 20- and 40-MHz channels ● PHY data rates up to 1.5 Gbps (40 MHz with 5 GHz and 20 MHz with 2.4 GHz) ● Packet aggregation: Aggregate MAC Protocol Data Unit (A-MPDU) (transmit and receive), Aggregate MAC Service Data Unit (A-MSDU) (transmit and receive) ● 802.11 Dynamic Frequency Selection (DFS) ● Cyclic Shift Diversity (CSD) support
802.11ac	● 8x8 downlink MU-MIMO with eight spatial streams ● MRC ● 802.11ac beamforming ● 20-, 40-, 80-, and 160-MHz channels ● PHY data rates up to 6.9 Gbps (160 MHz with 5 GHz) ● Packet aggregation: A-MPDU (transmit and receive), A-MSDU (transmit and receive) ● 802.11 DFS ● CSD support ● WPA3 support
802.11ax	● 8x8 uplink/downlink MU-MIMO with eight spatial streams ● Uplink/downlink OFDMA ● TWT ● BSS coloring ● MRC ● 802.11ax beamforming ● 20-, 40-, 80-, and 160-MHz channels ● PHY data rates up to 10 Gbps (160 MHz with 5 GHz and 20 MHz with 2.4 GHz) ● Packet aggregation: A-MPDU (transmit and receive), A-MSDU (transmit and receive) ● 802.11 DFS ● CSD support ● WPA3 support
Integrated antenna	● 2.4 GHz: Peak gain 4 dBi, internal antenna, omnidirectional in azimuth ● 5 GHz: Peak gain 6 dBi, internal antenna, omnidirectional in azimuth
Interfaces	● 1x 100, 1000, 2500, 5000 Multigigabit Ethernet (RJ-45) – IEEE 802.3bz ● Management console port (RJ-45) ● USB 2.0 at 4.5W (enabled via future software)

Indicators	● Status LED indicates boot loader status, association status, operating status, boot loader warnings, and boot loader errors

N. Type 3 Access point (outdoor)

Item	Specifications
802.11ac Wave 1 and 2 capabilities	● 1542I/D: 2 x 2 MIMO with two spatial streams ● Multiuser and single-user MIMO ● Maximal Ratio Combining (MRC) ● 802.11ac beamforming (transmit beamforming) ● 20-, 40-, and 80-MHz channels ● PHY data rates up to 867 Mbps (80 MHz in 5 GHz) ● Packet aggregation: A-MPDU (Tx/Rx) and A-MSDU (Tx/Rx) ● 802.11 Dynamic Frequency Selection (DFS) ● Cyclic-Shift-Diversity (CSD) support
802.11n (and related) capa-bilities	● 1542I/D: 2 x 2 MIMO with two spatial streams ● MRC ● 20- and 40-MHz channels (40 MHz in 5 GHz) ● PHY data rates up to 300 Mbps ● Packet aggregation: A-MPDU (Tx/Rx) and A-MSDU (Tx/Rx) ● 802.11 DFS ● CSD support
Data rates supported	802.11a: 6, 9, 12, 18, 24, 36, 48, and 54 Mbps 802.11b/g: 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, and 54 Mbps
Clients Sup-ported	200 per radio / 400 per access point
Interfaces	● WAN port 10/100/1000BASE-T Ethernet, autosensing (RJ-45), PoE in ● Management console port (RJ-45) ● Multicolor LED/Reset button
Uplink op-tions	Ethernet and wireless mesh
Environmental ratings	● IEC 60529 IP67 ● Icing protection NEMA 250-2008 ● Corrosion NEMA 250-2008 (600 hours) ● Solar radiation EN 60068-2-5 (1200 W/m2)

	• Vibration	MIL-STD-810

O. WIRELESS LAN CONTROLLER

Feature	Description
Maximum number of Access points	250, 500 (with Performance license)
Maximum number of clients	5000, 10,000 (with Performance license)
Maximum throughput	5 Gbps, 10 Gbps (with Performance license)
Maximum WLANs	4096
Maximum VLANs	4096
Fixed uplinks	2x 10G/Multigigabit copper or 2x 10G/Multigigabit fiber
Power supply	110W, 12V DC, AC/DC adapter
Form factor	1RU; half-width chassis allows side-by-side installation in standard 19-in. rack

P. WIRELESS MANAGEMENT

1. Architecture & Manageability

- Customized portal for users interface
- Quota management for 500 concurrent users
- Physical or virtual appliance scalable up to 2000 Concurrent users
- Redundancy / load balancing capacity
- Cloud or private service management platform
- flexible licenses

2. Security

- Data ownership for customer
- Sponsored access (desk, employees can sponsor)
- Traceability
- User, device, location, time profiling
- Password policies
- 802.1x, Wisp'R, LDAP, RADIUS
- ANSSI certification
- Terms of use management
- SNMP monitoring
- URL filtering
- Granular access for admins

3. BYOD

- Per device access profile
- End user device list management
- Active Directory based authentication

4. Data Collection And Analysis

- Self registration (form, SMS, email, social networks)
- Social media authentication
- Open SQL database
- Customizable analytics and reporting (technical reporting or demographic and usage trends for marketing needs)
- Integration of external survey systems with the splash page

5. Monetization And Branding

- Online payment (PayPal, Ogone)
- Integration with PMS & PPS
- Data volume or bandwidth quota
- Welcome back message
- Account refill options
- Possibility of Profiled advertising while user is browsing
- Landing page customization
- Mobile app toolkit
- Marketing Opt-In

6. End User Seamless Experience

- One click login,
- Automatic re-authentication, granular device management options
- 16 languages supported
- Zero configuration

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI's "Telecommunications Distribution Methods Manual" for layout of communications equipment spaces.

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation of equipment in communications equipment spaces.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Coordinate layout and installation of communications equipment in tracks and in room. Coordinate service entrance configuration with service provider.

1. Meet jointly with systems providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize configurations and space requirements of communications equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

G. All Data Communications System equipment hardware shall be mounted in standard equipment rack enclosures. Contractor is responsible for providing special power wiring, earth connections, surge suppression, patch panels, patch cords, cables, connectors and adapters of any kind necessary to accommodate the system installation, operation, testing, or maintenance.

H. Components of the Data Communications System shall be installed in a neat, workmanlike manner.

I. Contractor shall install all equipment items in accordance with contract drawings, manufacturer’s instructions and approved submittal data.

J. System installation and construction methods shall conform to the requirements of the applicable International Standards.

K. Contractor shall install all equipment items in accordance with the manufacturer's instructions, and adjustments required to deliver a complete and operable system.

L. Contractor shall ensure that the sufficient documentation is provided to assist in the final system configuration.

3.3 FIRESTOPPING

A. Comply with requirements in Section 078400 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual," "Firestopping Practices" Ch.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrial Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 50-mm clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 27 Section "Identification for Communication Systems."

3.6 TESTING

A. Periodic and Final Inspection

1. Provide a statement of completion certifying that the system is installed and is ready for acceptance testing and equalization to the Consultant.
2. Schedule a time for the Engineer to perform system acceptance testing and equalization with at least 14 days advance notice.
3. Furnish technicians and engineers who are familiar with the system to assist the Consultant during the acceptance testing and equalization for the duration of time it takes to complete the adjustments (regular time or overtime as required). A minimum of four days is required to complete the adjustments.
4. Provide a statement of completion certifying that the system is installed and is ready for acceptance testing to the Consultant.
5. Schedule a time for the Consultant to perform system acceptance testing with at least 14 days advance notice.

B. Performance Verification Test

1. Demonstrate that the completed Data Communications System comply with the contract requirements. Using approved test procedures, all physical and functional requirements of the system at a room level and at the central server head end level. The performance verification test, as specified, shall not be started until receipt by the Contractor of written permission from the Owner, based on the Contractor's written report. This shall include certification of successful completion of Contractor Field Testing as specified and upon successful completion of training as specified. The Owner may terminate testing at any time when the system fails to perform as specified. Upon termination of testing by the Owner or by the Contractor, the Contractor shall submit a report outlining the required repairs to the Owner then commence system repairs upon direction by the Owner. Upon successful completion of the performance verification test, the Contractor shall deliver test reports and other documentation as specified to the Owner.

2. Record final settings on all equipment and submit with contract closeout documents.
3. Upon completion of initial tests and adjustments, submit written report of tests to the Consultant along with all documents, diagrams, and record drawings required herein.

C. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on CD-ROM.
2. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. CAD drawings are to incorporate test data imported from the test instruments.
3. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labelling, cable termination points, equipment room layouts and frame installation details. The as-built drawings shall include all field changes made up to construction completion:

D. Testing

1. Provide a statement of completion certifying that the system is installed and is ready for acceptance testing to the Consultant.
2. Schedule a time for the Consultant to perform system acceptance testing with at least 14 days advance notice.
3. Furnish technicians and engineers who are familiar with the system to assist the Consultant during the acceptance testing for the duration of time it takes to complete the adjustments. A minimum of four days is required to complete the adjustments.
4. Record final settings on all equipment and submit with contract closeout documents.
5. Upon completion of initial tests and adjustments, submit written report of tests to the Consultant along with all documents, diagrams, and record drawings required herein.
6. Record copy and as-built drawings.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION 271100

DIVISION 28

SECTION 284621.11 - ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Existing fire-alarm system to be modified.
2. Addressable fire-alarm system.
3. Fire-alarm control unit (FACU).
4. Manual fire-alarm boxes.
5. System smoke detectors.
6. Duct smoke detectors.
7. Projected beam smoke detectors.
8. Carbon monoxide detectors.
9. Heat detectors.
10. Multicriteria and multisensor fire detectors.
11. Nonsystem smoke detectors.
12. Fire-alarm notification appliances.
13. Exit-marking audible notification appliances.
14. Firefighters' two-way telephone communication service.
15. Fire-alarm graphic annunciators.
16. Fire-alarm remote annunciators.
17. Fire-alarm addressable interface devices.

B. Related Requirements:

1. Section 087100 "Door Hardware" for magnetic door holders that release in response to fire-alarm outputs.
2. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" or Section 260523 "Control Voltage Electrical Power Cables" for cables and conductors for fire-alarm systems.

1.3 DEFINITIONS

A. DACT: Digital alarm communicator transmitter.

B. EMT: Electrical metallic tubing.

C. FACU: Fire-alarm control unit.

D. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.

E. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the 2007 Energy Independence and Security Act (EISA).

F. NICET: National Institute for Certification in Engineering Technologies.

G. PC: Personal computer.

H. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.4 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. When new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.5 ACTION SUBMITTALS

A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.

B. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

C. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, and details, including details of attachments to other Work.

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Graphic Annunciator panel details as required by authorities having jurisdiction.
5. Detail assembly and support requirements.
6. Include voltage drop calculations for notification-appliance circuits.
7. Include battery-size calculations.
8. Include input/output matrix.
9. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
10. Include performance parameters and installation details for each detector.
11. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
12. Provide program report showing that air-sampling detector pipe layout balances pneumatically within airflow range of air-sampling detector.
13. Provide control wiring diagrams for fire-alarm interface to HVAC; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring and equipment required for HVAC unit shutdown on alarm.
    c. Locate detectors in accordance with manufacturer's written instructions.

14. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
15. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

1.6 INFORMATIONAL SUBMITTALS

A. Certificates:

1. Seismic Performance Certificates: For FACU, accessories, and components, from manufacturer. Include the following information:

    a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
    c. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

B. Field quality-control reports.

C. Qualification Statements: For Installer.

D. Sample Warranty: Submittal must include line item pricing for replacement parts and labor.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
    b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
    c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
    d. Riser diagram.
    e. Device addresses.
    f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
    g. Record copy of site-specific software.
    h. Provide "Inspection and Testing Form" in accordance with "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

        1) Equipment tested.
        2) Frequency of testing of installed components.
        3) Frequency of inspection of installed components.
        4) Requirements and recommendations related to results of maintenance.
        5) Manufacturer's user training manuals.

    i. Manufacturer's required maintenance related to system warranty requirements.
    j. Abbreviated operating instructions for mounting at FACU and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media
3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 10 units.
2. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 10 unit of each type.

3. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
4. Keys and Tools: One extra set for access to locked or tamper proofed components.
5. Audible and Visual Notification Appliances: 5 of each type installed.
6. Fuses: Two of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:

1. Personnel must be trained and certified by manufacturer for installation of units required for this Project.
2. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
3. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.
4. Comply with SBC 401:2018 and SBC 401:2018.
5. Licensed or certified by authorities having jurisdiction.

1.10 FIELD CONDITIONS

A. Seismic Conditions: Unless otherwise indicated on Contract Documents, specified Work in this Section must withstand the seismic hazard design loads determined in accordance with the applicable specifications section for installed elevation above or below grade.

1. The term "withstand" means "unit must remain in place without separation of parts from unit when subjected to specified seismic design loads and unit must be fully operational after seismic event.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. FACP and Equipment:

a. Hochiki

2.2 ADDRESSABLE FIRE-ALARM SYSTEM

A. Description:

1. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice, horn]-and-strobe notification for evacuation.

B. Performance Criteria:

1. Regulatory Requirements:

a. Fire-Alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 70 for use with selected fire-alarm system and marked for intended location and application.

2. General Characteristics:

a. Automatic sensitivity control of certain smoke detectors.
b. Fire-alarm signal initiation must be by one or more of the following devices and systems:

1) Manual stations.
2) Heat detectors.
3) Flame detectors.
4) Smoke detectors.
5) Duct smoke detectors.
6) Air-sampling smoke-detection system.
7) Carbon monoxide detectors.
8) Combustible gas detectors.
9) Automatic sprinkler system water flow.
10) Preaction system.
11) Fire-extinguishing system operation.
12) Fire standpipe system.
13) Dry system pressure flow switch.
14) Fire pump running.

c. Fire-alarm signal must initiate the following actions:

1) Continuously operate alarm notification appliances, including voice evacuation notices.
2) Identify alarm and specific initiating device at FACU, connected network control panels, off-premises network control panels, and remote annunciators.
3) Transmit alarm signal to remote alarm receiving station.
4) Unlock electric door locks in designated egress paths.
5) Release fire and smoke doors held open by magnetic door holders.
6) Activate voice/alarm communication system.
7) Switch HVAC equipment controls to fire-alarm mode.

8) Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
9) Activate stairwell and elevator-shaft pressurization systems.
10) Close smoke dampers in air ducts of designated air-conditioning duct systems.
11) Activate preaction system.
12) Recall elevators to primary or alternate recall floors.
13) Activate elevator power shunt trip.
14) Activate emergency lighting control.
15) Activate emergency shutoffs for gas and fuel supplies, except for shutoffs serving legally required life-safety systems such as emergency generators and fire pumps.
16) Record events in system memory.
17) Record events by system printer.
18) Indicate device in alarm on graphic annunciator.

d. Supervisory signal initiation must be by one or more of the following devices and actions:

1) Valve supervisory switch.
2) High- or low-air-pressure switch of dry-pipe or preaction sprinkler system.
3) Alert and Action signals of air-sampling detector system.
4) Elevator shunt-trip supervision.
5) Independent fire-detection and -suppression systems.
6) Fire pump is running.
7) Fire pump has lost power.
8) Power to fire pump has phase reversal.
9) Zones or individual devices have been disabled.
10) FACU has lost communication with network.

e. System trouble signal initiation must be by one or more of the following devices and actions:

1) Open circuits, shorts, and grounds in designated circuits.
2) Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3) Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4) Loss of primary power at FACU.
5) Ground or single break in internal circuits of FACU.
6) Abnormal ac voltage at FACU.
7) Break in standby battery circuitry.
8) Failure of battery charging.
9) Abnormal position of switch at FACU or annunciator.
10) Voice signal amplifier failure.

f. System Supervisory Signal Actions:

1) Initiate notification appliances.
2) Identify specific device initiating event at FACU, connected network control panels, off-premises network control panels and remote annunciators.

3) Record event on system printer.
4) After time delay of 200 seconds, transmit trouble or supervisory signal to remote alarm receiving station.
5) Transmit system status to building management system.
6) Display system status on graphic annunciator.

g. Network Communications:

1) Provide network communications for fire-alarm system in accordance with fire-alarm manufacturer's written instructions.
2) Provide network communications pathway per manufacturer's written instructions and requirements in NFPA 72 and NFPA 70.
3) Provide integration gateway using BACnet protocol for connection to building automation system.

h. System Printer:

1) Printer must be listed and labeled as integral part of fire-alarm system.

i. Device Guards:

1) Description: Welded wire mesh of size and shape for manual station, smoke detector, gong, or other device requiring protection.

a) Factory fabricated and furnished by device manufacturer.
b) Finish: Paint of color to match protected device.

j. Document Storage Box:

1) Description: Enclosure to accommodate standard 216-by-279 mm manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key contacts, and system information. Provide two key ring holders with location to mount standard business cards for key contact personnel.
2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
3) Color: Red powder-coat epoxy finish.
4) Labeling: Permanently screened with 25 mm high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
5) Security: Locked with 19 mm barrel lock. Provide solid 304 mm stainless steel piano hinge.

2.3 FIRE-ALARM CONTROL UNIT (FACU)

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
a. Hochiki

C. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.

D. Performance Criteria:

1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
2. General Characteristics:

a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
b. Include real-time clock for time annotation of events on event recorder and printer.
c. Provide communication between FACU and remote circuit interface panels, annunciators, and displays.
d. FACU must be listed for connection to central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACU must provide minimum 500-event history log.
f. Addressable Initiation Device Circuits: FACU must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.

1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACU must be listed for releasing service.

2) Annunciator and Display: LCD, [80] <Insert number> characters, minimum.
3) Keypad: Arranged to permit entry and execution of programming, display, and control commands.

g. Alphanumeric Display and System Controls: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

1) Annunciator and Display: LCD, three line(s) of 80 characters, minimum.
2) Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into system for control of smoke-detector sensitivity and other parameters.

E. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.
2. Install no more than 128 addressable devices on each signaling-line circuit.
3. Serial Interfaces:

a. One dedicated RS 485 port for central-station operation using point ID DACT.
b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
c. One RS 232 port for PC configuration.
d. One RS 232 port for VESDA HLI connection.

e. One RS 232 port for voice evacuation interface.

f. Stairwell and Elevator Shaft Pressurization: Provide output signal using addressable relay to start stairwell and elevator shaft pressurization system. Signal must remain on until alarm conditions are cleared and fire-alarm system is reset. Signal must not stop in response to alarm acknowledge or signal silence commands.

1) Pressurization starts when alarm is received at FACU.
2) Alarm signals from smoke detectors at pressurization air supplies have higher priority than other alarm signals that start system.

g. Smoke-Alarm Verification:

1) Initiate audible and visible indication of "alarm-verification" signal at FACU.
2) Activate approved "alarm-verification" sequence at FACU and detector.
3) Record events by system printer.
4) Sound general alarm if alarm is verified.
5) Cancel FACU indication and system reset if alarm is not verified.

h. Notification-Appliance Circuit:

1) Audible appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
2) Where notification appliances provide signals to sleeping areas, alarm signal must be 520 Hz square wave with intensity 15 dB above average ambient sound level or 5 dB above maximum sound level, or at least 75 dB(A-weighted), whichever is greater, measured at pillow.
3) Visual alarm appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.

i. Elevator Recall: Initiate by one of the following alarm-initiating devices:

1) Elevator lobby detectors except lobby detector on designated floor.
2) Smoke detectors in elevator machine room.
3) Smoke detectors in elevator hoistway.

j. Elevator controller must be programmed to move cars to alternate recall floor if lobby detectors located on designated recall floors are activated.

k. Water-flow alarm connected to sprinkler in elevator shaft and elevator machine room must shut down elevators associated with location without time delay.

1) Water-flow switch associated with sprinkler in elevator pit may have delay to allow elevators to move to designated floor.

l. Remote Smoke-Detector Sensitivity Adjustment: Controls must select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment

schedule changes in system memory, and print out final adjusted values on system printer.

m. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to remote alarm station.

n. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in separate cabinet located in fire command center.

o. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of central-control microphone. Amplifiers must comply with UL 1711.

1) Allow application of, and evacuation signal to, indicated number of zones and simultaneously allow voice paging to other zones selectively or in combination.
2) Programmable tone and message sequence selection.
3) Standard digitally recorded messages for "Evacuation" and "All Clear."
4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of FACU.

p. Status Annunciator: Indicate status of various voice/alarm speaker zones and status of firefighters' two-way telephone communication zones.

q. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.

r. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands initiate printing of list of existing alarm, supervisory, and trouble conditions in system and historical log of events.

s. Primary Power: 24 V(dc) obtained from 230 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, and supervisory signals must be powered by 24 V(dc) source.

t. Alarm current draw of entire fire-alarm system must not exceed 80 percent of power-supply module rating.

u. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch.

v. Batteries: Sealed, valve-regulated, recombinant lead acid.

F. Accessories:

1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.
2. Preaction System Functionality:

a. Initiate Presignal Alarm: This function must cause audible and visual alarm and indication to be provided at FACU. Activation of initiation device connected as

part of preaction system must be annunciated at FACU only, without activation of general evacuation alarm.

2.4 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Hochiki
      .

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   1. Double-action mechanism requiring two actions to initiate alarm, breaking-glass or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACU.
   2. Station Reset: Key- or wrench-operated switch.
   3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false-alarm operation.
   4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm.
   5. Able to perform at up to 90 percent relative humidity at (50 deg C)

2.5 SYSTEM SMOKE DETECTORS

A. Photoelectric Smoke Detectors:

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Hochiki

C. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.
      2) UL 268.

   b. General Characteristics:

      1) Detectors must be two-wire type.
      2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      3) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.

4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5) Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
6) Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
7) Operator at FACU, having designated access level, must be able to manually access the following for each detector:

    a) Primary status.
    b) Device type.
    c) Present average value.
    d) Present sensitivity selected.
    e) Sensor range (normal, dirty, etc.).
8) Built in isolators for all initiating devices.
9) Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
10) Multiple levels of detection sensitivity for each sensor.
11) Sensitivity levels based on time of day.
12) Color: White.
13) Rate-of-rise temperature characteristic of combination smoke- and heat-detection units must be selectable at FACU for (8 or 11 deg C) per minute.
14) Fixed-temperature sensing characteristic of combination smoke- and heat-detection units must be independent of rate-of-rise sensing and must be settable at FACU to operate at (57 or 68 deg C).
15) Multiple levels of detection sensitivity for each sensor.
16) Sensitivity levels based on time of day.

2.6 DUCT SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    1. Hochiki

B. Description: Photoelectric-type, duct-mounted smoke detector.

C. Performance Criteria:

    1. Regulatory Requirements:

        a. NFPA 72.
        b. UL 268A.

    2. General Characteristics:

        a. Detectors must be two wire type.
        b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.

c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
d. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
e. Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
f. Operator at FACU, having designated access level, must be able to manually access the following for each detector:

1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).

g. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with supplied detector for smoke detection in HVAC system ducts.
h. Each sensor must have multiple levels of detection sensitivity.
i. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
j. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 PROJECTED BEAM SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hochiki

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Projected Beam Light Source and Receiver: Designed to accommodate small angular movements and continue to operate and not cause nuisance alarms.
b. Detector Address: Accessible from FACU and able to identify detector's location within system and its sensitivity setting.
c. Operator at FACU, having designated access level, must be able to manually access the following for each detector:

1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).

2.8 CARBON MONOXIDE DETECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Hochiki

B. Description: Carbon monoxide detector listed for connection to fire-alarm system.

C. Performance Criteria:

   1. Regulatory Requirements:

      a. NFPA 72
      b. NFPA 720.
      c. UL 2075.

   2. General Characteristics:

      a. Mounting: Adapter plate for outlet box mounting.
      b. Testable by introducing test carbon monoxide into sensing cell.
      c. Detector must provide alarm contacts and trouble contacts.
      d. Detector must send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
      e. Locate, mount, and wire in accordance with manufacturer's written instructions.
      f. Provide means for addressable connection to fire-alarm system.
      g. Test button simulates alarm condition.

2.9 HEAT DETECTORS

A. Combination-Type Heat Detectors:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      - Hochiki

   2. Performance Criteria:

      a. Regulatory Requirements:

         1) NFPA 72.
         2) UL 521.

      b. General Characteristics:

         1) Temperature sensors must test for and communicate sensitivity range of device.

      c. Actuated by fixed temperature of (57 deg C) or rate of rise that exceeds (8 deg C) per minute unless otherwise indicated.
      d. Mounting: Twist-lock base interchangeable with smoke-detector bases.

e. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
f. Color: White.

B. Fixed-Temperature-Type Heat Detectors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Hochiki

2. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.
      2) UL 521.

   b. General Characteristics:

      1) Actuated by temperature that exceeds fixed temperature of (88 deg C).
      2) Mounting: Twist-lock base interchangeable with smoke-detector bases.
      3) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      4) Color: White.

2.10 MULTICRITERIA AND MULTISENSOR FIRE DETECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Hochiki
   -

B. Description: Fire-sensing detectors using multiple means of detection.

C. Performance Criteria:

1. Regulatory Requirements:

   a. NFPA 72.

2. General Characteristics:

   a. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.

c. Automatically adjusts its sensitivity by means of drift compensation and smoothing algorithms. Detector must send trouble alarm if it is incapable of compensating for existing conditions.
d. Test button tests sensors in detector.
e. Operator at FACU, having designated access level, must be able to manually access the following for each detector:

1) Primary status.
2) Device type.
3) Present sensitivity selected.
4) Sensor range (normal, dirty, etc.).

f. Color: White.
g. Comply with UL requirements.
h. Sensors (Multisensor Type): Detector must be comprised of four sensing elements including smoke sensor, carbon monoxide sensor, infrared sensor, and heat sensor.

1) Smoke sensor must be photoelectric type as described in "System Smoke Detectors" Article.
2) Carbon monoxide sensor must be as described in "Carbon Monoxide Detectors" Article.
3) Heat sensor must be as described in "Heat Detectors" Article.
4) Each sensor must be separately listed in accordance with requirements for its detector type.

2.11 NONSYSTEM SMOKE DETECTORS

A. Single-Station Smoke Detectors:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- Hochiki
-

2. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.

b. General Characteristics:

1) Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120 V(ac) with 9 V(dc) battery as secondary power source. Provide with "low" or "missing" battery chirping-sound device.
2) Auxiliary Relays: Form A and one Form C, both rated at 0.5 A.
3) Audible Notification Appliance: Piezoelectric sounder rated at 90 dB(A-weighted) at (3 m) in accordance with UL 464.
4) Visible Notification Appliance: 177 cd strobe.
5) Heat sensor, (57 deg C) combination rate-of-rise and fixed temperature.
6) Test Switch: Push to test; simulates smoke at rated obscuration.

7) Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector must actuate notification on connected detectors.
8) Plug-in Arrangement: Detector and associated electronic components must be mounted in plug-in module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
9) Self-Restoring: Detectors must not require resetting or readjustment after actuation to restore them to normal operation.
10) Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

B. Single-Station Duct Smoke Detectors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Hochiki

2. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.
      2) UL 268A.

   b. General Characteristics:

      1) Sensor: LED or infrared light source with matching silicon-cell receiver.
      2) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Fixed base must be designed for mounting directly to air duct. Provide terminals in fixed base for connection to building wiring.

         a) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; listed for use with supplied detector.

      3) Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
      4) Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.12 FIRE-ALARM NOTIFICATION APPLIANCES

A. Fire-Alarm Audible Notification Appliances:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Hochiki
2. Description: Horns, bells, or other notification devices that cannot output voice messages.
3. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.

b. General Characteristics:

1) Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
2) Chimes, Low-Level Output: Vibrating type, 75 dB(A-weighted) minimum rated output.
3) Chimes, High-Level Output: Vibrating type, 81 dB(A-weighted) minimum rated output.
4) Sounders, High Volume 24 V(dc): Less than 6 mA of alarm current.
5) Sounders, Low Volume 24 V(dc): Less than 4 mA of alarm current.
6) ISO Temporal 3 Evacuation Tone: 90 plus or minus 4 dB(A-weighted) at 24 V.
7) ISO Temporal 3 Alert Tone: 95 plus or minus 5 dB(A-weighted at 24 V.
8) AS2220 Evacuation Tone: 93 plus or minus 4 dB(A-weighted)] <Insert number> at 24 V.
9) AS2220 Alert Tone: 93 plus or minus 5 dB(A-weighted) at 24 V.
10) Horns: Electric-vibrating-polarized type, 24 V(dc); with provision for housing operating mechanism behind grille. Comply with UL 464. Horns must produce sound-pressure level of 90 dB(A-weighted), measured (3 m) from horn, using coded signal prescribed in UL 464 test protocol.
11) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Fire-Alarm Voice/Tone Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Hochiki

2. Description: Notification appliances capable of outputting voice evacuation messages.
3. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.
2) UL 1480.

b. General Characteristics:

1) Speakers for Voice Notification: Locate speakers for voice notification to provide intelligibility requirements of "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
2) High-Range Units: Rated 2 to 15 W.
3) Low-Range Units: Rated 1 to 2 W.
4) Mounting: Flush or surface mounted and bidirectional.
5) Matching Transformers: Tap range matched to acoustical environment of speaker location.

6) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
7) Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
8) Type S1 - High-Range Units: Rated 2 to 15 W for noisy environments, weatherproof.
9) Type S2 - Low-Range Units: ceiling mounted speakers shall be with field selectable output taps from 0.25 to 2 watts.
10) Type S3 - Low-Range Units: ceiling mounted speakers shall be with field selectable output taps from 0.25 to 2 watts, with combined strobe.
11) Type S4 - Low-Range Units : wall mounted speakers shall be fitted with domes to the approval of the interior designer for front of house spaces, speaker provided with field selectable output taps from 0.25 to 2 watts.
12) Type S5 - Low-Range Units : wall mounted speakers shall be fitted with domes to the approval of the interior designer for front of house spaces, speaker provided with field selectable output taps from 0.25 to 2 watts, weatherproof.
13) Speakers in corridors and public spaces shall produce a minimum nominal sound output of 84 dBA at 10 feet (3m).
14) The back of each speaker shall be sealed to protect the speaker cone from damage and dust.
15) Voice Speaker with integrated strobe light: same as voice speaker with strobe light as defined in item above.

C. Fire-Alarm Visible Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   - Hochiki

2. Performance Criteria:

   a. Regulatory Requirements:

      1) NFPA 72.
      2) UL 1971.

   b. General Characteristics:

Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 25-mm- high letters on the lens.

1. Rated Light Output:
   a. 15/30/60/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, white/red to the approval of the architect.

2.13 EXIT-MARKING AUDIBLE NOTIFICATION APPLIANCES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- Hochiki

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Provide exit-marking audible notification appliances at entrance to building exits.
b. Provide exit-marking audible notification appliances at entrance to areas of refuge with audible signals distinct from those used for building exit marking.

2.14 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- Hochiki
- Notifier.
- Siemens Industry, Inc.; Fire Safety Division.
- SimplexGrinnell LP.
- System Sensor

B. Description: Dedicated, two-way, supervised, telephone voice communication links between FACU and remote firefighters' telephone stations. Supervised telephone lines must be connected to talk circuits by controls in control module.

C. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:
a. Selective-talk type for use by firefighters and fire wardens.

b. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously. Indicator lamp must flash if phone is disconnected from talk circuits.
c. Addressable firefighters' phone modules to monitor and control loop of firefighter phones. Module must be capable of differentiating between normal, off-hook, and trouble conditions.
d. Audible Pulse and Tone Generator, and High-Intensity Lamp: When remote telephone is taken off hook, it causes audible signal to sound and high-intensity lamp to flash at FACU.
e. Selector panel controls to provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on panel front by individual LEDs.
f. Display: Graphic to indicate location of caller.
g. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated; factory-standard red finish; with handset.

    1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."
    2) With "break-glass" door access lock.

h. Remote Telephone Jack Stations: Single-gang, stainless steel-plate mounted plug, engraved "Fire Emergency Phone."
i. Handsets: 15 sets with noise-canceling microphone stored in cabinet adjacent to FACU.

2.15 FIRE-ALARM GRAPHIC ANNUNCIATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- Hochiki
- Notifier.
- Siemens Industry, Inc.; Fire Safety Division.
- SimplexGrinnell LP.
- System Sensor

B. Performance Criteria:

1. Regulatory Requirements:

    a. NFPA 72.

2. General Characteristics:

    a. Graphic Annunciator Panel: Mounted in aluminum frame with nonglare, minimum (4.76 mm) thick, clear acrylic cover over graphic representation of facility. Detector locations must be represented by red LED lamps. Normal system operation must be indicated by lighted, green LED. Trouble and supervisory alarms must be represented by amber LED.

1) Comply with UL 864.
2) Operating voltage must be 24 V(dc) provided by local 24 V power supply provided with annunciator.
3) Include built-in voltage regulation, reverse polarity protection, RS 232/422 serial communications, and lamp test switch.
4) Surface mounted in NEMA 250, Type 1 cabinet, with key lock and no exposed screws or hinges.
5) Graphic representation of facility must be CAD drawing and each detector must be represented by LED in its actual location. CAD drawing must be at (1:100) scale or larger.
6) LED representing detector must flash two times per second while detector is in alarm.

b. Graphic Annunciator Workstation: PC-based, with fire-alarm annunciator software with historical logging, report generation, and graphic interface showing alarm points in system. PC with operating system software, minimum 1 TB hard drive, 24” LCD digital display monitor, with wireless keyboard and mouse.

2.16 FIRE-ALARM REMOTE ANNUNCIATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- Hochiki
- Notifier.
- Siemens Industry, Inc.; Fire Safety Division.
- SimplexGrinnell LP.
- System Sensor

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Annunciator functions must match those of FACU for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACU, including acknowledging, silencing, resetting, and testing.

1) Mounting: Flush or Surface cabinet, NEMA 250, Type 1.

b. Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of FACU. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.17 FIRE-ALARM ADDRESSABLE INTERFACE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- Hochiki
- Notifier.
- Siemens Industry, Inc.; Fire Safety Division.
- SimplexGrinnell LP.
- System Sensor

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Include address-setting means on module.
b. Store internal identifying code for control panel use to identify module type.
c. Listed for controlling HVAC fan motor controllers.
d. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.
e. Integral Relay: Capable of providing direct signal to elevator controller to initiate elevator recall

1) Allow control panel to switch relay contacts on command.
2) Have minimum of two normally open and two normally closed contacts available for field wiring.

f. Control Module:

1) Operate notification devices.
2) Operate solenoids for use in sprinkler service.
3) As pet project fire alarm matrix shown on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Preinstallation Testing: Perform verification of functionality of installed components of existing system prior to starting work. Document equipment or components not functioning as designed.

B. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.3 INSTALLATION OF EQUIPMENT

A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before other trades have completed cleanup must be replaced.
2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.

B. Equipment Floor Mounting: Install FACU on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install seismic bracing. Comply with requirements in Section 270548.16 "Seismic Controls for Communications Systems."
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on (460 mm) centers around full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Floor and Wall Mounting: Install FACU on finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Install wall-mounted equipment, with tops of cabinets not more than (1980 mm) above finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in normal path of egress within (1520 mm) of exit doorway.

2. Mount manual fire-alarm box on background of contrasting color.
3. Operable part of manual fire-alarm box must be between (1060 and 1220 mm) above floor level. Devices must be mounted at same height unless otherwise indicated.

F. Smoke- and Heat-Detector Spacing:

1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing must not exceed (9 m)
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex A in NFPA 72.
5. HVAC: Locate detectors not closer than (910 mm) from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than (300 mm) from lighting fixture and not directly above pendant mounted or indirect lighting.

G. Install cover on each smoke detector that is not placed in service during construction. Cover must remain in place except during system testing. Remove cover prior to system turnover.

H. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend full width of duct. Tubes more than (9100 mm) long must be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

I. Air-Sampling Smoke Detectors: If using multiple pipe runs, runs must be pneumatically balanced.

J. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

K. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within dwelling or suite, they must be connected so that operation of smoke alarm causes alarm in smoke alarms to sound.

L. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

M. Audible Alarm-Indicating Devices: Install not less than (150 mm) below ceiling. Install bells and horns on flush-mounted back boxes with device-operating mechanism concealed behind grille. Install devices at same height unless otherwise indicated.

N. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least (150 mm) below ceiling. Install devices at same height unless otherwise indicated.

O. Device Location-Indicating Lights: Locate in public space near device they monitor.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least (13 mm) high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 PATHWAYS

A. Pathways must be installed in EMT.

B. Exposed EMT must be painted red enamel.

3.7 CONNECTIONS

A. Make addressable connections with supervised interface device to the following devices and systems. Install interface device less than (910 mm) from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.

   1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
   2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
   3. Smoke dampers in air ducts of designated HVAC duct systems.
   4. Magnetically held-open doors.
   5. Electronically locked doors and access gates.
   6. Alarm-initiating connection to elevator recall system and components.
   7. Alarm-initiating connection to activate emergency lighting control.
   8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
   9. Supervisory connections at valve supervisory switches.

10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
11. Supervisory connections at elevator shunt-trip breaker.
12. Data communication circuits for connection to building management system.
13. Data communication circuits for connection to mass notification system.
14. Supervisory connections at fire-extinguisher locations.
15. Supervisory connections at fire-pump power failure including dead-phase or phase-reversal condition.
16. Supervisory connections at fire-pump engine control panel.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in location visible from FACU.

3.9 GROUNDING

A. Ground FACU and associated circuits in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.10 FIELD QUALITY CONTROL

A. Field tests must be witnessed by authorities having jurisdiction and/or engineer on site.

B. Administrant for Tests and Inspections:

1. Owner will engage qualified testing agency to administer and perform tests and inspections.
2. Engage qualified testing agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
    b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.

2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
4. Test audible appliances for private operating mode in accordance with manufacturer's written instructions.
5. Test visible appliances for public operating mode in accordance with manufacturer's written instructions.
6. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Provide video recording of training to Owner.

3.12 MAINTENANCE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections in accordance with "Visual Inspection Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in "Test Methods" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per "Testing Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.13 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement must include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software must include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

END OF SECTION 284621.11