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END OF SECTION

SECTION 16100

COMMON WORK RESULTS FOR ELECTRICAL

Part 1 GENERAL

1.1 Summary

A. This Section includes the following:
   1. General provisions applicable to Division 16 work and other Sections of the specification that refer to this Section.

B. Electrical Work, unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the drawings and/or described in the Specification together with all associated ancillary work, support work and builder's work required to achieve full functionality as per the design intent.

C. The scope of electrical works shall include, but shall not be necessarily limited to the following:
   1. Main distribution boards.
   2. Distribution panels.
   3. Feeders, sub-feeders and wires.
   4. Conduits, cable trays, and supporting systems.
   5. Functional and decorative lighting.
   6. Emergency lighting and exit signs.
   7. Lighting control and dimming systems.
   8. Wiring devices & miscellaneous equipment.
   9. Uninterruptible Power Supply.
   10. Structured Cabling Network.
   11. Access Control System (ACS).
   12. Video Surveillance (CCTV).
   13. Fire Detection and Alarm system.
   14. Voice Evacuation System.
   15. Audio System.
   16. Audio Video System.

1.2 Regulations and Standards

A. Regulations: Carry out electrical work in accordance with the current issue of the local codes of practice, local power authority regulations - JEPCO and Requirements for Electrical Installations – IET Wiring Regulations (BS 7671) as published by the Institution of Engineering and Technology and IEC Standards were not in contradiction with the local codes of practice and regulations, herein referred to collectively as 'the Regulations'.

B. Conflict: Should an instance occur in this Specification or on the Drawings in which material or construction methods called for is less than minimum requirement of the Regulations, immediately inform the Engineer in writing. Consequent to Engineer's approval, supply the materials and perform the work as though called for to minimum code standards.

1.3 Power Supply

A. The Local Power Authority-JEPCO will provide incoming power supply and connection from 11/0.4kV substations located within the building.

B. Power Supply: Liaise with the Local Power Authority to confirm:

1. Characteristics of supply and system earthing.
2. Location of incoming supply shown on the Drawings.
3. Space requirements and associated builder's work for the Authority's installations.
4. Make necessary arrangements at the earliest opportunity to ensure connection as and when required, and inform the Engineer in the event of any foreseen delay.
5. KWH-metering: Liaise with the Local Power Authority and provide necessary instrumentation, enclosures and accessories required by them to effect a complete kWH-metering installation.
6. KWH-metering will be at as per JEPCO requirements unless otherwise shown on the Drawings.

1.4 Equipment

A. Equipment Spaces and Rooms: Verify that dimensions, structure, ventilating and cooling arrangements and other provisions in equipment spaces and rooms are suitable for installation, operation and maintenance of proposed equipment. Note any discrepancies on the shop and construction drawings.

B. Equipment shall be designed for the system voltage and frequency previously described, unless otherwise specified. Special provisions shall be made for equipment sensitive to power supply frequency and voltage variations and for equipment operated at other voltages/frequencies or by direct current sources.

1.5 Climatic Conditions

A. Climatic Conditions at Project's Site:
   1. Altitude: 900 m above sea level.
   2. Maximum ambient temperature: 38.5degrees C (in the shade).
   3. Minimum ambient temperature: -0.8 degrees C.
   4. Maximum relative humidity: 70 %.

B. Equipment, apparatus, material accessories installed outdoors shall be corrosion and salinity proof. UV stabilized requirement shall be applied for outdoor installations and their surface finish and due certification shall be provided by manufacturer as necessary.

1.6 Drawings

A. Equipment locations shown on the Drawings indicate approximate locations and general layout of equipment. Exact and final locations and layouts together with dimensions, weights, mounting methods and accessories, where relevant, shall be shown on Contractor's shop and construction drawings.

B. Symbols: In order to provide sufficient detail and a minimum degree of clarity on the Drawings, the symbols used for various electrical devices, particularly wall mounted devices, take up more space on the Drawings than the device does on the wall. Because of drafting limitations these locations must be considered as being indicative rather than exact physical locations of the devices. The devices shall be installed with prime regard for convenience of operation and the proper usage of the wall space rather than to coincide with the scaled locations of the symbols. In locating the outlets, follow the criteria provided on detail Drawings

where provided, and coordinate with furniture. Do not scale from design Drawings.

C. Wiring layouts shown on the Drawings shall be used as a guide only to defining basic positions, circuiting, loading and switching arrangements. Actual layouts and details of routing of circuits shall be shown on the Contractor's shop and construction drawings.

D. Wiring layouts shown on the Drawings for work not included in the Electrical Work are shown for convenience and reference only.

1.7 Submittals

A. Generally: Submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.

B. Product Data: Submit for approval detailed product data such as model no., all relevant ratings, country of manufacture, interface details as necessary, covers and supports.

C. Calculations: Submit for approval the manufacturer/supplier calculations for the following systems, prior to ordering/manufacturing the material:
   1. Indoor and outdoor lighting distribution, with necessary supporting documents and photometric data of the lighting fixtures proposed and approved by the Contractor.
   2. Circuit breakers selectivity and discrimination calculation study for a full selective and discriminated distribution scheme
   3. Voltage drop and short circuit calculations after verification of cable and breaker sizes.
   4. Rating / de-rating calculations for the specified equipment.
   5. Design calculations associated with communications and security systems engineering, Power consumption and heat dissipation, link budget, fiber count, Quality of Service (QoS), redundancy, reliability and service availability.
   6. Any required calculation necessary to define component/equipment sizes for the proper operation of the electrical and ELV systems, and to confirm compliance with specified Regulations and Standards.

D. Shop and Construction Drawings:

   1. Dimensioned plans and sections or elevation layouts of electrical equipment, as applicable.

   2. Shop and construction drawings must demonstrate that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings

shall clearly state the name and location of the work, the names of Engineer and Contractor, submission date, cross-references to the Drawings and Specification and the specific reference number, location, service and function of each item.

3. Shop and construction drawings shall be submitted at a scale of 1:50 for general layout plans, and 1:10, or 1:20 as approved by the Engineer for sections, details, elevations, congested layouts, etc. Drawings shall include but not be limited to the following:
    i. Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for passage through floor structure.
    ii. Composite construction drawings fully dimensioned, in metric, showing locations of cables, conduits, bus ducts, shafts, mechanical and electrical equipment rooms, ceiling spaces and all other critical locations
    iii. Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
    iv. Plans, sections and elevations of electrical spaces to illustrate compliance with Standards for allocation of spaces for maintenance, movement, installation, etc.
    v. Elevations showing all electrical wiring installations on all walls.

4. Single Line Diagrams: Detailed single line diagrams and control schematics clearly indicating all equipment ratings, frame sizes, cable sizes, and nomenclature/identification number shall be submitted for the Engineer’s approval.

E. Technical Literature: Include detailed manufacturers' specifications and original catalogues or catalogue cuts, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy Engineer that proposed equipment and systems are suitable and adequate.

F. Test Certificates and Reports: Submit manufacturer's type and routine test certificates and reports for equipment and devices. Complete test results shall be submitted in clearly identified and organized booklets, indicating item of equipment, make, model, type, date of tests, and type of tests, descriptions and procedures. Include in the test reports the Quality Assurance Certification, the standards to which the equipment comply, and the standards to which the equipment was tested.

G. Factory Testing: Locally manufactured/assembled equipment shall comply with the relevant standards recommendations and shall be witnessed by Engineer, where required in the relevant Specifications Section. If the manufacturer's test certificates/tests are not complying with the standards, then independent laboratory tests shall be carried out on equipment in accordance with the Specification and the Standards, and as required by Engineer. The Engineer's requirements in that respect are final and not subject to discussion.

H. Spare Parts Schedules: Submit with the Tender itemized schedules of spare parts to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.

I. Labeling Schedule: Submit for approval, prior to installation, a schedule of all equipment and devices to be labeled and the suggested details, lettering, position and fixing methods of each label indicating its application.

J. Samples: Submit samples of all equipment and materials for approval. Major items of equipment for which samples cannot be submitted shall be demonstrated in existing installations or by manufacturer's information, test certificates and reports.

K. As-Built (Record) Drawings: Prior to Issuing Taking Over certificate, submit Record Drawings certified by the Engineer on installed electrical systems. The As-Built (Record) Drawings, where applicable, shall include data on existing works. The As-Built Records shall be made progressively as the Work proceeds.

1.8 Coordination

A. Coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
B. Coordinate electrical service connections to components furnished by utility companies.
C. The locations of access panels shall be coordinated and proposed to ensure that all electrical equipment are accessible within "hand-reach" through the access provided.
D. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
E. Where acoustical ceilings and similar finishes will conceal electrical identification markings and devices, coordinate installation of these items before ceiling installation.
F. Locations of all ceiling lighting fixtures, fire alarm detectors, emergency lighting, CCTV cameras, etc. shall be coordinated with false ceiling subcontractor and other mechanical services outlets, to the satisfaction of the Engineer and technical and functional requirements.

1.9 Equipment and Materials

A. Availability: Confirm availability of equipment and materials proposed for use in the work prior to submission for approval. If, after approval, equipment or materials cease to be available, submit alternative items of equal quality and type for approval.
B. Acceptance by Authority: Confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other Authorities having jurisdiction and are acceptable to them. Inform Engineer of any modifications necessary to comply with the Local Power Authority's requirements.
C. Manufacturers' Standards: Equipment shall be the latest standard product of the manufacturer. Component parts shall be the product of a single manufacturer,

unless otherwise approved and provided that components made by other manufacturers are of a standard design and are interchangeable.

D. Factory Assembly: Equipment generally shall be supplied in complete factory assembled units ready for installation on site. Dis-assembly necessary for transportation or other purposes shall be arranged to limit site work to simple re-assembly and inter-wiring of control and power cabling.
E. Storage of Materials: Equipment and materials shall be stored in an approved location, under cover, free from humidity, dust, debris and rodents. Equipment sensitive to heat and humidity shall be kept in climatically conditioned areas until installed and handed over.
F. Warranty: Where required by the Specification, provide a warranty, signed by the manufacturer (including his agreement to replace promptly, defective equipment or parts thereof, as instructed by the Engineer) covering materials and workmanship for the period stated in the Specification, starting at Issuing Taking Over certificate. Assign the benefits of such warranty to the Employer.
G. Spare Parts: Not later than the date of Issuing Taking Over certificate, provide spare parts required by the Specification, together with suitable means of identifying, storing and securing same.
H. Label and identify all equipment, instruments, control and electrical devices etc. to indicate duty, service or function, to the satisfaction of Engineer. Labels shall be laminated anodized aluminum discs with black surface and white core with incised lettering in English. Alternative methods of labelling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent
I. All panels and electrical boards shall have designs permitting easy access of internal components for maintenance and replacement without disturbing other components. All equipment shall be designed for easy and simple operation.

1.10 Dismantling

A. Contractor to submit for approval method of statement indicating the dismantling procedure in tidy manner.

B. Follow related drawings for dismantling along with all indication for devices stated on layouts, and non-mentioned item in the drawings shall be clearly identified by the proposed method of statement.

C. Dismantling with care, removing out of site all of the refuse and debris, handling with care, storing in secured and adequate storage area, handling to the client on site all of the dismantled and removed equipment. All as per the drawings, approved method of statement and as the instructions of Engineer.

D. All civil works associated with electrical works demolition including but not limited to excavation and back filling, opening or chasing in block/concrete walls and slabs to be included.

END OF SECTION 16100

SECTION 16195

IDENTFICATION FOR ELECTRICAL SYSTEMS

Part 1 GENERAL

1.1 Summary

A. This Section includes the following:

1. Electrical identification.

B. Electrical Work, unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the drawings and/or described in the Specification together with all associated ancillary work, support work and builder's work required to achieve full functionality as per the design intent.

1.1 Submittals

A. Generally: Submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.

B. Product Data: Submit for approval detailed product data such as model no., all relevant ratings, country of manufacture, interface details as necessary, covers and supports.

Part 2 PRODUCTS

2.1 Description

A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by these Specifications.

B. Raceway and Cable Labels: Minimum size of letters for legend and minimum length of color field for each raceway and cable size to meet IEC Standards.
   1. Type: Pre-tensioned, wraparound plastic sleeves. Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the item it identifies.
   2. Color: Black letters on orange background.
   3. Legend: Indicates voltage.

C. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 25 mm wide by 0.08 mm thick.

D. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

E. Equipment Nameplates: Non-corroding, robust metal, inscribed in English, and firmly fixed to equipment at factory. Nameplates shall indicate name and address of manufacturer, model, serial number, basic characteristics and ratings of equipment and shall include elementary diagrams etc., all in accordance with the Standards. Equipment shall also be further identified after location at site, indicating the nomenclature number as per approval. As a general practice, the identification labels shall be suitably located on adjoining surface or on separate support and not on the electrical device which could be removed and replaced.

F. Color-Coding Cable Ties: Nylon, self-locking type. Colors to suit coding scheme.

G. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1.6-mm minimum thickness for signs up to 129 sq. cm and 3.2-mm minimum thickness for larger sizes. Engraved legend in black letters on white background.

H. Interior Warning and Caution Signs: Preprinted, aluminum, baked-enamel-finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.

I. Exterior Warning and Caution Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 1-mm, galvanized-steel backing, with colors, legend, and size appropriate to the application. 6-mm grommets in corners for mounting.

J. Fasteners for Nameplates and Signs: Self-tapping, stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat and lock washers.

Part 3 EXECUTION

3.1 Description

A. Comply with BS 822 and IEC 60034-8.

B. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.

D. Identify raceways and cables with color banding as follows:
   1. Bands: Pre-tensioned, snap-around, colored plastic sleeves or colored adhesive marking tape. Make each color band 50-mm wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
   2. Band Locations: At changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 8-m maximum intervals in congested areas
   3. Colors: As follows:
      i. Fire Alarm System: Red.
      ii. Security System: Blue and yellow.
      iii. Telecommunication System: Green and yellow

E. Install warning, caution, and instruction signs where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

F. Install engraved-laminated emergency-operating signs with white letters on red background with minimum 9-mm- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

G. Labels: Labels shall be provided inside the boxes or cubicles to describe the functions of the various items of equipment. Where the cubicle is divided into compartments each door shall have an external label to identify the compartment.

END OF SECTION 16195

SECTION 16205

SCHEDULE FOR APPROVED MANUFACTURERS

Part 1 GENERAL

1.1 Summary

A. The design is based on the equipment performance under listed in this section.
B. The tender pricing shall be based on any of the under listed manufacturers / brands for each type / system.
C. The contractor must submit the base tender complying with the under listed manufacturers. An alternative offer from alternative manufacturers may be submitted in addition to the base tender, provided that full substantiating data of the equipment, and noting of the non-compliant features of the alternative equipment / system together with the cost implications is provided.
D. All alternative equipment /system offers may be accepted or rejected at the sole discretion of the Engineer as it shall be subject to the review, approval and final acceptance of the Engineer.
E. Submit the compliance form with the Tender indicating the proposed manufacturer(s) for major equipment / system. Treat all equipment / system for which data submissions are required as major equipment / system for this purpose.
F. Changes from the listed equipment / system offered during the tender stage will not normally be permitted unless the Engineer is satisfied that there is significant advantage in Principle.

1.2 Schedule

Equipment	**Manufacturer**	**Country Of origin**
All switchgears; Main Distribution Boards, Sub-main, secondary distribution boards and motor control centre	ABB	Italy
Starters, relays, contactors, indication lamps, push buttons, selector switches, motion /presence Detectors, wiring terminal blocks...etc	ABB	Italy
Wiring Accessories	LEGRAND (Decorative Range)	France
Floor Boxes	LEGRAND	France

Equipment	**Manufacturer**	**Country Of origin**
PVC Conduits	Addasani	Kuwait
EMT Conduits	ITCC Panasonic Electroline	Saudi Arabia China Turkey
GI Cable Trays and Trunking	Ardic Euro Tray	Turkey Turkey
Wiring/Power Cables	UCIC Cabelco	Jordan Jordan
Data/Security System Cabling Data Patch Panel	Leviton	UK
Isolator	ABB Schneider	Germeny France
CCTV System	Dahua	China
Fire Alarm System	Simplex	USA
UPS	APC/Schneider Electric	France
Generator	Cummins	India/US
Lighting Control	JUNG	Germany
Earthing	Furse-ABB	UK

END OF SECTION 16205

SECTION 16210

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

Part 1 GENERAL

1.1 Submittals

A. Product Data: Submit data for approval including, but not limited to, manufacturers' catalogues with specifications of raceways including conduits, trunking, boxes, etc. and related accessories

B. Point-wise compliance statement to the specifications, duly signed by the manufacturer / materials supplier and the contractor.

C. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
   1. Exact routing of conduits, trunking etc. with indication of boxes, accessories and expansion joints, size and type of conduits and boxes.
   2. Typical assembly details of installation of trunking, trays etc.
   3. Construction details of pull boxes.
   4. For prewired installations, submit drawings for approval showing the complete layout of all products that make up the complete system for each floor prior to the installation of raceway lengths, device type (power and data), locations and circuits identified.

D. Samples of each type of raceway, box, and accessory.

E. As-Built (Record) Drawings: At Project close-out, submit Record Drawings of installed electrical raceways and boxes

1.2 Quality Assurance

A. Regulations and Standards: Conduits, wire ways, cable trays and fittings shall be designed, constructed and installed to give safe installation and reliable mechanical protection for wires and cables in accordance with the Regulations. Standards of products shall be as specified.

B. All products shall carry permanent marking by manufacturer.

C. All materials shall be stored in covered areas and protected from dust and dampness.

D. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

Part 2 PRODUCTS

2.1 Electrical Metal Tubing

A. Electrical Metallic Tubing (EMT): welded steel, non-threaded type, galvanized externally and protected internally with corrosion resistant enamel, and to U.S. Federal Specifications, UL 797 and ANSI C80.3.

B. EMT Fittings Generally: thread-less pressure type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres shall be specially treated. Factory made bends shall be provided where site bending is not possible.

C. Corrosion Resistance: conduits used in corrosive atmospheres shall be made of aluminum or PVC coated EMT conduits and highly resistant to corrosion.

2.2 Flexible Steel Conduit

A. Material: Steel, cold rolled and annealed, non-threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside, and to IEC 61386 or UL 1.

B. Liquid-tight flexible conduit shall be used in indoor wet areas and shall have PVC jacket extruded over core.

C. Flexible steel conduits used outdoors shall be liquid tight, stainless steel grade 316, to UL360.

D. Fittings Generally: Threadless, hinged clamp type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres shall be specially treated.

E. Straight Connectors: One piece body, female end, having hinged clamp and deep slotted machine screws for securing to conduit, male end having thread and locknut.

F. Angle connectors of 45 or 90 degree and terminal connectors shall be as specified for straight connectors, except that body shall be two-piece with removable upper section.

2.3 Rigid PVC-U Conduit

A. Material: Rigid unplasticized polyvinyl chloride (PVC-U) with high temperature resistance, flame retardant, non-hygroscopic and non-porous, to BS 4607, IEC 61386-1 and IEC 61386-21 or DIN 49016, heavy grade, classification code 4421, compression force 1250 N, IEC 61386-21, DIN 49016-1 or other equal and approved standards conforming to IEC 60423.

B. Fittings Generally: Unbreakable, non-inflammable, self-extinguishing, heavy molded plastic. Expansion couplings shall be telescoping double tube type, with at least two inner water-tight neoprene rings.

C. Assembly: Conduits, boxes and accessories shall be assembled by cementing, using manufacturer's recommended products and appropriate connectors or spouts. Where no spouts are available use smooth bore male PVC bushes and sockets.

2.4 Flexible PVC-U Conduit

A. Material: flexible unplasticized polyvinyl chloride (PVC-U), flame retardant, heat resistant, nonhygroscopic, high resistance to impact, ribbed on circumference for flexibility to IEC 61386-1, classification code 3321, compression force 750 N or other equal and approved standards.

B. Fittings Generally: unbreakable, non-inflammable, self extinguishing, heavy molded plastic. Expansion couplings shall be telescoping double tube type, with at least two inner water-tight neoprene rings.

2.5 Outlet Boxes

A. Wiring devices back boxes and conduits pull boxes shall comply with BS 4662 / IEC 60670. Conduit circular pull boxes shall comply with BS 4607 / IEC 61386. Conduit junction boxes shall comply with IEC 60670-22. Floor boxes shall comply with IEC 60670-23.

B. Surface or recessed boxes shall be suitable for type of related conduit or cable system. Shapes and sizes of boxes shall be of compatible standards as switches and socket outlets specified under Division 16 Section "Wiring Devices 16240", and lighting fixtures selected and of various types and mounting methods required.

C. Unused openings in outlet boxes shall be closed with molded caps or knock-out closers manufactured for the purpose.

D. Floor outlets and plates shall be water-tight and impact resistant.

2.6 Metallic Outlet Boxes

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

B. Exposed Surface Mounted Boxes: Galvanized cast iron with threaded hubs. As an alternative, UL listed boxes may be provided.

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. As an alternative, UL listed boxes may be provided.

D. Floor Boxes: 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, internal components as per the design drawings.

2.7 Molded Plastic Outlet Boxes

A. Type: Boxes and covers used with PVC conduit systems shall be heavy gauge pressure molded plastic, minimum 2 mm thick, self-extinguishing, with softening point not less than 85 deg. C. Boxes shall have provision for securely terminating conduits and shall be manufacturer's standard for required application.

B. Fittings: Boxes shall have brass inset threads to receive cover screws and for mounting devices or accessories, push-fit brass earth terminals, and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets shall be provided for weatherproof installations.

C. Molded plastic outlet boxes shall not be used outdoors.

Part 3 EXECUTION

3.1 Examination

A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 General

A. Use: Unless otherwise specifically indicated all light and power circuits, communications, signal and low current systems wiring shall be drawn inside conduits or wire ways up to the various electric power consuming equipment as shown on the Drawings.

B. Cables of different voltages shall not be mixed within the same conduit or wire way as per the regulations.

C. Boxes: Pull, and splice boxes of ample capacity shall be provided as indicated or required. Boxes shall remain permanently accessible

D. Recessed Outlet Boxes: Make neat openings, to the satisfaction of Engineer, allowing for thickness of finishing, and use extension rings if required. Repair damaged finishing to original condition before installation of fittings or plates.

E. Boxes Mounting Heights and Location: As specified under division "16240 Wiring Devices", and as shown on drawings.

F. Spare capacity shall not be less than 25 percent for all raceways for all systems (LV and ELV).

G. Mechanical Continuity: Conduits and wire ways shall be effectively joined together and connected to electrical boxes, fittings and cabinets to provide firm mechanical assembly. Earthing jumpers shall be installed on steel conduits where required to ensure effective electrical continuity irrespective of whether a separate protective earth conductor is required or not.

3.3 Applications

A. Electrical Metallic Tubing (EMT) shall be used for exposed installations over false ceilings when the false ceiling is used as a return plenum.

B. Electrical Metallic Tubing (EMT) shall be used for exposed and above false ceiling wiring

C. Installations used in conjunction with exit and escape route lighting/emergency lighting circuits, fire alarm & security installations.

D. Electrical Metallic Tubing (EMT) shall be used for all installations in rooms and shafts, electrical equipment rooms and mechanical rooms.

E. Rigid PVC-U conduit shall be used for lighting and power circuits, low current, communication and signal system wiring, where embedded in concrete, masonry, underfloor, except where otherwise shown on the Drawings or described in the particular section of the specification.

F. Rigid PVC-U conduit shall be used above false ceilings for lighting and power circuits, low current, communication and signal system wiring, when the false ceiling is not used as return plenum – and in furred walls. Use flexible PVC-U conduits from outlet boxes to fixtures in conjunction with the use of PVC-U conduits.

G. Flexible conduit of same material as corresponding conduit system shall be used for connection to motors, vibrating and non-rigidly fixed equipment and to fixtures installed in false ceilings.

H. Flexible steel conduit shall be used in movable partitions and from outlet boxes to fixture over false ceilings when used as a return plenum. Conduits shall be liquid tight in damp areas.

I. Clearances: Install conduits at least, 150 mm clear of and preferably above pipes of other nonelectrical services. (Hot water pipes, etc.). Wherever possible, install horizontal conduit and wire ways runs above water and steam piping.

J. Make good all holes for conduits passing through walls, floors and ceilings with cement or similar fire-resisting material to full thickness.

K. Bends: Conduit runs between outlet and outlet, fitting and fitting or outlet and fitting shall not contain more than the equivalent of 2 quarter bends (180 degree total).

L. W. Bending shall be made without damaging conduit or tubing and without reducing internal diameter. Methods of field bending shall be approved.

3.4 PVC Conduits

A. Coupling of conduit and/or termination into spouted fittings shall be made watertight and permanent using special cement.

B. Termination: Connect conduits terminating in switchgear, fuse boards, trunking, adaptable boxes or other non-spouted enclosures etc. with smooth bore male PVC bushes and sockets.

C. Ends of conduit and conduit fittings shall be cleaned and jointed using PVC cement recommended by manufacturer.

D. Semi-Permanent Adhesive: Use in joints requiring expansion couplers.

E. Bends: Conduits not exceeding 25 mm diameter may be cold bent using bending springs. Conduits over 25 mm shall be hot bent by an approved method.

3.5 Embedded Conduits

A. Conduits in Partitions or Side Walls: Horizontal or cross runs shall be avoided.

B. Pull-boxes shall not be used except for concealed installations above false ceiling at accessible locations. If unavoidable, pull-boxes may be approved if located inconspicuously

C. Conduits in floor of beds on grade: Encase in concrete, minimum thickness 50 mm or to thickness allowed by architectural detail.

3.6 Exposed Conduits

A. Spacing of clamps or clips for supporting steel conduits shall be as per the following:
    1. Maximum spacing of 3 meters for conduits with sizes 25mm and below
    2. Maximum spacing of 4 meters for conduits with sizes 32mm & 38mm
    3. Maximum spacing of 5 meters for conduits with sizes above 38mm.

B. Spacing of clamps or clips for supporting PVC conduits shall be as per the following:
    1. Maximum spacing of 0.6 meters for conduits with sizes 25mm and below
    2. Maximum spacing of 0.75 meters for conduits with sizes 32mm, 38mm & 50mm
    3. Maximum spacing of 0.9 meters for conduits with sizes above 50mm.

END OF SECTION 16210

SECTION 16220

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

Part 1 GENERAL

1.1 Submittals

A. Technical Data: Submit data for approval including, but not limited to, the following:
   1. Constructional details, standards to which cables comply, current carrying capacities, dating factors for grouping and temperature.
   2. Manufacturer's catalogue cuts.
   3. Dimensional and electrical characteristics.
   4. Manufacturer's drawings showing the outline of the lugs and sleeve connectors together with all pertinent dimensions. Any variation in these dimensions due to manufacturing tolerances shall be indicated.

B. Samples of each cable and wire and, if requested by Engineer, other accessories.

C. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
   1. Exact routing layouts, sections and profiles of trays, feeder, sub-feeder cables and branch circuits, with indication of any equipment to show and verify coordination between various trades.
   2. Details of supports and fixings for buses, trays and cables.
   3. Details of connections to transformers, switchboards, panel boards etc.
   4. Details of terminations, splices and tapings where permitted, glands and bushings at enclosures.
   5. Number and size of conductors in conduit for all branch circuits in accordance with final conduit routing.

D. Certificate of Origin: For each lot of cable supplied, provide a certificate of origin issued by manufacturer stating origin, date of manufacture, composition, standards to which it complies and test certificates. All test certificates shall comply with the test requirements of the relevant standard to which the cable is manufactured.

E. Tests and Certificates: Submit complete certified manufacturer's type test records for cables and accessories in accordance with the Standards.

F. Point-wise compliance statement to the specifications, duly signed by the manufacturer / manufacturer’s authorized representative and the contractor.

G. Cable Jointing Qualifications: Submit details of the proposed cable jointers qualifications prior to work commencing on site.

H. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.2 Quality Assurance

A. Installer Qualifications: Engage an experienced and certified cable splicer to install, splice and terminate low-voltage cables.

B. Standards: Wires and cables shall comply with IEC or other equally approved standards and shall bear the mark of identification of the Standards to which they are manufactured. Wires and cables not having this identification will be rejected.

C. Current carrying capacities of conductors have been determined in accordance with the regulations for specified type of insulation and expected conditions of installation. No change will be accepted in specified type of insulation unless warranted by special conditions and approved by Engineer. Check various loads and current carrying capacities and report any discrepancies or insufficiency of sizes indicated to Engineer.

1.3 Delivery, Storage, and Handling

A. Deliver wires and cables properly packaged in factory packed or fabricated containers, wound on factory reels.

B. Store wires and cables in dry areas, and protect from weather, fumes, water, debris, etc.

C. Handle wire and cable carefully to avoid abrasing, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

1.4 Coordination

A. Coordinate layout and installation of cables with other installations.

B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Engineer.

Part 2 PRODUCTS

2.1 Description

A. Conductors: Unless otherwise specified or shown on the Drawings, cables and other feeders shall have copper conductors. Cable conductors shall be stranded for sections 4 mm2 and above, based on BS 7671 18th edition. Signal and control cables shall have solid conductors unless otherwise specified. Flexible cords shall have finely stranded conductors. Conductors of single-core cables 25-mm2 and above shall be compacted. Multi-core cables 35-mm2 and above shall be sectorial shape.

B. Conductor sizes shall be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted.

C. Low voltage cables, cable terminations and building wiring insulation shall be color coded or otherwise identified as required by the Regulations and as follows:
   1. Neutral shall be black.
   2. Protective earth shall be green/yellow striped.
   3. Phase colors shall be red, yellow, blue or use color coding in accordance with local regulations and standards.

D. Maintain color coding throughout installation. Phase-conductors for which outer jacket is not color-coded shall have engraved alphanumeric mark (L1, L2, L3) or color coded heat-shrinkable sleeves.

E. Outdoor cables exposed to sunlight shall be provided with ultraviolet resistant PVC sheath having 2.5% black carbon content.

2.2 LV Wires and Cables

A. Single Core PVC Insulated Non-Sheathed Cables (Building Wires): Unless otherwise specified, single conductor cables for wiring in conduit shall have annealed copper conductors, compacted, generally with concentric strands and insulated with flame retardant insulation to IEC 60332-1, moisture and heat resistant PVC/E to IEC 60227-1 and 3, suitable for wet locations and for conductor temperature of 70 deg. C. Wires and cables shall be 450/750 V grade.

B. Multi-Core PVC Insulated Cables (0.6/1 kV): To have annealed, copper conductors, compacted, insulated with PVC/A to IEC 60502-1, moisture and heat resistant, suitable for wet locations and conductor temperatures of 70 deg. C, laid up, bedded with suitable filler and sheathed with flame retardant PVC/ST2. Armored cables shall have single layer of galvanized steel wire armor with flame retardant PVC/ST2 over-sheath. Cables shall comply with IEC 60332-3, and IEC 60811.

C. C. Single Core XLPE Insulated Feeder Cables (0.6/1 kV): Single-core circular stranded, annealed copper conductors, compacted, insulated with moisture and heat resistant cross-linked polyethylene (XLPE), suitable for wet locations and conductor temperatures of 90 deg. C. and flame retardant PVC/ST2 over-sheath.

Armored cables shall have taped bedding, single wire aluminum armor and flame retardant PVC/ST2 over-sheath. Cables shall comply with IEC 60502- 1, IEC 60332-3, and IEC 60811.

D. Multi-Core XLPE Insulated Feeder Cables (0.6/1 kV): Multicore annealed copper conductors, compacted, XLPE insulated, for conductor temperature of 90 deg. C, laid up and bedded with suitable non-hygroscopic material compatible with the insulation and flame retardant PVC/ST2 over-sheathed, color black. Armored cables shall have single layer of galvanized steel wire applied helically over extruded flame retardant PVC/ST2 bedding (which may be an integral part of filling) and over-sheathed with flame retardant PVC/ST2, color black. Cables shall comply with IEC 60502-1, IEC 60332-3, and IEC 60811.

2.3 Termination and Splice Connectors (LV Power)

A. Connector terminations and splices shall be of class A to IEC 61238-1.

B. Connectors shall be compression, barrel crimped type.

C. Connectors for copper conductors shall be made of electrolytic copper.

D. All termination and splice connectors specified above shall be tin plated with minimum thickness of 5 microns for copper material

E. Splice connectors shall have a central stop to divide the connector into two equal parts to facilitate the correct cable positioning.

F. Connectors shall be as recommended by manufacturer, to render joints equal to cable in characteristics, in terms of insulation, stress distribution and water-tightness. Materials and methods of jointing shall be approved before confirmation of order.

G. Connectors shall be suitable for cable size used.

H. K. Connector - Type A-1: Heat shrinkable or cold shrinkable for making T-taps and splices on conductors used in external lighting fittings connections.

I. Connector - Type A-2: Pressure indent type, for terminating or making T-taps and splices on conductors 10 mm2 and smaller. Connector shall be non-ferrous copper alloy applied to conductor by mechanical crimping pressure, with vinyl insulating sleeves or phenolic insulating covers.

J. Connector - Type A-3: Bolted pressure split type for terminating or making T-taps and splices on conductors 16 mm2 and larger. Connector shall be cast non-ferrous copper alloy applied to conductor by clamping with minimum of two screws and provided with phenolic insulating cover.

K. Connector - Type B-1: Pre-insulated, spring type, for branch circuit and fixture wiring. Connector shall be steel encased spring with shell, insulated with vinyl cap and skirt.

L. All components of lugs and connectors shall be clearly marked with the manufacturer's name, die number, cable / conductor size, number of crimps and position.

2.4 Cable Glands

A. Cable glands shall comply with BS 6121-1, BS 6121-5 and BS EN 50262.

B. Cable glands used with unarmored cables shall be made of brass, type A2 to BS 6121-5, with mechanical retention class B to BS EN 50262, impact resistance category 8 to BS EN 50262 and an environmental seal to the cable outer sheath. Glands shall be deluge protected, with IP66 degree of protection to IEC 60529.

C. Cable glands used with single steel wire armored cables shall be made of brass, type CW to BS 6121-5, with mechanical retention class B to BS EN 50262, impact resistance category 8 to BS EN 50262, electrical continuity via armor wire termination category B to BS EN 50262, earth tag to BS EN 50262 and an environmental seal to the cable outer sheath. Glands shall have IP66 degree of protection to IEC 60529.

D. Cable glands used with steel tape or wire braid armor shall have similar characteristics as specified in paragraph 2.6C except gland type which shall be CX instead of CW to BS 6121-5.

E. Cable glands used with single steel wire armored cables where sprinkler / water mist firefighting systems are used shall be made of brass, type E1W to BS 6121-5, with mechanical retention class B to BS EN 50262, impact resistance category 8 to BS EN 50262, electrical continuity via armor wire termination category B to BS EN 50262, earth tag to BS EN 50262 and an environmental seal to the cable inner and outer sheaths. Glands shall be deluge protected, with IP66 degree of protection to IEC 60529.

F. Cable glands used with LS0H or fire resistant cables shall be of the applicable type as stated above and provided with low smoke fume shroud.

G. Cable glands shall be suitable for cable size used.

Part 3 EXECUTION

3.1 Examination

A. Examine raceways and building finishes receiving wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Before pulling wires in conduit check that inside of conduit (and raceway in general) is free of burrs and is dry and clean.

3.2 Installation

A. General: Building wires and cables shall be installed in conduit, trunking or ducts indoors and in conduit outdoors, unless otherwise shown the Drawings.

B. Circuits: Unless otherwise shown on the Drawings, final branch circuit wiring shall be run inside trunking or conduits, D.C. wiring shall be run in separate conduits from A.C. wiring, and emergency lighting and power circuits shall be run in separate conduits from normal circuits.

C. Branch circuit work originating from light and power panel boards shall be arranged as shown on the Drawings. Loads on various phases of panel boards shall be balanced. Ensure that the lighting load and other loads are balanced with a difference of not more than 10% between the phases.

D. Control cables may be fixed to racks, installed directly on cable trays or pulled in conduit and trunking indoors, or in conduit outdoors.

E. Bunching of wires in raceways shall be in accordance with raceway filling factors permitted by the Regulations.

F. Lubricants shall be used for pulling wire or cable if character of pull would otherwise damage conductors, insulation or jacket. Lubricants shall be approved by the Engineer.

G. Pull conductors into raceways simultaneously where more than one is being installed in the same raceway.

H. Support: Cables and wires pulled inside very high conduit risers shall be supported at upper end of risers and at intermediate points by split rubber grommets to relieve any stresses on conductors, where required.

I. Wiring at Outlets: Leave a slack of at least 200mm at each outlet.
J. Extra Length: At every branch circuit outlet and pull-box, every cable passing through shall be left slack to allow inspection and for connections to be made.

Cables terminating in outlet boxes shall be left with at least 250-mm extra length for terminations.

K. Joints or taps in wires and cables, if permitted, shall be permanently accessible or made only in boxes or cabinet gutters.

L. Insulating covers shall be applied to prevent exposure of bare cable connections.

M. Switch legs for local wall switches shall have distinctive color, selected as complementary to cable color coding used in the project.

N. Terminations: Conductors of wires and cables up to 6 mm2 for copper conductors and up to 10 mm2 for aluminum conductors shall be tightly twisted and where possible doubled back before being clamped with set screws. Where two or more wires are looped into same terminal these conductors shall be tightly twisted together before inserting into terminals. As an alternative, fork / ring, compression / twisting type connectors may be used for cable termination. In no case bare conductor shall be allowed to project beyond any insulated shrouding or mounting of a line terminal. Cables sizes 10 mm2 and larger for copper conductors and 16 mm2 and larger for aluminum conductors shall terminate in compression lug connectors.

O. Tagging: Tag main and feeder cables in pull-boxes, wire ways and wiring gutters of panel boards or distribution cabinets. Tags shall identify cable or circuit number and conductor size in accordance with the Schedules.

P. Tagging: Where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit shall be tagged as a guide in making connections.

3.3 Feeder and Sub-Feeder Installation (0.6/1 KV)

A. Cables generally shall be run through duct-banks, shafts or special recesses, clamped to steel racks or cable trays. Cables run through ventilation shafts shall be LS0H type or installed in steel conduits.

B. Fixing: Single cables above suspended ceilings or in concealed spaces shall be fixed directly to walls or ceilings but must be accessible. Where two or more cables are run in parallel, they shall be fixed on galvanized steel perforated trays or on other approved special cable supporting and protecting arrangement.

C. Clamps: Where cables are fixed to steel trays or supporting structures, approved galvanized cast steel clamps (or nonmagnetic clamps for single core cables) shall be used at distances not exceeding 20 diameters.

D. Joints or splices will not be accepted on main and sub-feeders. Cables shall be supplied in lengths sufficient for straight-through un-jointed termination to termination pull.

E. Exposure to Heat: Route wires and cables to prevent exposure to excessive heat or to corrosive agents. If such condition is unavoidable, cables shall be type designed for particular condition.

F. Insulating covers shall be applied to prevent exposure of bare cable connections. Insulating cover shall be purpose made and shall provide minimum insulation level equal to that of conductor insulation.

G. Glands for various single-core and multi-core cables shall be purpose made and suitable for rigid mounting to equipment enclosure.

3.4 Cable Connections, Jointing and Terminations

A. Through joints will not be allowed in feeder cables where adequate manufacturer's lengths are available. Where a joint is necessary, it has to be made inside boxes, hand holes or manholes.

B. Recommendations: Through joints and terminations shall be carried out strictly in accordance with cable manufacturer's recommendations, and made with correct specified materials, boxes, tapes, compounds or mixtures, stress cones, glands and bonds as applicable.

C. Jointing: Joints shall be filled with epoxy resin after taping unless contrary to cable manufacturer's recommendations. Sample site constructed cable terminations and through-joints shall be submitted prior to commencing work on site. Samples shall be constructed in the presence of the Engineer and shall be available for test and inspection in accordance with manufacturer's recommendations.

D. Cutting tools for jointing and terminating cables shall be purpose made, to prevent damage to insulation in general.

E. Cleaning of lacquer on conductors shall be by use of 'Scotch Brite' sponge and white spirit or equal approved.

F. Tighten electrical connectors and terminals including screws and bolts, in accordance with manufacturers published torque-tightening values. Where manufacturer’ torquing requirements are not indicated, tighten connectors and terminals to comply with international standards.

3.5 Field Quality Control

A. Cable tests shall be carried out in accordance with the requirements of the Regulations and Standards.

B. Test Equipment: Provide megger testers of various ranges as applicable. Use 500 V megger on installations with nominal voltage up to 500 V, and 1000 V megger on installations with nominal voltage over 500 V up to 1000 V.

C. Insulation resistance for LV power and lighting installations shall be carried out in accordance with BS 7671 ("The IEE wiring Regulations").

D. Insulation resistance for control and signal cables shall be minimum 10000 Meg ohm-km for PE insulated cables and 100 Meg ohm-km for PVC insulated cables, all measured core-core and core earth, in accordance with the Regulations.

E. Prior to energization of circuitry, check installed wires and cables with meg ohm meter to determine insulation resistance levels to ensure requirements are fulfilled.

F. Prior to energization, test wires and cables for electrical continuity and for short-circuits.

G. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION 16220

SECTION 16230

CABLE TRAYS FOR ELECTRICAL SYSTEMS

Part 1 GENERAL

1.1 Submittals

A. Technical Data: Submit data for approval including, but not limited to, the following:
   1. Manufacturers' catalogues with specifications of cable trays / ladders and related accessories.
   2. Samples of each type of tray / ladder and accessory

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
   1. Detail fabrication and installation of cable tray / ladder, 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, fittings and earthing connections.

C. Point-wise compliance statement to the specifications, duly signed by the manufacturer/ manufacturer's authorized representative and the contractor.

D. Approved Third Party Test Certificates: Submit to verify compliance with the IEC 61537 or NEMA VE-1, as applicable.

E. Coordination Drawings: Include floor plans and sections drawn to scale. Include scaled cable tray / ladder layout and relationships between components and adjacent structural and mechanical elements.

F. Design Calculations: Submit design calculations to verify the following:
   1. Loading capacities for supports.
   2. Perforation base area for cable trays according to the specified Class.

G. Factory Test: Submit Factory tests including safe working load, deflection tests and measurement of steel and galvanization thicknesses.

H. As-Built (Record) Drawings: At Project close-out, submit Record Drawings of installed cable trays

1.2 Quality Assurance

A. Source Limitations: Obtain cable trays and components through one source from a single manufacturer.

B. Comply with the following standards:
   1. IEC 61537.
   2. ISO 1461.

3. ISO 12944-2.

1.3 Delivery, Storage, and Handling

A. Materials shall not be stored in damp and open environment and shall be stored in covered places only.

1.4 Coordination

A. Coordinate layout and installation of cable tray / ladder with other installations to ensure clear access to the cable trays to facilitate maintenance, checking and further pulling of cables.

B. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Engineer.

Part 2 PRODUCTS

2.1 General

A. Cable trays and ladders shall comply with IEC 61537.

B. Cable trays shall meet Class C requirements for perforation free area as per IEC 61537 as a minimum.

C. Cable ladders shall meet Class Y requirements for free base area as per IEC 61537 as a minimum.

D. Components: To include cable trays or ladders (as shown on the Drawings), bends, elbows, tees, couplings and plates, rubber grommets, hangers, bracket supports and other system accessories required for safety and protection of the cable installations. All fittings and accessories shall be purpose made from the manufacturer. Field fabricated fittings and accessories are not acceptable.

E. Trays: Provide to carry the maximum load of cables with a factor of safety 300% or 90 kg concentrated load whichever is more stringent.

F. Trays: Heavy gauge perforated sheet steel, heavy duty, hot-dip galvanized after manufacture, minimum 1.5 mm thickness for cable trays up to 300 mm width and 2 mm thickness for cable trays exceeding 300 mm width, with sides not less than 50 mm depth for cable trays up to 300 mm width, 60 mm depth for cable trays exceeding 300 mm width and up to 600 mm width and 85 mm depth for cable trays exceeding 600 mm width with outwards return flanges, unless otherwise recommended by manufacturer and approved by the Engineer. Fittings shall be made of the same material as tray. Covers, where shown on the Drawings, shall be minimum 1.0 mm thick for cable trays up to 600 mm width and 1.5 mm thick for cable trays exceeding 600 mm width and shall be made of sheet steel hot-dip galvanized after manufacture, snap-on or bolt type, forming a rigid assembly with the tray.

G. Trays Perforation: Cable trays perforation size and direction shall be properly designed to suit cable ties or cleats to be used for cable fixation. Contractor shall submit method of cable fixation for Engineer's approval prior to installation.

H. Ladders: Hot-dip galvanized after manufacture, fabricated from 2 mm mild carbon steel. Ladder side channels shall be minimum 125 x 22 mm, strengthened by reinforcing inserts for torsional rigidity. Rungs shall be slotted to take cable cleats or ties and conduit clamps. Rungs shall be minimum 50 x 25 mm channels, spaced at 300 mm centers.

I. Fully controlled, stringent pretreatment process including, alkaline de-greasing, rinsing, pickling, fluxing and drying shall be carried out before hot dip galvanizing.

J. J. Galvanizing shall be in accordance with ISO 1461, applied after fabrication with local coat thickness of 45 µm (local coating mass of 325 g/m2) and mean coat thickness of 55 µm (mean coating mass of 395 g/m2). Cable trays manufactured

to NEMA VE1 shall have galvanization in accordance with NEMA VE 1 requirements.

K. Cable trays / ladders installed in corrosive atmosphere shall be provided with powder coating over hot dip galvanization of high chemical resistant polyster / epoxy to meet the requirements of the below classification. High bonding between the galvanizing and the paint finish shall be certified by the manufacturer with a guaranteed life of 20 years.

1. For installations in outdoor industrial areas and coastal areas with moderate salinity and indoor in swimming pools, chemical plants, coastal ship and boatyards; use galvanization and powder coating in compliance with corrosion risk category C4 to ISO 12944-2.
2. For installations in outdoor industrial areas with high humidity and aggressive atmosphere and in indoor areas with almost permanent condensation and with high pollution; use galvanization and powder coating in compliance with corrosion risk category C5-I to ISO 12944-2.

L. Bolts and Screws: Cadmium plated or electrolytically galvanized.

M. M. Sizes: Trays and ladders shall be standard metric sizes, 150, 300, 450, 600 and 900 mm wide, and at least 3 m length of section. Size of tray or ladder shall be determined by number and sizes of cables in accordance with the Regulations and / or as shown on the Drawings. Tray or ladder shall have strength and rigidity to provide support for cables contained within. Deflection between supports shall comply with IEC 61537 requirements.

N. Earthing connector for trays or ladders shall be provided on each coupling between adjacent sections.

O. Products shall be provided with stamped markings by manufacturers.

P. Cable trays and ladders shall be provided with galvanized ventilated sunshade covers when installed in outdoor locations. Sun shade and fixings shall be from the same manufacturer of cable tray/ladder.

Q. Finish of the cable trays/ladders used outdoors shall be certified to be UV stabilized

Part 3 EXECUTION

3.1 Installation

A. Install cable tray / ladder level and supporting system according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Spare capacity shall be 25 % for vertical installations and 15% for horizontal installations.

C. Each run shall be completed before installation of cables. Submit calculations taking into consideration the maximum cables load on cable trays with a factor of safety 300%.

D. Remove burrs and sharp edges from cable trays / ladders. Fix trays / ladders using approved suspension rods or uni-struts or angle brackets at spacing not exceeding 1.5 m and as per the approved supports calculations.

E. Cables Fixation: Secure cables to tray / ladder with purpose made straps, cleats or saddles as specified in section 16220 - Low-Voltage Electrical Power Conductors and Cables. Cable cleats and ties shall be correctly sized and tightened to secure the cable without indenting the insulation sheath.

F. Cables Arrangement: Arrange cables in one layer only, with minimum spacing of one diameter of the larger of the two adjacent cables or of a trefoil formation of single core cable circuit, unless otherwise shown on the Drawings.

G. Cables Bending Radius: Cables installation on trays / ladders shall ensure that the minimum cable bending radius as recommended by the manufacturer is not violated.

H. Cables Installation on Trays / Ladders: Use necessary rollers and pulleys at proper spacing for installation of large and long run cables. Pulleys / rollers shall be fixed to structural elements and not cable trays / ladders. Necessary pulling tools such as basket grips or pulling eyes shall be used with a proper force and speed to ensure not exceeding the manufacturer’s recommended maximum cable pulling tension.

I. Make connections to equipment with flanged fittings fastened to cable tray / ladder and to equipment. Support cable tray / ladder independently of fittings. Do not carry weight of cable tray / ladder on equipment enclosure.

J. Install expansion connectors where cable tray / ladder crosses a building expansion joint and in cable tray / ladder runs that exceed 39 m, unless otherwise calculated by the manufacturer and approved by the Engineer considering a maximum movement of 25 mm.

K. Make cable tray / ladder connections, changes in direction and elevation using standard fittings. Fittings shall be properly curved / designed to satisfy the minimum bending radius requirements and avoid sharp edges / corners.

L. Locate cable tray / ladder above piping, unless accessibility to cable tray / ladder is required or unless otherwise indicated.

M. Seal penetrations through fire zones or smoke barriers shall be treated with the same rating as per the fire zone requirement.

N. If cable trays / ladders are sized for future cables, furnish necessary provisions for penetrations with capped sleeves for future cables through fire-rated partitions, or use "repairable" fire stopping-penetration sealing material.

O. O. Workspace: Install cable trays / ladders with sufficient space to permit access for installing cables. Minimum clearance of 250 mm shall be maintained between top of tray / ladder and ceiling, beams and other services and between tray and ladders in multi-tier formation.

P. Install covers after installation of cable is completed.

Q. Labeling of trays shall be provided at every change in direction and at every 12 meters on straight runs. Size of letters and color of labels, marking and references shall be as per the relevant standard regulations.

R. Cable trays/ladders shall not be installed in lengths below water/sewage pipes.

S. S. Electrical continuity strips / links shall be provided by the manufacturer of the tray/ladder.

END OF SECTION 16230

SECTION 16235

Packaged Generator Assemblies

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SECTION 16235

Packaged Generator Assemblies

Part 1 GENERAL

1.1 Submittals

A. Product Data: Submit full technical data of equipment for approval including, but not limited to, the following:
   1. General description and characteristics of engine- generating sets, standards with which components comply, site rating and overload capability, overall efficiency, and fuel and lubricant consumption at 100%, 75%, 50% and 25% of rated load.
   2. Description and operating criteria of engine; type, model, manufacturer, fuel and lubricating oil types and specific consumption, starting conditions and starting periods from cold to full-load pick-up, governor and response characteristics due to sudden load changes, super-charger, fuel injection system, cooling system and radiator, air filters, fuel filters, soot filters, oil filters and pumps.
   3. Description and operating criteria of generator, exciter and voltage regulator, with loading response and short-circuit characteristics, insulation, cooling and accessories.
   4. Dimensioned outline plan and elevation drawings of engine generator set and other components specified, weights and forces, mounting methods, vibration protection etc.
   5. Battery type, make, charge/discharge characteristics, capacity and constructional features.
   6. Battery charger, method of charging, equalizing and trickle charging.
   7. Daily fuel tanks, pipes and accessories; materials and construction.
   8. Exhaust system and silencers; materials and construction.
   9. Control instruments, protection, alarms, cut-outs, indicating lamps, indicating instruments and all other devices or components.
   10. Time-current characteristic curves for generator protective device.
   11. Synchronization system where specified for two or more sets are in parallel, including technical data, instruments, governor and voltage regulation, with characteristic curves etc.
   12. Calculation of noise levels in dBA at typical points within engine room and at various locations inside and outside.
   13. Calculation of static pressure on radiator fan including indication of Manufacturer's required C.F.M. and fan static pressure.

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
   1. Certified manufacturers' dimensional drawings, templates and installation instructions for equipment and accessories, showing weights and distribution of forces, location and size of cabling (power and control), piping connections to equipment, and other pertinent data.
   2. Plans and elevations of all equipment.

3. Separate unit wiring diagrams, schematics and interconnecting wiring diagrams.
4. Constructional details of daily service fuel tank, including outline drawings showing piping arrangements, connections and dimensions.
5. Complete execution drawings of associated auxiliaries.
6. Overall Single Line Diagram of the plant, indicating ratings of different equipment and metering & protection devices.

C. Point-wise compliance statement to the specifications, duly signed by the manufacturer / manufacturer's authorized representative and the contractor.
D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
E. Routine Tests and Factory Test Reports: Fully assembled plant or equipment shall be tested at the factory, before shipping. Complete performance tests shall be carried out under site simulated conditions, in accordance with the Standards and as described in the Specification, showing evidence of compliance with specified requirements.
F. Field Test and Observation Reports: Indicate and interpret test results and inspection records relative to compliance with performance requirements.
G. Sound measurement test report.
H. Generator sizing calculation and stepping criteria as per the design drawings and loads to comply that the provided size is sufficient for the design load.
I. Supplier to verify and confirm that the available design/ site spaces for the generator are adequate for generators installation and ventilation..etc. and will not affect the generator capacity performance and life time.
J. Field test report of tests specified in Part 3.
K. Maintenance Data: For each packaged engine generator and accessories to include in maintenance manuals with Detail operating instructions for both normal and abnormal conditions.

1.2 Quality Assurance

A. Local Representative: Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy Engineer may disqualify a manufacturer.
B. Standards: Equipment and component parts shall comply with ISO 3046, ISO 8528, IEC 60034, IEC 60085 and CISPR, or equivalent NEMA, ANSI, IEEE and DIN Standards and recommendations of ABGSM (Association of British Set Manufacturers) where such standards meet with or supersede the ISO and IEC Standards.

1.3 Delivery, Storage, And Handling

A. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

1.4 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

B. Warranty Period: 5 year from date of substantial completion

1.5 Maintenance Service

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance service by skilled, competent employees of the generator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper generator operation at rated speed and capacity. Use parts and supplies as used in the manufacture and installation of original equipment.
    1. Perform maintenance, including emergency callback service, during normal working hours.
    2. Include 24-hour-per-day, 7-day-per-week emergency callback service.

1.6 Extra Materials

A. Spare Parts: Provide manufacturer's recommended spare parts for 1000 hours operation of the plant. Provide list of manufacturer's spare parts for 2000 hours operation together with current prices. Pack with protective covering for storage and identify with labels describing contents.

B. Tools and Instruments: Provide tools and instruments required for normal routine inspection, testing, operation and general maintenance, as recommended by the manufacturer.

1.7 Factory Acceptance Test

A. Factory testing units for 20% of the total number of the generators to be supplied, minimum one unit shall be witnessed by the Engineer. Selection of generators for witness test shall be randomly carried out by the Engineer and shall cover all ratings to be delivered. Witness test shall include complete routine and function testing. Test procedure and program shall be submitted for approval prior to test conduction, by at least 14 days.

Part 2 PRODUCTS

2.1 Approved Manufacturer

Caterpillar – USA

Cummins – UK

SDMO - France

2.2 Plant Description

A. Performance Class: Diesel generator set shall be class G2 (20% voltage drop / free drop at 100% loading) to ISO 8528-1.
B. Generator Set Assembly: Compact package type, with all equipment mounted on one rigid steel bed frame suitable for skidding. Radiator shall be mounted on the set or remotely as shown on the Drawings. Design shall permit easy operation, maintenance and repair.
C. Vibration reduction shall be achieved by appropriate design and careful balancing at factory. Compact set shall have approved anti-vibration isolators of steel spring or resilient neoprene between rotating equipment and bed-frame, limiting transmission of vibration to building to a maximum of 0.04 mm amplitude throughout the operating vibration frequency range.
D. Noise reduction shall be achieved by approved methods at source of noise, including all necessary acoustic louvers, inlet and outlet air attenuators, residential exhaust silencer(s), acoustic treatment of the room walls, floors, doors and ceiling, etc. with sound level measured at 1 m in any direction outside the room/enclosure limited to 80 dBA in accordance with ISO standards for residential areas. Generator supplier to coordinate with the main contractor for the required installations.
E. Sand trap louvers: generator room louvers shall be of approved sand trap type if required on the drawings or recommended by the Manufacturer. Contractor to coordinate with the building works for the required installations.
F. Cold Starting: Engine shall be fully equipped to start and pick up initial load specified at specified minimum ambient temperature. Provide coolant heater.
G. Equipment ratings shall be as shown on the Drawings or the next higher standard ratings provided by the manufacturer. Ratings shall be net Standby, limited time running power (LTP, excluding fan and any auxiliaries, auxiliary drives and losses, delivered at specified frequency, voltage and power factor and under worst climatic conditions on site.

2.3 Diesel Generator Set

A. Components: Set shall basically consist of diesel engine, brushless synchronous generator with direct flexible coupling to engine and single or parallel control cubicle as required and shown on the Drawings.
B. Governing shall conform with ISO 3046-4, electronic type governor with limits of speed control as specified below.

C. Starting and Stopping: When in the automatic mode the set shall start and stop automatically by a signal sensed through an auxiliary contact in the load transfer switchgear. The set shall stop, after an adjustable cool- down period (2 - 30 minutes).
D. Duty: Plant shall reach full speed within 10 seconds from start impulse and accept immediately 60% of net rated output (load being mixed, steady and inductive, with motor starting loads as shown on the Drawings). Transient voltage variation shall not exceed 20 % under any step-load application for which the system is intended, up to full rated load, recovering to within +/-2% within a few cycles.
E. Failure To Start: Should engine fail to start following a start impulse, the system shall come to rest for a few seconds. Two further starting attempts shall be automatically made with intermediate 20- second maximum periods of rest. Should the set fail to start after three attempts, an alarm shall sound and a 'start failure' signal illuminate.
F. Hand operation shall be possible for testing or normal operation through a test/manual/off/auto selector switch.
G. Regular Exercising: While on 'auto', the set shall start regularly and automatically every week and shall operate for 30 minutes before stopping.

2.4 Diesel Engine and Auxiliaries

A. Design: Diesel engine shall be designed for type of load and application required. Engine and governor shall be selected to meet operating requirements and response specified.
B. Engine Type: Compression-ignition type, with direct solid-injection, turbo-charged after-cooled, for ratings over 100 kW, water cooled, with air-cooled radiator inline or V-type cylinder arrangement suitable for direct coupling to driven machine.
C. Engine Cycle: 4-stroke cycle.
D. Engine Speed: 1500 rpm.
E. Type of Fuel: Light fuel diesel oil.
F. Flywheel shall be suitably sized for type of service and constraints specified, and capable of being rotated at 125% of rated speed without failure. Torsion vibration dampers shall be provided.
G. Engine rating shall be such that alternator can deliver net specified rated output as specified earlier, with temperature rise not exceeding rise allowed by the Standards.
H. Accessibility: It shall be possible to:
    1. Remove rocker-box covers without disturbing fuel injection pipes or other components.
    2. Remove and replace pistons and piston rods, liners, big and small end shells and caps without dismounting engine.
    3. Bar engine over by hand for spill timing check and adjustment.
I. Measuring Instruments: Engine mounted instruments shall include, at least, water temperature gauge, lubricating oil temperature gauge and pressure gauge, speedometer and running time meter. It shall be possible to measure, with extra instrumentation, coolant temperature at lower end of radiator, air depression after air filter, air boost and temperature using methods recommended by manufacturer. Instrument accesses shall be normally sealed by threaded blanking caps. Speed shall be sensed via a magnetic.
J. Cooling System: Engine shall be water cooled with gear- driven water pumps. System shall be pressurized, with heavy-duty tropical radiator cooled by reverse flow fan. Radiator shall be set mounted or remote as shown on drawings. Remote radiators, if

used, can be horizontal or vertical as recommended by the Manufacturer or shown on the drawings. Fan cowl and hand protection guards shall be fitted. Coolant temperature shall be controlled by one or more thermostats as determined by design of system. Radiator shall be sized for continuous performance at 100 % rated load at worst operating ambient conditions with a 10 deg. C temperature differential. Radiator shall be non-ferrous metal, incorporating pressure valve, radiator cap and drain cock and with integral expansion tank. Direct acting modulating thermostatic diversion valve shall control engine cooling water temperature. Under normal operation, by-pass shall not be fully closed. Treated or fresh cooling water and anti-corrosion and anti-freeze additives shall be used as recommended by Manufacturer for Specific Conditions of Installation. Coordinate with the plumbing works for the provisions/piping needed for coolant drain.

K. Cooling Airflow: Obstructions in path of cooling air flow (openings, louvers, attenuators, grilles, mesh, ducts, bends etc.) shall not reduce air flow below that needed at full rated output. Fan and radiator characteristics shall be selected accordingly. Advise if additional booster fans are required and provide necessary control gear for automatic operation. Submit static pressure calculation vs. fan capacity to substantiate the Selection.

L. Cylinders shall have removable liners. Wet type liners shall have witness hole between liner sealing rings of each cylinder for early detection of coolant or oil leakage. Each cylinder shall have drilled and tapped hole and valve for connections of pressure indicator, unless other wise recommended by the manufacturer and approved by the Engineer.

M. Lubricating Oil System: Pressurized circulating type, using two engine-driven, gear type lubricating oil pumps with full flow filters and replaceable elements and lubricating oil heat exchanger. Filter system shall have spring loaded by-pass valve to permit oil circulation if filters become clogged. Audible and visual alarms shall cut-in when valve starts opening. Lubricating oil cooler shall be shell and tube heat exchanger with water from engine radiator as the cooling medium. Direct acting thermostatic diversion valve shall control oil temperature. Under normal operation by-pass shall not be fully closed. Coordinate with the plumbing works for the provisions/piping needed for proper and neat oil change.

N. Each Generator set shall have soot filter to reduce the soot emission of the gen set, the performance of the soot filter shall be approved by electrical engineer.

O. Fuel system shall have injection pump and injectors that are easily removable and replaceable for servicing. Engine shall have integral, gear type, engine driven transfer pump to lift fuel against a head of 2.5 m and supply it through filters to injection pump at constant pressure. Fuel filter elements shall be easily replaceable.

P. Exhaust system shall be complete with flanged, bolted, black steel pipe sections, long sweep elbows, flexible steel expansion sections, clean-outs, silencer, wall thimbles and supporting steelwork. Silencer shall be independently supported. Indoor hot exhaust parts shall be insulated with mineral rock wool material, not less than 50 mm thick, retained by wire ties and cladded with sheet metal aluminum (22 - SWG) covers to protect insulation. Exhaust piping shall be fitted with rain cap, drain measures (condensate traps, drain plugs/valves, etc.) to avoid rain ingress and internal corrosion. Exhaust system shall be designed to reduce back-pressure to below maximum specified by the manufacturer, in relation to exhaust pipe length shown on the Drawings. Manufacturer's calculations for exhaust pipe sizing shall be submitted

for approval including back pressure temperature and necessary measures to be applied against corrosion and to ensure efficient operation.

Q. Electric Starting System: Engine starting shall be manual by push-button or automatic through control system at control panel. System shall consist of heavy-duty 24 V D.C. starter motor, heavy-duty battery and battery charger. Cranking motor and battery shall be rated for cranking the engine when cold and at lowest temperature recorded. Starting pinion shall automatically disengage when engine fires.

R. Storage Battery: Lead-acid, sealed-in-plastic type, complete with battery rack and inter-cell connectors. Battery shall have sufficient capacity to provide minimum four cranking periods.

S. Battery Charger: 25% over-rated, solid state, full-wave rectifier type, adequate to fully recharge depleted battery in not more than 8 hours and to automatically control rate of charge (providing a high-charge rate to a depleted battery and reducing to a trickle-charge rate when battery is fully charged). Ammeter shall be provided to indicate charging rate, which shall be adjustable. Battery charger shall be mounted in control cubicle, unless otherwise approved.

T. Electronic Governor shall provide isochronous governing, (and paralleling and load sharing of generator sets in the case of paralleled generators). Governor shall have zero percent (isochronous) setting and adjustable droop from zero percent to 10% droop. System shall include power supply unit, magnetic speed pick-up, control module and actuator using fast response D.C. motor drive or equally approved alternative. Governor shall be designed for fast-response and high precision of speed (frequency) control, automatic paralleling and load sharing and shall include speed adjustment to +/-5% of normal, while running, and with remote control interface.

U. Governor over-speed trip shall automatically close fuel pump racks in event of engine over-speed. Device shall be separate and independent from governing mechanism.

V. Protective system shall comprise automatic engine shut- down and generator trip with visual and audible alarms in event of over-speed, low lubricating oil pressure, high cooling water temperature and over cranking.

2.5 Alternator

A. Type: Synchronous, low reactance, high efficiency, revolving field type, with brushless exciter and flexible coupling, sized to pick up effective load without exceeding transient and steady-state voltage deviation limits specified up to its full nominal rating and designed for the performance stipulated in the Specification. It shall be one for ratings up to 2000KVA and two for ratings above 2000KVA bearing construction with bearings of the sleeve or sealed ball type.

B. Leads and Cables: Phase leads shall be brought out fully insulated to a terminal cable box of heavy gauge sheet steel, protection IP 44. Control and protection cables shall be brought out to a separate terminal box.

C. Maximum voltage difference between the three phases at 100%-balanced load shall not exceed 1%. With unbalanced load up to 30% on one phase at unity power factor and zero load on other phases, the line-to-neutral voltages shall not differ by more than 5%.

D. Characteristics:
    1. Number of Phases: 3 phases, 4-wires.
    2. Rated Voltage, Frequency, and Net Rated Output: As shown on the Drawings. Rated power factor: 0.8.
    3. Winding Connection: Re-connectable with ends brought out and fully insulated.
    4. Maximum Unbalanced Load Current, (negative sequence component of current) with None of the Phase Currents Exceeding Rated Current: 8% of the rated current.
    5. Rotor: Salient pole type, incorporating damping grid.
    6. Excitation: Brushless, with rotating armature rectifiers and discharge resistors.
    7. Voltage Regulator: Automatic, with readily accessible controls for voltage level.
    8. Insulation: Class H for stator and class H for rotor & exciter, with class F temperature rise, unless otherwise indicated on the drawings.
    9. Enclosure: Drip proof and screen protected (IP 21 to IEC 60529).
    10. Cooling: Built-in centrifugal fans.
    11. Maintained Short Circuit: 250% for 3 seconds.
    12. Over-speed: 120% (minimum) for 2 minutes.

E. Voltage Regulation: Overall voltage deviation within normal speed variations shall be within limits specified from no-load to full-load, from hot to cold and with load power factor from 0.8 lagging to unity. Regulator shall automatically reduce voltage if load exceeds capacity of generator. Voltage build-up shall be positive and rapid even when full load is suddenly applied. Line-to-line voltage waveform deviation factor shall not exceed +/-5%. Total harmonic content shall not exceed 5% and that of one harmonic not to exceed 3%. Radio interference suppression shall be within the limits set by the Standards, grade (N).

F. Exciter: Armature shall be 3-phase, directly mounted to generator shaft and connected to generator field windings through six solid state, hermetically sealed, silicon rectifiers, accessible for maintenance or repair. Exciter shall have field suppression system to eliminate any source of diode failure resulting from high inductive loads and surges. Exciter field windings shall be stationary. Exciter-regulator combination shall maintain output voltage within limits specified for any load up to full generator rating and under any sudden load changes specified.

G. Voltage Regulator: Solid state, volts/Hz type, utilizing silicon semi-conductor devices in control and power stages, with built-in Electro-magnetic interference suppression and designed for single or parallel operation. Manual adjustment to +/-5% of regulated voltage level shall be possible by a potentiometer at control panel. All components shall be sealed, moisture and heat resistant, with a suitable environmentally protected enclosure. Voltage regulator shall automatically reduce voltage if load exceeds capacity of generator and shall sustain a 3-phase short- circuit current at the generator terminals for the period for which the short-circuit protection operates and at least for 3 seconds. Voltage regulator power shall be supported by generator voltage and current to maintain excitation field power.

H. Two-position switch shall be provided for selection of manual or automatic mode of regulated voltage control.

I. Sets Operating In Parallel: Cross-current compensation and necessary paralleling modules shall be provided to effect sharing of active and reactive loads equally between generators.

2.6 Control Equipment

A. Generating Set Instruments, Protection And Controls: Control relays, sensing equipment, switchgear protective relays and devices and start, stop and shutdown controls shall be provided as necessary for operation specified. Generating set, instruments, protection and controls shall be mounted preferably in one control cubicle.

B. Generator controls, metering, monitoring and protection shall be carried out via modular solid state, microprocessor based units, with digital display facility

C. Instruments and controls for a non-paralleled set shall include at least the following:
   1. Line and phase voltage metering on the 3 phases.
   2. Current metering on the 3 phases.
   3. Frequency meter.
   4. Off/test/manual/auto duty switch.
   5. Manual-start and stop push buttons.
   6. Kilowatt-hour meter.
   7. Power factor meter.
   8. Service-hour running counter.
   9. Plant exerciser.
   10. Potentiometer for voltage level control.
   11. Speed raise/lower device.
   12. Cool-down time setting controls.
   13. Over cranking monitoring and alarm
   14. Illuminated indicator panel with LEDs at least for low oil pressure, high water temperature, over-speed, fail-to-start, generator overload, reverse-power, generator on load, battery low charge state
   15. Lamp test push-button.
   16. Indicating gauge and low level fuel alarm.
   17. Battery charger, on/off switch, pilot lights.
   18. D.C. ammeter.
   19. Alarm sounder and reset controls.
   20. Anti-condensation heater.

D. Protective gear shall ensure orderly engine stop or shutdown with reset relays, as required for safety and operational reliability, and shall include the following:
   1. Output molded case circuit breaker (MCCB) for ratings up to 1250A and air-break metal enclosed circuit breaker (ACB) fro ratings above 1250A with solid state trip unit, in accordance with Division 16 Section "Switchboards", (electrically operated and electrically tripped by shunt release) for over-current and external earth fault protection.
   2. Over-voltage protection with voltage and time lag adjustment.
   3. Loss-of-field protection.
   4. Negative phase sequence protection.
   5. Restricted earth-fault protection, with current adjustable settings between 0 and 20% of rated current, and time adjustable settings 0 to 3 seconds.

E. Control and Protective Gear Cubicles: Generator set mounted instrument and/or control cubicles shall be resiliently mounted, preventing transmission of vibration to the components. Separately mounted instrument and control cubicles shall be self-supporting, floor mounted and freestanding. Cubicles shall be sheet steel construction, ventilated indoor type, vermin and dust-proof, (IP 42 to IEC 60529), with lockable hinged doors and instrument panels, separate compartments for control devices, protective relays, circuit breaker(s) and neutral earthing device. Inner and outer surfaces of steel enclosures shall be cleaned, phosphatized, primed with heavy-duty rust inhibiting primer and finished with two coats of enamel. Wiring shall be 600/1000 V, modularly arranged, with connections made at front terminal blocks with no live conductors exposed. Wires shall have approved numbered ferrules at each terminal. Printed circuit plug-in boards, where applicable, shall be of industry standards, accessible and withdrawable, mounted in standard racks.

F. Load Shedding: An automatic microprocessor-based load shedding system shall be provided for load connection / disconnection according to load priorities and generator power availability as described on the drawings.

G. Step Loading: An automatic step loading system shall be provided for sequential application of emergency loads with an adjustable (0- 30 sec) time delay between each two steps as described on the drawings. The system shall comprise all necessary control equipment including under over/ voltage sensing relays, time delay relays, interface devices and wiring with respective circuit breakers.

H. Relays: electronic, microprocessor based front settable / programmable, sealed type, with dusttight enclosures, removable covers, test terminal blocks and plugs for testing relay without removal from case. Removal from casing shall automatically short-circuit respective current transformer secondary windings.

I. Instruments shall be housed in enameled metal cases for switchboard flush installation and shall be grounded in accordance with the approved standards.

J. Current Transformers: Class 2 for measuring and protection. Refer to switchgear sections for particulars.

K. Voltage Transformers: Single phase, dry type, 0.5 accuracy class. Refer to switchgear sections for particulars.

L. KWH Meter: digital (part of microprocessor unit) for unbalanced 3-phase, 4- wire loads.

2.7 Outdoor Generator-Set Enclosure

A. Description: Prefabricated or pre-engineered enclosure with the following features:
   1. Construction: Galvanized steel, metal-clad, integral structural-steel-framed housing erected on concrete foundation, corrosion proof and painted against all weather conditions with life guarantee of 10 years minimum.
   2. Full accessibility to all parts of the complete set.
   3. Structural Design and Anchorage: Adequate to resist loads imposed by 160km/h wind. In addition to other structural loads, including roof, seismic, and auxiliary loads, are as indicated.
   4. Space Heater: Thermostatically controlled to prevent condensation.
   5. Louvers: Equipped with insect/rodent screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust and rodents.
   6. Hinged Doors: With padlocking provisions.

7. Two-coats enamel finish over cleaned and primed surfaces.
8. Ventilation: Louvers equipped with insect/rodent screen and filter arranged to permit air circulation while excluding exterior dust and rodents.
9. Thermal Insulation: As required to maintain winter interior temperature within limits required by components.
10. Finish: Two-coat enamel finish over cleaned and primed surfaces.

B. Muffler Location: Within enclosure.
C. Engine Cooling Airflow through Enclosure: Adequate to maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
D. Louvers: shall prevent entry of rain and snow.
E. Automatic Dampers: dampers, if used, shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
F. Interior Lights: With switch. Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external circuit supply.
G. Convenience Outlets: Factory wired. Arrange for external circuit supply.

2.8 Fuel Storage and Transfer

A. Day-tank Construction: Closed cylindrical steel, inclined at least 3 degrees from horizontal and fitted with drain plug, inlet and outlet pipe connectors and breather pipe.
B. Day-tank breather pipe shall have replaceable paper air filter or breather caps with air filters.
C. Day-tank instruments shall include float switch, solenoid valve and dial-type level indicator to give alarm on over-fill and low-level, stainless steel electronic multi-point magnetic float diesel tank level switch/sensor for high/low level with switch signal output
D. Day-tank Filling Pumps: Electrically operated, automatically started and stopped, duplex pumps and standby manual pump, installed on piping system between storage tank and one or more daytanks for fuel transfer. Motor shall be totally enclosed, fan-cooled, squirrel-cage induction type, with integrally coupled pump-rotor contained on one base. Pump shall be self-priming type against the specific head shown on the Drawings. Priming plug, sealed and protected bearings and combination starter with thermal overload protection and circuit breaker for short-circuit protection shall be provided. Operation shall be interlocked with float switches in day-tank. All necessary check valves, by- pass valves, float valves and maintenance valves on piping system shall be provided as shown on the Drawings.
E. Day-tank Connections: Female threaded, black forged steel pipe couplings, fitted through holes in top of tank and welded all around inside and outside. Connections, except vent connection, shall extend inside tank to within 150 mm of bottom and shall be seamless black steel pipes of same size as connection and braced to tank walls. Vent connection shall not extend inside tank more than 20 mm. A manual valve shall be provided on the fuel supply line to the genset.
F. Fuel Lines: Heavy gauge, black seamless steel, to ISO/65 or equal, treated internally with corrosion resistant paint and with joints sealed with PTEE tape. Plumber's twine or gasket sealing compound shall not be used. Changes in direction and branching

and jointing shall be with regular pipefitting. Field fabricated and bent fittings shall not be used.

G. Fuel Lines: Fuel feed line to day-tank shall have by- pass with stopcock. Size of fuel return line from day-tank to main fuel tank shall be to manufacturer's recommendations.
H. Valves Generally: 827.4 kPa (125 psi) steam working pressure rating and 1380 kPa (200 psi) cold water non-shock pressure rating and type that can be repacked under pressure.
I. Pipe Hangers and Supports: Galvanized steel.

Part 3 EXECUTION

3.1 Installation

A. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and manufacturers' equipment drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
B. Install packaged engine generator to provide access for periodic maintenance, including removal of drivers and accessories.
C. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which shall be built into concrete foundations, bases or building structure are provided as and when required and that they are properly installed.
D. Tools: Use only tools recommended by equipment manufacturers for installations, particularly in making connections and adjustments.
E. Supervision: Carry out equipment installation under the direct supervision of a qualified technician, licensed by and trained at the factory. Final adjustments and putting into satisfactory operation shall be made by a specialist delegated by the factory.
F. Generating Set: Install to maintain alignment and minimize engine and generator stresses. Protect instrumentation and control equipment including engine mounted instruments from machine vibration. Mountings and method of mounting shall be as recommended by the manufacturer and approved by Engineer.
G. Engine exhaust piping shall be slightly sloped away from engine to avoid condensation returning to engine and shall have drain plugs or clean-out at lower end as required.
H. Engine Hot-Air Exhaust Duct: Install approved canvas duct with metal frames between radiator and louvered opening in wall for radiator exhaust air.
I. Tank Vent Pipe: Extend to nearest outside wall of building and carry up to at least 2 m above ground level with end at least 1 m away from any building opening. Slope vent pipe back to tank without traps and support securely. Provide replaceable dust filter and gooseneck bend or approved weatherproof vent cap at top of pipe.

J. Pipe Hangers And Supports: Fasten securely to building structure with approved masonry expansion bolts, minimum 20 mm diameter and install in accordance with manufacturers' instructions.
K. Earthing: Install earthing system in accordance with Division 16 Section "Grounding and Bonding" of the Specification.

3.2 Connections

A. Piping installation requirements are specified in Division 15 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
    1. Install piping adjacent to packaged engine generator to allow service and maintenance.

2. Connect water supply to cooling system.
3. Connect cooling-system water supply and drain piping to diesel engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.
4. Connect exhaust-system piping to diesel engines.

B. Electrical wiring and connections are specified in Division 16 Sections.

C. Ground equipment. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.3 Field Quality Control

A. Equipment: Inspect equipment upon delivery to Site and report any loss or damage to Engineer.

B. Earthing resistance tests if any shall be carried out to verify specified requirements.

C. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

D. Load tests shall be carried out at low loads to overload conditions, at various power factors. Measurements shall include voltage and frequency deviations and regulating time under various step loading conditions, temperature measurements and pressure measurements at various locations, and in accordance with an approved plan under conditions equal to worst site ambient conditions.

E. Tests shall include:
   1. Full load test for 30 minutes at each of 25%, 50%, 75% load and load test for 3 hours at 100% load immediately followed (in case of prime generators) by 10% overload test, without interruption.
   2. Insulation measurement.
   3. Functional tests for voltage sensing, automatic start and synchronization (if applicable), transfer of load and load sharing as requested and shown on electrical design drawings.
   4. Operation of engine shutdown and alarm signaling and indication, under simulated fault conditions.
   5. Measurement of vibration transmission to building structure.

F. Load Banks: If actual loads are not made available at time of acceptance testing, provide load banks to carry out complete test cycle of the system under loading and switching conditions necessary to prove compliance with the Specification.

G. Piping System: Using carbon dioxide or nitrogen from pressurized cylinder, test each system to 1.5 times normal operating pressure. Do not subject equipment, apparatus or to pressure exceeding prescribed test pressure obtained from nameplate data or from manufacturers' published data. Apply tests before connecting piping to equipment. Remove or disconnect and blank off relief valves, instruments and devices that might be damaged by test pressure. Maintain test pressure on system for 24 hours during which time there shall be no noticeable drop in pressure. Check for leaks using soap solution. Isolate source of pressure during testing.

H. Coordinate tests with tests for transfer switches and run them concurrently.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Test instruments shall have been calibrated within the last 12 months, traceable to applicable standards, and adequate for making positive observation of test results. Make calibration records available for examination on request.

3.4 Inspection and Tests at Site

A. Supervised Adjusting and Pretesting: under supervision of factory-authorized service representative, pretest all system functions, operations, and protective features. Provide all instruments and equipment required for tests. Adjust to ensure operation is according to Specifications. Load system using a variable resistive and reactive load bank to be provided during testing only simulating kW, and power factor of loads for which unit is rated.

B. Tests: provide the services of a qualified independent testing agency to perform the tests listed below according to manufacturer's recommendations upon completion of installation of system. Use instruments bearing records of calibration within the last 12 months, traceable to approved standards, and adequate for making positive observation of test results. Include the following tests:

1. Insulation Tests: test generator windings using 500 V d.c. for units rated up to 250 volts and 1000 V d.c. for units rated between 250 and 600 volts. Verify minimum insulation resistance is 25 megaohms for units up to 250 volts, and 100 megaohms for units 251 to 600 volts. Verify by dielectric absorption test that polarization index levels are according to manufacturer's industry standards approved.
2. Battery Tests: measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
3. Battery Charger Tests: verify specified rates of charge for both equalizing and floatcharging conditions.
4. System Integrity Tests: methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
5. Simulation of malfunctions to verify proper operation of local and remote protective, alarm, and monitoring devices.
6. Load Test: use variable load bank capable of simulating kVA, kW, and power factor of load for which unit is rated. Run unit at 25, 50, and 75 percent of rated capacity for 30 minutes each, and at 100 percent for 3 hours immediately followed (in case of prime generators) by 10 % overload test for 30 minutes. Make the 100-percent load run at 80 percent power factor. Record voltage, frequency, load current, battery-charging current, power output, oil pressure, and coolant temperature periodically during the test.
7. Vibration Baseline Test: measure amplitude for nominal frequency and for frequencies 5, 10, 15, and 20 percent above and below nominal at each main

bearing cap. Vibration levels not exceeding those specified in NEMA MG1, "Motors and Generators," are acceptable.

8. Exhaust System Back-Pressure Test: use a manometer with a scale exceeding 40 inches of water. Connect to the exhaust line close to the engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's published allowable limits for the engine.
9. Exhaust Emissions Test: conform to applicable government test criteria.
10. Voltage and Frequency Transient Stability Tests: use recording oscilloscope to measure voltage and frequency transients for 50-percent and 100-percent step-load increases and decreases and verify that performance is as specified.
11. Harmonic Content Tests: measure harmonic content of input and output current under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
12. Efficiency Tests: perform at 50 percent, 75 percent, and 100 percent of rated load.

END OF SECTION 16235

SECTION 16240

WIRING DEVICES

Part 1 GENERAL

1.1 Submittals

A. Technical Data: Submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each item.

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
   1. Exact indication of position of each item and outlet box and fitting on layout drawings, with box and equipment types and sizes.
   2. Installation details of special devices including fans etc.
   3. Wiring diagrams of special items.

C. Samples: Submit samples of each type of device to be approved by the client and interior design.

1.2 Spare Parts and Extra Materials

A. Furnish 3 % (with minimum of four each) extra materials for all products that match those installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Employer.

Part 2 PRODUCTS

2.1 Socket Outlets

A. Types: All socket outlets are to conform to Multi-Standard Socket type – Universal Type.

B. Universal socket outlets (230 V service): 13 A, 240V, three holes-pins with multiple pin configuration, switched type, with decorative cover, to be used as shown on the drawings, finish material and color should be as per ID / Engineer approval, however sample should be provided to be approved by ID engineer before approving the material submittal.

C. Weatherproof socket outlets are to be any of the types indicated, enclosed in surface mounted cast metal box and with cover comprising spring-retained gasket hinged flap. Enclosure is to be predesigned box and cover for type of socket outlet specified.

D. Floor Mounted Socket Outlet (floor box): Flush floor mounted steel box housing, with steel cover, cover final finish shall match the floor finish material, the floor box shall include all related accessories to accommodate the required electrical fixtures. Depth shall be suitable to socket and related plug, IP 65 protection to be achieved. Compartments and internal sockets outlets as per drawings.

E. Floor/Table Pop up outlet (floor Pop Up outlet): Flush floor mounted steel/metal box housing, with steel/metal cover, final finish shall be as per the engineers approval, the outlet shall include all related accessories to accommodate the required electrical fixtures. IP 65 protection to be achieved. Compartments and internal sockets outlets as per drawings.

Part 3 EXECUTION

3.1 Installation

A. Locations: Drawings generally show approximate locations of outlets and equipment. Exact locations are to be determined from interior finishing and detail drawings. Any condition that would place an outlet in an unsuitable location is to be referred to the Engineer. Locate switches at strike sides of doors, whether shown on the Drawings or not. In locating outlets allow for overhead pipes, ducts, variations in arrangement, thickness of finishing, window trim, paneling and other engineering features.

B. Mounting heights for outlet boxes and similar equipment are to be uniform within the same or similar areas. Mounting is to be as shown on the Drawings or as approved by Engineer.

C. Additional outlets to those shown on the Drawings are to be provided as required by equipment manufacturers for control or other wiring.

D. Recessed Outlet Boxes: Make neat openings, to the satisfaction of the Engineer, allowing for thickness of finishing, and use extension rings if required. Repair damaged finishing to original condition before installation of fittings or plates.

E. Appearance: Install exposed boxes and plates plumb, square and parallel to finished wall surface. Exposed plates covering recessed boxes are to rest neatly on wall surface without gaps, and fully covering the box.

F. Grouped Outlets: Arrange neatly so that use of fittings is convenient and clear.

G. G. Waterproof and Explosion-Proof Fittings: Follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.

H. Damaged Fittings: Reject damaged fittings or plates with damaged finish. Protect fittings and plates against damage after installation and until handed over.

3.2 Identification

A. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.

B. Receptacles: Identify panel board and circuit number from which served. Use machine printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

3.3 Connections

A. Single pole switches are to switch the phase wire. Do not run neutral wire through switches having neutral shunt or bridge.

B. Exposed Outlet Boxes: Securely fasten to wall with machine screws to permanent inserts or lead anchors.

C. Connection Of Appliances:

1. Where appliance is designed to adapt directly to outlet box, extend electrical wiring to incoming terminals inside appliance.
2. Where appliance is not designed to adapt to outlet box, install the connecting wiring in flexible conduit firmly fixed to outlet box cover plate and to terminal box on appliance.

D. Tighten electrical connectors and terminals according to manufacturers published torque tightening values.

3.4 Field Quality Control

A. Visual Inspection: Fittings and equipment are to be inspected for fixing and workmanship.

B. Megger tests are to include switch and socket outlet tests together with insulation resistance of wiring installations.

C. Operation: Devices are to be tested for operation and are to perform as intended at full load without any signs of heating.

D. Equipment is to be insulation tested and observed, under full-load for not less than 3 days operation, with respect to undue heating and performance in general.

3.5 Cleaning

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 16240

SECTION 16251

SWITCH BOARDS

Part 1 GENERAL

1.1 Submittals

A. Product Data: Submit for approval detailed description of main distribution boards including all components supported by manufacturer's catalogues, indicating compliance with the Standards specified under "Quality Assurance" Article, equipment characteristics, details of construction, operating data, dimensions and weights etc. Give details of miscellaneous items including incoming and outgoing feeder terminal arrangement, connections at bus bars, isolating, earthing, interlocks, control devices, indicating and metering instruments etc. Boards shall be factory assembled and tested and shipped as complete package (s).

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
   1. Plans and elevations with indication of built-on equipment, exact dimensions, and weights.
   2. Arrangement of boards inside rooms allocated, indicating spaces and clearances.
   3. Arrangement of equipment inside board.
   4. One-line diagram of power system showing current ratings of switchgear and bus bars and types and locations of protective gear (relays, instruments, CTs, VTs etc.)
   5. Schematics and wiring diagrams of control circuits. Differentiate between manufacturer installed and field-installed wiring.
   6. Foundation details and grouting holes installation details.
   7. Arrangement of incoming and outgoing feeders, terminal fittings, instruments, bus bar connections etc.
   8. Utility Company's metering provisions with indication of approval by utility company.

C. Point-wise compliance statement to the specifications, duly signed by the manufacturer / manufacturer's authorized representative and the contractor.

D. Technical Literature: Submit the following for approval prior to placing orders for equipment manufacture:
   1. Schedule of circuit breakers application, indicating type, range, features and characteristics, short- circuit ratings, time-current curves etc.
   2. Method of setting of protective devices for overload, short-circuit and earth-fault currents as coordinated with upstream and downstream systems based on specific coordination curves of protective devices used and specific calculated prospective short-circuit currents at various points.
   3. Test methods on site and references, including testing equipment for microprocessor controlled trip units.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article. Provide evidence of applicable registration or certification.

F. Tests and Certificates: Submit complete certified manufacturer's type and routine test records, in accordance with the Standards specified in "Quality assurance" Article.

G. Field Test Reports: Submit written test reports and include the following:
   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.

H. Manufacturer's field service report.

I. Maintenance Data: For main distribution boards and components to the following:
   1. Routine maintenance requirements for main distribution boards and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

J. Coordination Study: Submit coordination study along with setting of protective devices for overload, short-circuit and earth-fault currents as coordinated with upstream and downstream systems based on specific coordination curves of protective devices used and specific calculated prospective short-circuit currents at various points.

1.2 Quality Assurance

A. Installer Qualifications: Engage an experienced installer with minimum five years of successful installation experience on projects utilizing main distribution boards units similar to those required for this project.

B. Manufacturer Qualification: A firm regularly engaged in the manufacture of main distribution boards, of types, sizes, and capacities required, and whose products have been in satisfactory use in similar service for not less than five years.

C. Codes and Standards: Comply with the latest issue of:
   1. IEC 61439-1 & IEC 61439-2: Low Voltage Switchgear and Control Gear Assemblies.
   2. IEC 60947-1: Low Voltage Switchgear and Control Gear: Part 1: General Rules.
   3. IEC 60947-2: Low Voltage Switchgear and Control Gear: Part 2: Circuit Breakers.
   4. Relevant IEC Standard for other components, where not otherwise specified.

D. Compliance with Local Requirements: Comply with applicable local regulations/code requirements of authorities having jurisdiction. These will have precedence over other codes/standards nominated for the project, unless otherwise approved in writing.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for main distribution boards, including clearances between main distribution

boards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.3 Delivery, Storage, and Handling

A. Deliver in sections of lengths that can be moved past obstructions in delivery path. Deliver MDB and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items.

B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. Handle MDBs carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

D. Relocation of existing panel shall be made carefully without any physical damage to the panel enclosure and internal components. Any damaged items shall be compensated with similar/complied items with the complete panel solution.

1.4 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period 5 years from date of Issuing Taking Over certificate.

1.5 Coordination

A. Coordinate layout and installation of main distribution boards and components with other construction and electrical work, including conduit, piping, equipment, adjacent surfaces, raceways, electrical boxes and fittings, and cabling/wiring work. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.6 Extra Materials

A. Spare Parts: Provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the following:
    1. One set of fixed and moving contacts for every type of replaceable (consumable) contact set.
    2. One operating motor and/or coil for each type of electrically operated circuit breaker.

3. Two sets of each type of indicating lights, fuses, LEDs, control switches, and similar devices subject to failure or breakage at any time.

B. Tools and Instruments: Provide tools and instruments required for normal routine inspection and maintenance and testing of circuit breakers and protective devices as appropriate for type of switchgear supplied.

1.7 Factory Acceptance Test

A. Factory acceptance tests of equipment under this Contract are subject to be witnessed by the Engineer for locally assembled equipment. Witness test shall include complete routine and function testing on all units to be witnessed. Test procedure and program shall be submitted for approval prior to test conduction.

Part 2 PRODUCTS

2.1 General

A. General Construction: Rigidly framed and bolted, with Electro-galvanized sheet steel enclosures, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating, gray color (RAL 7035 ANSI 61) or standard manufacturer's color subject to Engineer's approval. panel shall be vermin, dust and rodent proof, IP 31 protection to IEC 60529 for indoor installations. Test certificates for mechanical impact shall be submitted for approval; otherwise, enclosure thickness shall not be less than 1.5mm.

B. Ventilation: Compartments shall be ventilated, by approved methods complying with the Standards.

C. Main Distribution Boards shall have a short circuit withstand current of the rating shown on the Drawings for 1 sec.

D. Fastenings between structural members shall be bolted.

E. Arrangement shall permit incoming and outgoing bus bars and cables to enter enclosure as indicated on the Drawings and connect at respective terminals without inconvenience to installation or maintenance.

F. Removing Circuit Breakers: Suitable arrangements and equipment shall be provided for extracting, lifting and unloading switchgear from enclosures as appropriate for type of switchgear.

G. Spare and space positions are defined as follows:
    1. Spare position: Fully equipped enclosure with switchgear
    2. Space position: Fully equipped enclosure ready to receive switchgear.

H. Bus bars: Site rated to same rating of main circuit breaker frame size as a minimum unless otherwise shown on drawings, and braced for a symmetrical rms short-circuit duty as specified. Bus bars shall be copper, of sufficient size to limit temperature rise to allowable equipment temperature ratings, and not exceeding IEC 61439-1&-2 limits. Connections and bus work shall be bolted with compatible hardware material as per manufacturer's recommendations and shall be accessible for inspection and maintenance. Contact surfaces shall be properly tin or Electro-silver plated as necessary.

I. Connections from bus bar to switching element shall be rated to carry full continuous current rating of switching element frame as a minimum, unless otherwise shown on drawings.

J. Main horizontal busbars and vertical distribution busbars shall be insulated unless bare busbars are recommended by the manufacturer and used in the type test.

K. Full size neutral shall be continuous through all sections. Neutral bus shall be insulated and separate from earth bus and connected to it with removable links, at every bus section. Links shall be of the same cross-section of the earth bus.

L. Earth bus shall extend full length of board, firmly fixed to each section in accordance with the Regulations and Standards, complete with two main earthing lugs (one at each end), and required number of feeder protective earth connectors.

M. Earth bus shall be half size of phase buses, unless otherwise indicated on drawings.

N. Fixed main circuit breaker section shall individually accommodate main circuit breaker, main cable entry with terminal fitting assembly and metering compartment. Where placed against a wall, accessibility shall be possible from front and sides or only from front of section.

O. Pull Sections: An additional cable pull section shall be provided, depending on actual configuration shown on the Drawing, and subject to Engineer's approval.

P. Form 1 and Form 2 switchboards shall be front accessible, unless otherwise indicated on the ratings; front, rear or front and rear aligned as recommended by the manufacturer and approved by the Engineer, fixed group mounted MCCB distribution sections, with all devices removable from the front and mounted on a panel board type base. Construction shall allow all connections and maintenance to be made without rear access. Cables shall be accommodated in extra wide vertical gutters. Sides, top and rear shall be covered with removable screw-on plates having formed edges all around. Front plates shall be sectionalized and removable, covered by trims, and secured by self-tapping screws.

Q. THDi and THDv at the main distribution board section of each transformer (Point of Common Coupling) shall not exceed 10% with 8% individual harmonic order and 5% with 3% individual harmonic order respectively. Necessary supporting calculations based on actual nonlinear loads including VFD, UPS, lighting ballasts, etc. and all other linear loads on the same transformer shall be submitted for Engineer's approval. In case the specified harmonic limits cannot be achieved, the contractor is responsible for achieving the specified limits by providing necessary filters on MDB bus. Adopted solution shall be submitted for Engineer's approval prior to implementation.

R. All main distribution boards shall be equipped with combined Class I + II surge protective devices . SPDs along with their fused-disconnect switch shall be integrated within or adjacent to the MDB's enclosure.

2.2 Molded Case Circuit Breakers (MCCBs)

A. Type: Tested to approved standards, , totally enclosed, molded case, constructed from high quality, high temperature resistant, tropicalized, 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.

B. MCCBs shall be 160 A minimum frame size, unless otherwise shown on the drawings.

C. MCCBs generally shall be thermal-magnetic type for ratings below 250 A frame size, unless otherwise shown on the Drawings. MCCBs 250 A and larger shall be electronic solid-state trip type. All circuit breakers shall be 3-pole unless otherwise shown on drawings.

D. Thermal magnetic circuit breaker trip units: shall have bi-metallic inverse time delay over-current element for small overloads and instantaneous magnetic over-current trip element for operation under short-circuit conditions on each pole. Circuit breakers rated 150/160 A shall have adjustable instantaneous trips.

E. Electronic trip circuit breakers shall have solid state trip units with long time delay setting range at least between 0.5 and 1.0 times maximum trip rating with adjustable time delay up to 24 seconds, short time delay range 3 to 10 times maximum trip rating with 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 provided or built into trip unit where specified or shown on drawings, and shall be adjustable between 0.2 and 0.6 normal phase current pick-up with maximum time delay of 0.2 seconds, and shall be suitable for connection to external current sensor. Push-to-trip button shall be provided on cover for testing the trip unit. Short time over current protection is only required for circuit breakers 630A and above.

F. Deration: Thermal and electronic over-current trips shall be ambient temperature derated at specified ambient temperature. In case of adjustable thermal settings, range of adjustment shall not exceed maximum trip rating shown on the Drawings. MCCB shall not be derated if the space where the switch boards are installed is air-conditioned.

G. 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.

H. Trip current rating (amps) indicates nominal maximum rating at which overload element is set to operate.

I. MCCBs: MCCBs frames rated 800 A and above shall have utilization category B (with an intended short time withstand capability), 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 panel board location and schedules shown on the drawings, with declared ratings as percentage (100%, 75% or 50%) of the ultimate ratings as quoted by the circuit breaker manufacturer marked on the circuit breaker rating plate. MCCBs frames up to 630 A shall have utilization category A with rated ultimate short circuit breaking capacity (sequence III) to meet the electrical requirements at the switchboards locations.

J. 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.

K. Interchangeable Trips: Thermal magnetic circuit breakers of 150/160 A frame size shall have interchangeable trip units.

L. Sealing: Non-interchangeable trip circuit breakers shall have sealed covers. Circuit breakers with interchangeable trips shall have trip unit covers sealed to prevent tampering.

M. Accessories: Circuit breaker design shall allow addition of open / close electrical motor operator, control and interlocking functions, under-voltage release, shunt-trip coils, alarm and auxiliary switches, padlocking devices, key-lock devices, and the like.

2.3 Metering Instruments

A. Generally: Instruments 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.

B. Voltmeters: Moving iron type, with center zero adjuster, range 1.25 times nominal system voltage, 90 degree angle, size 76 x 76 mm.

C. Voltmeter Selector Switch: 7-position rotary type.

D. Ammeters: Moving iron type, with center zero adjuster, range 2 times nominal circuit amperage, 90 degree angle, size 76 x 76 mm.

E. Provide ammeters and pilot lights for each phase.

F. Provide p.f. meter moving iron type with center zero adjuster, size 76 x76mm.

G. Current Transformer (CT): Indoor dry type, rated secondary current 5 A. Rated primary current, core size and accuracy shall be determined in accordance with nominal current of plant protected, short-circuit level and burden.

H. Voltage Transformer (VT): Provide where required, complete with primary and secondary fuses and disconnecting device.

2.4 Digital Metering Units

A. Metering unit shall be provided on the incoming and outgoing feeders having the following functions for each phase:
   1. Voltage.
   2. Current.
   3. Frequency.
   4. Energy.
   5. Total power.
   6. Peak power demand.
   7. P.F
   8. Total Harmonic Distortion
   9. Reactive Power
   10. Apparent Power

B. The metering unit shall be provided by adequate interface link with the BMS system.

2.5 Digital Voltage Relay

A. This unit shall be provided on the incoming and coupler section to perform the following functions, for connection to the automatic transfer system and monitoring by BMS system:
   1. Over-voltage (adjustable from 90 to 120%, with time delay adjustable from 0.5-5 Sec).
   2. Under-voltage (adjustable from 75 to 95%, with time delay adjustable from 0.5-5 Sec).
   3. Phase Voltage unbalance (detect voltage unbalances over 10%).
   4. Phase reversal.

2.6 Wiring

A. Arrangement: Wiring shall be modularly and neatly arranged on master terminal boards with suitable numbering strips and appropriate cartridge type fuses where required.

B. Connections shall be made at front of terminal board and with no live metal exposed.

C. Metal cases of instruments, control switches, relays etc. shall be connected, by bare copper conductors' not less than 2.5 mm2 section, to nearest earthing bar.

D. Control Wiring: Copper, PVC insulated, 85 deg. C, 600 V grade, and PVC sheathed for multi-core cables. Finely stranded copper conductor, silicon rubber insulated cables shall be used in proximity to higher temperature components and as flexible cable.

E. Ferrules: Wires shall be fitted with numbered ferrules of approved type at each termination.

2.7 Miscellaneous

A. Anti-condensation heaters with disconnect switch and pilot lamp shall be provided in switchboard, controlled by thermostat and/or hygrostat.
B. Schematic and wiring diagram shall be provided suitably located within each cubicle.

Part 3 EXECUTION

3.1 Examination

A. Examine elements and surfaces to receive main distribution boards for compliance with installation tolerances and other conditions affecting performance. Notify Engineer in writing of conditions detrimental to proper completion of the work.

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

3.2 Installation

A. Install main distribution boards as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable requirements of applicable standards or codes approved.

B. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from main distribution board units and components.

D. Cable Trenches: Ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

E. Built-in Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which shall be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

F. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.

G. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.

H. Relays: Set in accordance with manufacturer's instructions and in accordance with an approved scheme.

I. Make Good damage painted surfaces, clean and apply rust-inhibiting prime coat and two finishing coats of approved enamel upon delivery of equipment to site, or as required by Engineer.

J. Operating Instructions: Frame and mount the printed basic operating instructions for main distribution boards, including control and key interlocking sequences and

emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of main distribution boards.

3.3 Identification

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section 16195 - Identification for Electrical Systems.

B. Main Distribution Board Nameplates: Label each main distribution board compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 Connections

A. Install equipment-grounding connections for main distribution boards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values and / or recommendations. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.5 Field Quality Control

A. Equipment: Inspect equipment upon delivery to Site and report any damage to Engineer.

B. Switchgear: Inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.

C. Prior to energization of circuitry, check all accessible connections to manufacturer's torque tightening specification.

D. Tests: After installation and before hand-over, carry out all visual and mechanical inspection and electrical tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including, but not limited to, the following. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

1. Insulation resistance tests for each main distribution board bus, component, connecting supply, feeder, and control circuit.
2. Continuity tests of each circuit.
3. Operational tests.

E. Main and Control Circuits: Using 1000 V megger (2000 Megohm range), check insulation resistance between phases, between phases and earth/enclosure and between neutral and earth.

F. Primary Injection Tests: Provide portable test equipment to test time-delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.

G. Instantaneous Trip Elements: Test by high current primary injection, using high-current primary injection test-sets and reports all readings.

H. Routine Tests on Site: Carry out on every main distribution board in accordance with the Standard specified (IEC 61439-1 and IEC 61439-2) for FBAs assembled from standardized components outside the works of the manufacturer. Routine tests are also to be carried out on every FBA, delivered to site, if requested by Engineer.

3.6 Adjusting

A. Set field-adjustable switches and circuit breaker trip ranges.

3.7 Cleaning

A. On completion of installation, inspect interior and exterior of main distribution boards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16251

SECTION 16260

PANEL BOARDS

Part 1 GENERAL

1.1 Submittals

A. Equipment Data: Submit data for approval including, but not limited to, the following:

1. Manufacturers' catalogues indicating specific equipment selected.
2. Types of panel boards and circuit breaker characteristics including duties and deration at specified ambient conditions and corresponding temperatures within the enclosures, MCB shall not be derated if the space where the panels are installed is air-conditioned.
3. Dimensions of panels and specific contents of each panel board.
4. Integrated equipment tabulations for coordinated short- circuit series combinations of circuit breakers.

B. Tests and Certificates: Submit complete certified manufacturer's type test and routine test records in accordance with the Standards.

C. Point-wise compliance statement to the specifications, duly signed by the manufacturer / manufacturer’s authorized representative and the contractor.

D. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
1. Exact composition of each panel board, indicating busbar rating, frame and trip ratings of circuit breakers.
2. Typical installation details of panel boards, indicating main feeder and branch circuit conduit connections, terminal provisions, tags, labels, mounting methods and materials used.

E. Coordination Study: Submit coordination study along with setting of protective devices for overload, short-circuit and earth-fault currents as coordinated with upstream and downstream systems based on specific coordination curves of protective devices used and specific calculated prospective short-circuit currents at various points.

F. Details of Electrical Closets: Submit details to verify clearances, spaces and ventilation of the installation of proposed equipment, prior to starting construction.

G. Field Test Reports: Submit written test reports and include the following:
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.

H. Panel board Schedules: For installation in panel boards submit final versions after load balancing.

I. Maintenance Data: For panel boards and components to include in maintenance manuals and to the satisfaction of the Employer's requirements. In addition to requirements include the following:
    1. Manufacturer's written instructions for testing and adjusting over-current protective devices.
    2. Time-current curves, including selectable ranges for each type of over-current protective device.

1.2 Quality Assurance

A. Comply with
    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 (DBO)".
    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, disconnections, switch disconnectors and fuse-combination units circuit breakers".
    6. IEC 60947-4-1 "Low Voltage switchgear and control gear - Contactors and motor-starters — Electromechanical contactors and motor-starters".
    7. IEC 60898-1 "Miniature circuit breakers".
    8. IEC 61009 "Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)".
    9. Other components where not specified shall comply with the relevant IEC standards.

1.3 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period
B. Warranty Period: 5 year from date of Issuing Taking Over certificate.

1.4 Coordination

A. Coordinate layout and installation of panel boards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.5 Schedules

A. Schedules shown on drawings indicate the designation and required type of panel board using the following criteria:
    1. Type of construction (MCB or MCCB), referring to type of branch circuit breakers.
    2. Voltage, number of phases and wires.
    3. Branch circuit breaker trip rating and wire size.

4. Main circuit breaker trip rating and frame size (maximum continuous rating) for MCCB and MCB.
5. Short-circuit interrupting capacity (IC) in kA.
6. Special arrangement or provisions.

1.6 Factory Acceptance Test

A. Factory acceptance tests of equipment under this Contract are subject to be witnessed by the Engineer for locally assembled equipment. Witness test shall include complete routine and function testing on all units to be witnessed. Test procedure and program shall be submitted for approval prior to test conduction.

Part 2 PRODUCTS

2.1 General

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

B. Panel boards shall be totally enclosed, dead front type, protection code IP 31 for indoor installations, IP54 for installations in wet areas including fire sprinkled Electrical rooms and IP 55 for outdoor installations, in accordance with IEC 60529, and shall be factory designed and assembled.

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

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

E. Protection shall be fully rated throughout the systems.

F. Circuit breakers shall be non-fused type.

G. Circuit Breaker Arrangement: Panel boards 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 panel boards shall be designed for sequence phase connection of branch circuit devices.

H. Branch Circuit Numbering: On 3-phase panel board schedules, [circuits 1 and 2 shall be connected to red (R) phase, 3 and 4 to yellow (Y) phase, 5 and 6 to blue (B) phase etc., to conform with branch circuit numbering shown on the drawings.

2.2 Panel board Enclosures

A. Type: General purpose type, suitable for relevant ambient conditions, flush or surface 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-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 panel board assembly.

C. 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 panel boards shall overlap box

and front shields by at least 20 mm. Trims for surface mounted panel boards shall be exactly sized to form flush fit to box.

D. 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.

E. 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 to the approval of Engineer.

F. 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 panel boards and clearly indicate circuit number and description of load.

G. Outdoor enclosures shall be heavy duty sheet steel cabinets, suitable for mechanical impact resistance of IK10 to IEC 62262, fully weatherproofed (IP 54), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

H. 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.

2.3 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 panel board 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. 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. 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.

E. Short-circuit Duty: Busbars shall carry at least 125% of the maximum short-circuit level at point of application for one second, without showing any signs of degradation.
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 setscrew 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 panel board 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.

2.4 Molded Case Circuit Breakers (MCCBs)

A. Type: Tested to approved standards, , totally enclosed, molded case, constructed from high quality, high temperature resistant, tropicalized, 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.

B. MCCBs shall be 160 A minimum frame size, unless otherwise shown on the drawings.

C. Circuit Breaker Trip Units: Unless otherwise specified or shown on the drawings, molded case circuit breakers of final branch circuit panel boards (LPs), power panel boards (PPs) and sub distribution panel boards (SDPs) shall be thermal magnetic type, while molded case circuit breakers of distribution panel boards (DPs) shall be thermal magnetic for frame sizes up to 160 amperes and electronic type for higher frame sizes.

D. Thermal magnetic circuit breaker trip units: shall have bi-metallic inverse time delay over-current element for small overloads and instantaneous magnetic over-current trip element for operation under short-circuit conditions on each pole. Circuit breakers rated 150/160 A shall have adjustable instantaneous trips.

E. 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.

F. Electronic trips units, applicable to circuit breakers 250 A frame size and larger, shall be solid state 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. Short time over current protection is only required for circuit breakers 630A and above.

G. 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.

H. Trip current rating (amps) indicates nominal maximum rating at which overload element is set to operate.

I. MCCBs for LPs, PPs, SDPs, DPs Type 2 and feeder pillars: Comply with IEC 60947-2 test sequences I, II, utilization category A, and shall have rated ultimate short circuit breaking capacities (sequence III) to meet the electrical requirements at the panel board location, with preferred ratings in accordance with following tables.

J. MCCBs for DP Type 1: MCCBs frames rated 800 A and above shall have utilization category B (with an intended short time withstand capability), 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 panel board location and schedules shown on the drawings, with declared ratings as percentage (100%, 75% or 50%) of the ultimate ratings as quoted by the circuit breaker manufacturer marked on the circuit breaker rating plate. MCCBs frames up to 630 A shall have utilization category A with rated ultimate short circuit breaking capacity (sequence III) to meet the electrical requirements at the panel boards locations with preferred ratings in accordance with the below tables.

K. Frame size is defined as maximum continuous current rating of circuit breaker which corresponds with its maximum trip range listed below and which shall be related to minimum acceptable short-circuit interrupting ratings, based on fully rated interrupting duties: normal duty (N), high break (H), or current limiting (L), as specified.

L. M. 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.

M. Interchangeable Trips: Thermal-magnetic trip circuit breakers of 150/160 A frame size shall have interchangeable trip units.

N. Sealing: Circuit breakers with non-interchangeable trip units shall be sealed. Circuit breakers wit interchangeable trip units shall have trip unit covers sealed to prevent tampering.

O. 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) 100 A and over. Padlocking devices shall be provided, where shown on the Drawings.

P. 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 as shown on the Drawings, 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.

Q. Current Limiting Circuit Breakers: Molded case type without fusible elements. When operating within current limiting range, the I2t of let-through current shall be less than 1/2 cycle wave of symmetrical protective short-circuit current as compatible with breaker construction.

R. Current limiting circuit breakers shall have, on each pole, adjustable inverse time-delay overcurrent characteristics for overload protection and instantaneous trip for short-circuit protection. Operation of main contacts shall be based on Electro-magnetic repulsion forces between contacts created by fault current. Ratings are specified at rated voltage for an rms value of prospective short-circuit current.

2.5 Miniature Circuit Breakers (MCBs)

A. Type: Thermal magnetic non-adjustable type, tested in accordance with IEC 60898-1.

B. Minimum short-circuit breaking capacities to IEC 60898-1shall be as 6 - 125A MCB for 10 or 15 kAat 220/240 - 380/415 V A.C.

C. Construction: MCBs shall be tropicalized for operation at ambient temperatures up to 70 degree C within panel board 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 40deg.c, available as 1, 2, 3 and 4-pole circuit breakers. De-rating above 40 deg C shall not exceed 1% per deg C and loading shall not exceed 70% of circuit breaker rating.

G. 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.

H. 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.

2.6 Final Branch Circuit, Power and Sub-Distribution Panel boards - Generally

A. Arrangement: Comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker or switch as shown on drawings. Single and multi-pole circuit breakers or other devices shall occupy modular spaces. Accommodation of contactors and split bus arrangement or other devices shall not change regularity of standard box width.

B. Indoor Enclosure: Sheet steel, minimum 0.8 mm thick for box/cabinet and minimum 1.5 mm thick for front shield, trim and door. Fixings for flush trim shall be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) shall be at least 100 mm wide. Larger gutters shall be provided where tap-off insulated split connectors are required. Knockouts shall be provided in top or bottom of enclosures and shall provide a neat and uniform conduit/cable terminal arrangement.

C. Contactors: 2 or 3-pole, Electro-magnetic type, class AC 5a for discharge lamps, class AC 5b for tungsten halogen lamps and class AC 3 for motors to IEC 60947-4, and rated not less than overload setting of protective device upstream. Contacts shall be double break, silver cadmium plated, having self-cleaning wiping action. Control shall be provided by phase-neutral (maximum 230 V) split-coil, for on/off activation by local and/or by remote direct-wired, on/off push buttons. Contactor shall be mechanically latched. Control circuit shall be fused. Auxiliaries shall include local pilot light, parallel remote indicating circuit, 2 N.O. and 2 N.C. auxiliary contacts.

D. Type: Rated insulation voltage rating of 500V as a minimum.

E. 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/combtype 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. Panel boards shall comply with IEC 61439-3.

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 panel boards 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 panel boards 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. TPN type panel board main circuit breakers shall be MCCB or MCS as shown on the drawings, 100A or 160A frame size as shown on the Drawings, with trip range from 32 A to 160A, normal (N) or high-break (H) duty with/without RCBO as shown on the Drawings.

Part 3 EXECUTION

3.1 Installation

A. Fixing Generally:
   1. Align, level and securely fasten panel boards to structure.
   2. Fix surface mounted outdoor panel boards at least 25mm from wall ensuring supporting members do not prevent flow of air.
   3. Do not use connecting conduits to support panel boards.
   4. Close unused openings in panel board cabinets.

B. Panel board Interiors: Do not install in cabinets until all conduit connections to cabinet have been completed.

C. Wiring Inside Panel boards: Neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections shall be split and bolted type, fully insulated.

D. Trim: Fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.

E. Mounting Heights: Top of trim 1880 mm above finished floor, unless otherwise indicated.

F. Mounting: Plumb and rigid without distortion of box. Mount recessed panel boards with fronts uniformly flush with wall finish.

G. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panel board loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

H. Protection: Treat concealed surfaces of recessed cabinets with heavy field application of waterproof compound prior to installation.

I. Install filler plates in unused spaces.

J. Provision for Future Circuits at Flush Panel boards: if asked by the engineer, stub four empty conduits from panel board into accessible ceiling space or space designated to be ceiling space in the future. Stub four empty conduits into raised floor space or below slab not on grade.

3.2 Identification

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in section 16100 - Common Work Results For Electrical.

B. Panel board Nameplates: Label each panel board with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 Connections

A. Install equipment-grounding connections for panel boards with ground continuity to main electrical ground bus.
B. Tighten electrical connectors and terminals, including screws and bolts, according to
C. Manufacturer's published torque-tightening values and / or recommendations. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.4 Field Quality Control

A. Generally: Carry out all tests, required by the governing codes and by the Engineer, on panel boards after installation, to verify compliance with the specifications and standards. Inspect conditions within panel boards and verify insulation conditions by use of a megger.

B. Circuit Breakers: Tests shall include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by Engineer, by applying necessary short-circuit, overload and earth leakage current for tripping circuit breaker as applicable and compare with manufacturer's data/characteristic curves. Measure and report ambient temperature inside enclosure.

C. Insulation Check Tests: Carry out insulation tests on all busbars, between phases and between phases and earth/cabinet, and between neutral and earth. Record all readings, using 500 V megger for equipment on 240 V systems, and 1000 V megger for equipment on systems up to 600 V, for 1-minute, with circuit breakers in open position.

D. Routine tests on site shall be carried out, in accordance with the Standards, on all panel boards assembled from standardized components of the manufacturer outside the works of the manufacturer.

E. Prepare for acceptance tests as follows:
    1. Test insulation resistance for each panel board bus, component, connecting supply, feeder, and control circuit.
    2. Test continuity of each circuit.

F. Testing: After installing panel boards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

3.5 Adjusting

A. Set field-adjustable switches and circuit breaker trip ranges.

3.6 Cleaning

A. On completion of installation, inspect interior and exterior of panel boards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16260

SECTION 16265

CONTROL DEVICES

INDEX

SECTION 16265

CONTROL DEVICES

Part 1 GENERAL

1.1 Submittals

A. Provide manufacturers' product data sheets for all material and equipment whose products are proposed. Only specified or approved manufacturer components shall appear in the Product Data Submittal. Bids shall not be considered without a complete Product Data Submittal.
   1. Mark each copy of the product data sheets to show applicable choices and options.
   2. Where product data includes information on several products, some of which are not required, mark copies to indicate the applicable information.
   3. Submit manufacturer's product data sheets for all fire stopping materials proposed for use on the project.
   4. Sample faceplates shall be submitted sufficiently in advance to allow ample time for review and re-submittal as may be required. Sample faceplates shall include labels on all outlet configurations, including modular furniture.

1.2 Shop Drawings

A. Provide shop drawings for the installation of the Work per direction in General Condition documents.

B. Provide detailed plan views and elevations of all spaces showing field conditions, ancillary room components, dimensions, equipment racks, termination blocks, and cable paths.

C. Provide drawings to show evidence of coordination with other trades.

D. All Shop Drawings shall be submitted sufficiently in advance of field requirements to allow ample time for review and re-submittal as may be required. All Submittals shall be complete and shall contain all required information properly detailed. Failure to submit Shop Drawings may result in re-work of installed material. Any such re-work shall not incur any additional costs.

1.3 As-Built Drawings:

A. The Contractor shall provide the 'As-Built' drawings in advance of completion of the Works and as a condition precedent to the certification by the Consultant that the Works are complete. These 'As-Built' drawings shall reflect the works as installed

1.4 Test Plan:

A. The Contractor shall submit a detailed & comprehensive test plan listing the following; which shall be submitted prior to intended test date.

    1. List of all the test equipment which will be used
    2. Certifications of all the test equipment which will be used
    3. Procedures for inspection and testing
    4. Checklist for the above procedures
    5. Intended test date

1.5 Field Test Reports:

A. The Contractor shall submit field test reports approved and signed Design Engineer for approval.

1.6 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

B. Warranty Period: 5 year from date of substantial completion

Part 2 PRODUCTS

2.1 General

A. The automation system shall have several user interfaces for operating the system and functions including light switching, dimming, curtains, FCUs (if applicable), etc.:
   1. Touch switches, of finish approved by Interior Designer.
   2. Keypads (with buttons as specified on the drawings)
   3. Provision only for Remote access via touch panel/ iPhone / android.

B. Containment, Lighting Controls, AC Controls, intelligent touch pad and all their needed wiring and accessories to be included in this contract

C. Provisions for integrating the CCTV, Intercom, Background Music System etc. at a future date.

D. Approved manufacturers:

   1. Crestron
   2. ABB
   3. Jung
   4. Lutron

2.2 System Controls

A. Keypads
   1. The keypads which are placed at strategic locations within the project have a combination of the following controls:
      i. Lighting controls
      ii. Curtain controls
   2. Number of buttons shall be as per the design drawings

B. Wall Mounted 10" Touch Screen
   1. The Lighting and Curtain controls available on the keypads can be controlled through the Wall Mounted touch screen as well.
   2. The project map can be implemented on the screen.

C. Day Light sensor Device
   1. The device shall consider daylight measuring, and having a setting for operation
   2. The device shall have the means to operate as PIR in parallel with the daylight measuring.
   3. The device shall be considered with digital/addressable device that follows the topology of the lighting control system, i.e. if the System is KNX, the sensor to be KNX.

D. PIR sensor Device

1. The device shall have the means to operate as PIR in parallel
2. The device shall be considered with digital/addressable device that follows the topology of the lighting control system, i.e. if the System is KNX, the sensor to be KNX.

2.3 System Components

A. Dedicated functional modules shall be used for each application such as lighting ON OFF, Dimming, Integrated modules which do all the functionalities shall not be accepted.

B. System will be DALI based, lighting fixtures will be provided to allow for connection to the DALI Gateway

C. Each DALI Gateway shall obtain 2 channels with minimum 128 points, the system shall include the adequate number of gateways as per the design drawings without adding any costs extra gateways if needed.

D. Switching Module (KNX Based)
   1. This shall be in 4, 8 and 12 independent channels to switch electrical loads Different types of load types shall be switched from each switching relay and shall be programmed to have different fail safe positions in the event of power failure or other emergency situation which are defined.

   2. Actuator shall have manual operation and display of the switching status

   3. Individual channel of switch actuator shall support special functions such as current detection, reaction to current threshold values, time functions, on/off delay, stair light function with preliminary warning and changeable stair light time, recall scenes/presets,, logic functions AND, OR, XOR, gate functions, status response, forced control and safety function, reaction to threshold values, selection of default position on bus voltage failure and recovery.

E. Dimming Modules (KNX Based)
   1. Universal Dimmer modules shall be in 2, 4, 6 and 8 channels used for dimming of different types of loads. The universal dimmer shall have short circuit, ambient temperature protection in built into them. Dimmer range shall start from 200 watts up to 2400 watts as per the requirement of the lighting load in a particular zone/circuit.
   2. Each dimmer circuit shall have line protection inside the electrical DB for isolation during lamp replacement and maintenance.

F. Curtain Modules
   1. These shall be in 2, 4 and 8 independent channels to control curtain motors of either 24 VDC or 230 VAC. The controller shall be able to control curtain motors, venetian blinds and linear drives. The device shall also be able to connect to the weather stations for automatic positioning of the venetian blind for maximum daylight harvesting and temperature control.

2. There shall be a mechanical interlock between Up & Down position to avoid any damages to the motor by activating both together. Controlling via normal switch actuators is not allowed.
3. The relay output shall be minimum 6A rated to drive higher capacity of motors. Local operation shall be possible via push buttons on the device to drive the motor. Individual channel of binary input shall support special functions using a single application program such as movement UP/DOWN, STOP/Louvre adjustment, wind, rain and frost alarm, disable, priority control, operation of ventilation flaps, movement into position, move to preset and set, feedback of position and status, default position on bus voltage failure and recovery and for programming, automatic sun protection and heating/cooling control, disable/enable manual operation.

2.4 System Power Supply

A. The power supply for the Automation system shall be reliable and designed to withstand any severe conditions during commissioning and operation. It shall be able to withstand high voltage surges in the line. The common power supplies available in the market shall not be accepted. The rating of the power supply shall be 640/320mA which can power up to 64/32 bus devices. The bus line shall be decoupled from the power supply with the integrated choke. The Power supply shall have the capacity to withstand short-circuit in the Bus for an infinite time. Once the short circuit is removed it will retain its normal operation. The power supplies with output fuse protection are not accepted. The unit shall have Green LED for output voltage and Red LED overload/short circuit.

B. The power supply shall be reliable and to be from the same manufacturer. The CE certification and Environmental information stating the model number showing manufacturer name shall be submitted along with the submittal and same shall be downloadable from online.

C. Power supply: 230 VAC, 50 ... 60 Hz

D. Output nominal voltage: 30 VDC +1 /-2 V, SELV

E. Output nominal current: 640 mA, short circuit proof (not by fuse) Connection 230 VAC

F. Installation on 35mm DIN rail, DIN EN 50 022

G. Width: 6 modules at 18 mm

Part 3 EXECUTION

3.1 Installation

A. Install products in accordance with manufacturer's instructions.

B. System cables shall be installed with extra care to eliminate any expected damage due to short bending radius.

3.2 Field Quality Control

A. Obtain all equipment and components from approved source.

B. Inspect all equipment and components on delivery, before fixing and after installation, and reject and replace any that are defective.

C. Record all commissioning, measurements and tests.

D. Perform Work in accordance with relevant British Standards and industry standard codes.

E. Provide field quality control under provisions of conditions of contract.

3.3 Testing and Commissioning

A. All system components shall only be tested in totally dust free and protected conditions and only after the approval of the installation works by the Client/Owner/Consultant

B. As a minimum the following testing and commissioning activities shall be carried out to the approval of the engineer.

1. Visual Inspection
2. Compliance on location and type of equipment
3. Circuit continuity and Insulation resistance test
4. Self-testing / Self Diagnostic testing
5. Functional testing
6. Manual and Automatic with simulation of all alarms

3.4 Cleaning

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION 16265

SECTION 16410

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

Part 1 GENERAL

1.1 Submittals

A. Technical Data: Submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each type of switch, circuit breaker, accessory, and component indicated.

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

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    i. Enclosure types and details.
    ii. Current and voltage ratings.
    iii. Short-circuit current rating.
    iv. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
    v. Cable terminal size.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer installed and field-installed wiring.
3. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Test Reports: Submit written test reports and include the following:
    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. Samples: Submit samples of each type of equipment for approval, unless otherwise agreed in writing by the Engineer.

E. Operation and Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals include the following and to the satisfaction of Employer’s requirements:
    1. Routine maintenance requirements for components.
    2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
    3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.2 Quality Assurance

A. Comply with UL98.
B. Comply with NEMA KS1.
C. Comply with NEMA 250.

1.3 Project Conditions

A. Environmental Limitations: Rate equipment for continuous operation under the conditions specified in Division 16 Section 16100 - Common Work Results For Electrical

1.4 Coordination

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.5 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified
B. Warranty period: 5 years from date of Issuing Taking Over certificate

Part 2 PRODUCTS

2.1 Switch Disconnector (Disconnecting Switch)

A. Type: Heavy duty, non-fused, air break, single throw, 600-V AC, suitable for motor circuits or for service entrance disconnecting applications, 2, 3, 4 or 6 poles as shown on the drawings. Disconnecting switches shall comply with UL 98 and NEMA KS 1, with ampere rating as shown on the Drawings ensuring its suitability for equipment horsepower rating where disconnecting switch is used for switching motors or other highly inductive loads.

B. Design: Safety type, housed in separate metallic enclosure with arc quenching devices on each pole.

C. Short Circuit Withstand: Switch disconnectors shall be capable of withstanding the maximum short circuit current at the point of installation in combination with the upstream protective device.

D. Operating Handle: A suitable handle made of conducting material shall be provided for safety and convenient operation of the switch and it shall be in electrical connection with the enclosure. In case the position of the switch contacts is indicated by the position of the operating handle, then there shall be definite off and on indicated positions for the handle, and the design of the operating mechanism shall be such that the handle cannot be left readily at or near the off position when the switch is on. A handle indicating the position of the switch contacts either closed or open shall be designed such that the door cannot be closed and secured in place with the handle indicating off while the switch contacts are in the on position.

E. Operating Mechanism: Quick-make, quick-break, double contact rotary blade mechanism, independent manual operation. The design of the operating mechanism in conjunction with the contact structure shall be such that, in normal operation, the persons operating the switch cannot restrain the operations of the contacts after they have initially touched or parted when closing or opening the switch. The design and construction of the operating mechanism shall assure ample strength and rigidity. Screws and nuts serving to attach operating parts to cross bars or other movable members shall be upset or otherwise locked to prevent loosening under the jarring of continued use. Stops shall be provided as necessary to remove undue strain from switch parts. Materials shall be suited for the particular application. Contacts and terminals shall be made of tin plated copper of 99.5% purity.

F. Mechanical Interlock: the box, cover and switch operating mechanism shall be mechanically interlocked so that the door is normally prevented from being opened when the switch contacts are in the closed position and the switch contacts are normally prevented from being closed when the door is open. Switch disconnector shall be provided with a defeatable interlock by which a qualified person using the necessary tools can open the door while the switch is in the on position or close the contacts when the door is open. Interlock shall be reactivated automatically when the enclosure door is closed.

G. Padlocking: Means shall be provided for padlocking enclosures shut, they shall be provided to positively lock the switch with the contacts in the off position with a padlock and shall accommodate at least three padlocks. Any single padlock shall be capable of providing locking.

H. Switch Disconnectors for Variable Frequency Drive (VFD) Motors: Switch Disconnectors connected to VFD motors shall have an auxiliary contact that interfaces with the motor's VFD to switch off the VFD drive before disconnecting the motor.

I. Enclosure: Enclosures shall be made of steel material, properly anti-corrosion treated and electrostatic coated unless otherwise specified. Enclosures shall comply with NEMA 250 type 1A for indoor general use installations, NEMA 250 type 12 for indoor industrial / mechanical rooms installations, NEMA 250 type 4X with stainless grade 304 for indoor wet areas; such as kitchen, laundry and hospital's central sterile supply department (CSSD) and clean rooms, and NEMA 250 type 3R for outdoor installations, unless otherwise required or shown on the Drawings. Enclosures shall be used with the appropriate conductor entry fittings; such as knockouts and bolt on hub kit in order to maintain the specified environmental capability after installation. External operating mechanisms mounted on or through the enclosure shall pass the applicable test for the enclosure as specified in NEMA 250.

J. Spacing in enclosed switches shall meet the requirements of NEMA KS-1.

K. Terminals: A switch shall have suitable wiring terminals for connection of conductors having an ampacity not less than the switch's current rating for only current rated switches.

L. Accessories:
    1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
    2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
    3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

2.2 Enclosed Circuit Breakers

A. Circuit Breaker: Refer to respective type specifications in Division 16 Section 16251 "Switchboards".

B. Enclosures: Meet environmental conditions of installed location in accordance with IEC 60529.

Part 3 EXECUTION

3.1 Installation

A. Locations: Drawings generally show approximate locations of equipment. Exact locations are to be determined from detail drawings. Any condition that would place equipment in an unsuitable location is to be referred to the Engineer.

B. Waterproof Fittings: Follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.

C. Damaged Equipment: Reject damaged equipment. Protect equipment against damage after installation and until handed over.

D. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.2 Identification

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section 16195 - Identification for Electrical Systems.

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 Connections

A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.

B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.

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

3.4 Field Quality Control

A. Visual Inspection: Equipment is to be inspected for fixing and workmanship.

B. Operation: Devices are to be tested for operation and are to perform as intended at full load without any signs of heating.

C. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
   2. Test continuity of each line- and load-side circuit.

D. Tests and Inspections:
    1. Perform each visual and mechanical inspection and electrical test stated in the relevant standards. 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. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers. 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 to fulfill the coordination study requirements.

3.6 Cleaning

A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16410

SECTION 16450

STATIC UNINTERRUPTIBLE POWER SUPPLY

Part 1 GENERAL

1.1 Submittals

A. Equipment Data: Submit full technical data of equipment for approval including, but not limited to, Manufacturers' catalogues, detailed description, compliance with the Standards, dimensions and weights, system operation, operating characteristics, methods of operation, protective and control provisions, heat losses, ambient conditions and limitations on electronic components, inverter cut-off voltage, battery calculation to IEEE 485, etc. beyond which such components may suffer partial or permanent damage.

B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
   1. Plans and front and side elevations, with indication of built-on control and indicating devices and instruments, exact dimensions and weights, cabling etc.
   2. One-line diagram with ratings of each piece of equipment, cabling, grounding etc.
   3. Control and elementary diagrams, wiring diagrams and the like.
   4. Installation and mounting details.
   5. Batteries arrangement and mounting details.

C. Point-wise compliance statement to the specifications, duly signed by the manufacturer /manufacturer's authorized representative and the contractor.

D. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Test Certificates: Submit type test and routine test certificates. System shall undergo a functional and load test program approved by the Engineer, and shall undergo a minimum 8 hours 'burn-in test, under site simulated conditions, prior to shipment.

G. G. Field Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

1.2 Quality Assurance

A. Manufacturer's Certification: The manufacturer shall be specialized in manufacturing of on line, double conversion three phase UPS modules specified in this document with a minimum of twenty years documented worldwide experience and shall have a nationwide first party service organization. The manufacturer shall be ISO 9001 certified and shall design to internationally accepted standard.

B. Factory Testing: Prior to shipment the manufacturer shall complete a documented test procedure to test all functions of the UPS modules and batteries (via a discharge test), when supplied by the UPS manufacturer and guarantee compliance with the specification. The manufacturer shall provide a copy of the test report upon request. Tests shall comply to IEC 62040-3 and include but not necessarily limited to the following:
    1. Light load test.
    2. AC input failure test.
    3. AC input return test.
    4. Transfer test.
    5. Full load test.
    6. UPS efficiency test.
    7. Unbalanced load test.
    8. Balanced load test.
    9. Short-circuit test.
    10. Harmonic components test.

C. Materials and Assemblies: All materials and parts comprising the UPS shall be new, of current manufacture, and have not been in prior service, except as required during factory testing. All active electronic devices shall be solid state and not exceed the manufacturer's recommended specified tolerances for temperature or current to ensure maximum reliability. All semiconductor devices shall be sealed. All relays shall be provided with dust covers. The manufacturer shall conduct inspection on incoming parts, modular assemblies, and final products.

D. Installer Qualifications: Experienced installer who is an authorized representative of UPS manufacturer for both installation and maintenance of units required for this Project.

E. Local Representative: Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy Engineer may disqualify a manufacturer.

F. Standards: Installation shall comply with the following standards:

    1. IEC 62040-1, 2&3 "Uninterruptible Power Systems".
    2. IEC 61000-3-4 "Electromagnetic compatibility (EMC) - Part 3-4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A".
    3. IEC 61000-4 "Electromagnetic compatibility (EMC) – Testing and Measurement Techniques".
    4. IEEE 485 "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications".
    5. IEC 62310 "Static Transfer Systems".
    6. IEC 61000-3-2 "Electromagnetic compatibility (EMC) - Part 3-4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A".

7. IEC 61000-3-3 "Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current 16 A per phase and not subject to conditional connection".
8. IEC 61000-6-2 "Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments".
9. IEC 61000-6-3 "Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments".
10. Materials and components shall be manufacturer's latest design, and Standards used shall be approved prior to manufacture.

1.3 Delivery, Storage, and Handling

A. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment shall be placed.

B. Prior to shipping all products shall be inspected at the factory for damage.

C. Store equipment in air-conditioned spaces with environments controlled within manufacturers' ambient temperature and humidity tolerances for non-operating equipment.

D. Equipment containing batteries shall not be stored for a period exceeding 3 months without powering up the equipment for a period of 8 hours to recharge the batteries. Relevant Certificate for the batteries production date shall be submitted to the engineer.

1.4 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period, Warranty Period: 5 years from date of Issuing Taking Over certificate.

B. Battery: The battery manufacturer's warranty shall be passed through to the final customer and shall have a minimum period of five years.

1.5 Extra Materials

A. Spare Parts: Provide and deliver to client stores manufacturer's recommended spare parts for one year operation of UPS system. Spare parts shall include as a minimum complete set of fuses for all types and ratings along with cooling fans.

Part 2 PRODUCTS

2.1 Description

A. System: UPS system shall be online, continuous duty, double conversion, and class VFI-SS-111 to IEC 62040-3.

B. System shall be of the programmable type, microprocessor based with CPU and memory capabilities for storage of alarms, faults, status change, etc. The UPS shall permit setting parameters for the environment and type of usage to be specified by the Engineer. UPS shall be of the self-diagnostic type, equipped with a self-test function to verify correct system operation. The self-test shall identify the parts of the UPS requiring repair in case of a fault.

C. General: System shall be interposed between normal AC power supply and critical load, to secure a minimum period of continuity of no-break battery back-up for the time shown on Drawings in case of failure of normal AC supply and maintain output voltage, frequency and phase deviation within specified tolerances.

D. UPS shall be maintained (continuously supplying load through the inverter), with automatic no-break transfer to or retransfer from alternate source (bypass) in case of failure or overload on rectifier- battery-inverter system. System shall employ decentralized bypass technique so that each UPS unit shall be provided with its own static bypass transfer switch. Each UPS unit shall be provided with its own master controller. Master and slave configuration is not acceptable.

E. Normal AC power supply will be available from one protected source fed from either normal AC network or from AC Characteristics of output of generator set (when provided) and UPS system shall be coordinated for best results. Study and advice on special requirements of generator characteristic output and stability.

F. Separate filters shall be provided for each rectifier/charger unit separately to limit the THD to less than 7% this applies for all load currents from 25 to 100% of full load.

G. System overall efficiency shall not be less than 92 % at full load and 90 % at half load

H. Noise level of complete assembly shall not exceed 65 dB (A).

2.2 System Operation

A. A. Under normal conditions inverter(s) shall be synchronized and phase locked to normal AC supply. Upon loss of normal AC supply, battery shall continue supply of no-break power to inverters, which then free-run on self- generated UPS frequency reference. Upon restoration of normal AC supply, inverters shall re-synchronize to AC line, gradually (at slew rate), if frequency and voltage deviation of normal AC supply is within preset limits specified.

B. Automatic Transfer To Bypass: Static transfer switch shall automatically transfer critical (100%) load from inverter to by-pass source (which is normal AC supply) if:

1. Inverter output voltage characteristics fall outside specified limits.
2. Critical load exceeds overload rating of UPS.
3. Over-temperature is sensed.

4. Manual (push button) command is given.
5. Transfer to by-pass mode shall be inhibited, and an alarm initiated if voltage, frequency and/or phase shift of by- pass power is outside acceptable tolerances.

C. Re-Transfer To Inverter: Re-transfer of critical load from auto by-pass source to inverter (UPS mode) is only to be possible under the following conditions:
   1. Inverter output voltage characteristics return to within specified tolerances.
   2. Original load current reduces to within rated full load capacity of UPS.
   3. Re-transfer selector switch is in automatic position.

D. Normal Power Restored: When normal power is restored following an outage, rectifier/charger shall initially draw no power except for transformer in-rush current and shall gradually continue providing power to the inverter and recharging the battery. After approximately 15 seconds (waking time), input power requirements shall rise to power level to drive critical load and recharge battery.

E. Automatic Restart: When normal power is restored to normal conditions following an outage and after a complete battery discharge, the UPS shall automatically restart and resume supplying power to the connected load via the inverter.

F. Provide maintenance disconnecting switch fully rated to carry the full load input current of the UPS.

2.3 System Characteristics

A. Rectifier/Charger Input:
   1. Nominal Input Voltage: 400V, three phase, 4 wire, 50Hz.
   2. Voltage input variation: +10%, -15% from nominal.
   3. Frequency: +/-5% from nominal.
   4. Transformer Exciting Current In Rush: Less than 600 % nominal current.
   5. Power Factor: minimum 0.9 lagging at full load and nominal input voltage.
   6. Total Feedback Current Harmonics: Maximum 8%
   7. Current Limiting: 115% max. Of that required to operate inverters and charge battery at full rated load, adjustment possible between 100% and 125%.
   8. Walk-in Current in Rush: 25% to 100% FLC in 15 seconds.

B. Rectifier/Charger Output:
   1. Float and Equalize Operation: Adjustable, automatic, compatible with battery.
   2. Regulation: +/-1% max. From 0-100% load.
   3. Ripple: +/-2% rms. (0 to 100% resistive load).

C. Static Inverters:
   1. Nominal net system power output rating in kVA: as shown on drawings with load power factor 0.8 lag.

2. Nominal output voltage: 400 V, three phase, 4 wire, 50 Hz, adjustable +/- 5% of nominal.
3. Output voltage regulation:
    i. Balanced load: +/-2% (0 - 100% load)
    ii. Unbalanced load (3-phase output only): +/-3% (at each 10% of load)
4. Phase Displacement: 120 deg. (+/-3 deg.) at 100% load unbalance.
5. Output Voltage Waveform: 5% max. Total harmonic, 3% max. Single harmonic.
6. Frequency Stability: Normally synchronized to input line frequency over +/-2 adjustable ranges; free running at +/-0.5. Full battery voltage variation, load and p.f. range; slew rate shall not exceed 0.1 Hz/sec.
7. Dynamic Output Voltage Tolerance Sudden Full Load Removal: +10,-8% max. recovering application or to within 1% in less than 40] milliseconds.
8. Over-load Rating: 125% for 10 minutes, 150% for 60 seconds, 1000% for 5 cycles, 105% continuous.
9. Load crest factor without derating (Ipk/Irms): 3:1

D. Automatic Static Bypass Transfer Switch:
    1. Transfer Time: 150 microsecond (overlapping) maximum.
    2. Total Sensing and Transfer/Retransfer Time: 2 milliseconds, maximum.
    3. Retransfer Mode: automatic/inhibit (selectable).
    4. Retransfer Delay: 2 - 32 secs. in auto mode (selectable).
    5. Transfer Point: +/-10% of nominal output voltage (adjustable).
    6. Retransfer Point: +/-5% of nominal output voltage (adjustable).
    7. Transfer Inhibit Point: +/-20% of nominal output voltage (adjustable).
    8. Bypass circuit shall be provided with backfeed protection to IEC 62040-1 through internal backfeed contactor to prevent feedback to the mains from the inverter in case of mains failure and a fault in bypass circuit.

2.4 Components and Accessories

A. Materials and Parts: Electronic devices shall be solid state, hermetically sealed. Indicator lights shall be twin LED type, those denoting blown fuse conditions shall be seen by operator without removing panels or opening cabinet doors. Power connections and remote alarm and control wiring shall be accessible at terminal boards. Power semi- conductors shall be fused. Metal surfaces including copper and aluminum heat sinks and busbars shall be treated with permanent protective coating. Electro-mechanical power devices and relays shall be vacuum impregnated, insulated for maximum operating voltage conditions, and enclosed in dust-tight enclosures. Cables shall be fire resistant high temperature grade.

B. Housing: Equipment shall be housed in a free-standing, well ventilated, totally enclosed modular assembly with front accessible lockable doors, giving easy access for maintenance, inspection and adjustments, and with provisions for handling and lifting during and after installation. Enclosures shall be suitable for industrial, tropical environments, protection IP 21 to IEC 60529, of galvanized sheet steel construction treated against corrosion and with light grey RAL7032 baked paint or epoxy finish to approved standard.

C. Ventilation: an integral, forced-air, cooling system shall be provided in each UPS module to remove dissipated heat efficiently, and ensure components operate

within environmental ratings. Air shall enter bottom of cabinet through replaceable filters, and exhaust through the top. At least two fans shall be provided for ventilating each enclosure. No degradation of performance shall occur in the event of a single fan failure. Temperature sensors, mounted on semi-conductor heat sinks, shall initiate alarm if maximum working temperature is exceeded.

D. Automatic static by bass transfer switch shall be continuously rated at full load (100% FL), hybrid type (make-before-break), solid state transfer device with logic thyristor assembly isolatable or completely removable for maintenance. When signal to close switch is initiated, thyristors shall instantaneously conduct power to prevent deviations and breaks in load voltage outside specified tolerances.

E. Maintenance By-Pass Switching: Manual (make-before- break) by-pass switch shall allow load to be transferred to by-pass source without interruption of output, and provide isolation of UPS and static switch during maintenance. Test position shall permit testing of static switch while load is being fed from bypass power circuit. Transfer inhibited warning circuit shall be provided to give an alarm indication in case by-pass supply is beyond acceptable tolerances.

F. Protection: UPS modules shall have built-in or inherent electronic current-limiting protection against permanent self-damage effective down to short-circuits. Fast acting, current limiting devices shall protect against failure of any solid state component. Internal failure in any UPS module shall cause immediate isolation from input and output by operation of static interrupters or causing shut down of faulty module. Protection shall be provided against, but is not limited to, the following:
    1. Input over and under voltage and power line surges
    2. Output over voltage and voltage surges
    3. Sudden abnormal changes in output load conditions
    4. Short-circuits at output terminals
    5. Inverter and rectifier overcurrent
    6. Auxiliary Control Circuit Overcurrent.

G. Battery: High-rate discharge, heavy duty, industrial, high impact resistant, clear plastic encased, sealed lead- acid (gas recombination) type cells with automatically re-closing explosion proof safety vents. Electrolyte specific gravity shall not exceed 1.25 when fully charged at 25 deg. C. Ampere-hour rating shall be sufficient for emergency period specified with all inverters operating at full rated output, to a discharge limit of not less than 1.75 V per cell. Cells shall be normally maintained at 2.25 V per cell. Guaranteed life shall not be less than 10 years, with a capacity drop down to not less than 80% under normal expected service.

H. The battery cells age, at the time of delivery into site, shall be less than three months.

I. Battery calculations according to IEEE 485 shall be carried out by UPS supplier and submitted for approval, based on the following, and it shall be for minimum of 30 minutes back up time:

    1. Nominal active power factor of not less than 0.8 Lag.

2. Temperature factor for operation at 25 Deg C.
3. Aging factor of 1.25.
4. Design margin factor of 1.15.
5. Recharge time up to 90% of its capacity within 10 to 12 hours.

J. Input active harmonic filter shall be provided to limit input current harmonic distortion to less than 7% THD at all load currents from 0 to 100% of full load and improve power factor to not less than 0.9. The input filter shall be mounted inside the UPS cabinet or in a separate enclosure.

Part 3 EXECUTION

3.1 Installation

A. Tools: Use only tools recommended by equipment manufacturers for installations, particularly in making connections and adjustments.

B. Supervision: Carry out equipment installation under the direct supervision of a qualified technician, licensed by and trained at the factory. Final adjustments and putting into satisfactory operation shall be made by a specialist delegated by the factory.

3.2 Grounding

A. Provide direct interference free grounding circuit.

3.3 Identification

A. Identify components and wiring according to Division 16 Section 16100 - Common Work Results for Electrical

3.4 Battery Equalization

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.5 Field Quality Control

A. Electrical Tests and Inspections: Perform tests and inspections according to manufacturer's written instructions and as listed below to demonstrate condition and performance of each component of the UPS:
    1. Inspect interiors of enclosures, including the following:
        i. Integrity of mechanical and electrical connections.
        ii. Component type and labeling verification.
        iii. Ratings of installed components.
    2. Test manual and automatic operational features and system protective and alarm functions.
    3. Test communication of status and alarms to remote monitoring equipment.

B. Power Supply Output Disturbance: Provide microprocessor based instrument, and monitor and record power supply output disturbance of voltage and frequency. Instrument details shall be submitted for approval.

C. Test Periods shall be prolonged (over 24 hours) and as requested by Engineer, to verify and obtain realistic voltage and frequency profile under any loading and switching conditions within the criteria specified.

D. Data logging shall include high and low average voltage, sags and surges, spikes and spike bursts, drop-outs, high and low frequencies etc. with print-out and

storage on cassette tape for subsequent re-entry into instrument's memory for display or print-out.

E. Tests shall include loads at various power factors from low-load to overload condition, and measurements of temperature, heat losses, output voltage, wave shape, and harmonic content and frequency stability.

F. Retest: Correct deficiencies and retest until specified requirements are met.

G. 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.

END OF SECTION 16450

SECTION 16510

INTERIOR LIGHTING

Part 1 GENERAL

1.1 Submittals

A. Equipment Data: Submit data for approval including, but not limited to, the following:

1. Detailed literature on each fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles
2. Details of changes to standard fixtures for adaptation to condition of installation and to the Specification
3. Photometric data for lighting calculations including polar light distribution curves, coefficient of utilization, glare classification, efficiency, depreciation factors etc.
4. Dimensions of fixtures.
5. Certified results of independent laboratory tests for fixtures and lamps for electrical ratings and photometric data.
6. Certified results of laboratory tests for fixtures and lamps for photometric performance.
7. Emergency lighting unit battery and charger.
8. LEDs control gears.
9. Energy-efficiency data.
10. Life, output (lumens, Color temperature, and CRI) and energy efficiency data for lamps.
11. Air and Thermal Performance Data: For air-handling fixtures.
12. Sound Performance Data: For air-handling fixtures. Indicate sound power level and sound transmission class.
13. Types of lamps.

B. Shop and Construction Drawings: Submit Drawings for approval including, but not limited to, the following:

1. Exact position of each fixture on reflected ceiling plans, with indication of ceiling features, structural members, ducts, pipes and other fittings, as applicable and pertinent to the installation.
2. Installation details including suspension and mounting provisions.
3. Purpose made fixtures or lighting assemblies with full details.
4. Wiring details, circuit and panel board references, special lighting control arrangements etc.
5. Show details of nonstandard or custom fixtures. Include plans, elevations, sections, details and attachments to other work. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, features, location and size of each field connection and accessories. Detail wiring for power, signal and control wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.

C. Samples: Submit fully equipped sample of each fixture type, modified if required, together with color and texture samples of each fixture.

D. Installation instructions.

E. Coordination Drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items, and other components in the vicinity.

F. Include work of all trades that shall be installed near lighting equipment.

G. Product Certificates: Signed by manufacturers of lighting fixtures certifying that products comply with requirements.

H. Dimming Ballast Compatibility Certificates: Signed by manufacturer of ballast certifying that ballasts are compatible with dimming systems and equipment with which they are used.

I. Addressable Ballast Compatibility Certificates: Signed by manufacturer of ballast certifying that ballasts are compatible with the central battery systems and equipment with which they are used.

1.2 Quality Assurance

A. Fixture Design and Standards: The Specification and the Drawings are a guide to the selection of lighting characteristics and lighting fixtures, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, fixtures shall be manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the Schedule of Lighting Fixtures and complying with IEC 60598 and BS EN 55015.

B. Mockups: Provide lighting fixtures for in operation were required by the engineer

1.3 Coordination

A. Design Layout: Fixture layout has been determined from photometric data of specified fixtures to achieve desired level and uniformity of illumination. Reflected ceiling plans shall be checked to ensure exact positions of fixtures with respect to structural members, ducts, pipes, other installations and ceiling panels/tiles, where required. Certain fixtures are shown in provisional positions, pending preparation of final equipment layout drawings. Such fixtures shall be located in coordination with final equipment layout so that illumination is as intended by the design.
B. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

1.4 Extra Materials

A. Spare Parts: Provide extra fixtures and drivers up to 4% (or nearest whole unit with minimum four for each type).

1.5 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

B. Warranty Period: 5 year from date of Issuing Taking Over certificate

Part 2 PRODUCTS

2.1 LED Fixtures

A. Fixtures shall be as per the selections made in the lighting schedules with applying the following points.

B. Light emitting diode shall be a solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current. It shall be part of the LED module which is supplied as a light source. Output color consistency shall be guaranteed and have a Color Rendering Index (CRI) greater than 90. LEDs shall have an efficacy of 100 lumens per watt as a minimum. Guaranteed rated life shall be above 50000 hours.

C. Housing shall incorporate an adequate heat sink which ensures the overall fittings and the LEDs are kept relatively cool,

D. Electronic control gear for LED modules: high efficiency, high power factor, suitable for operation at the ambient conditions specified for the project. Control gear shall have constant output current or constant output voltage over the whole wattage range independent of mains supply fluctuations as shown on drawings and sufficient for operating the number and wattage of LEDs connected. Guaranteed rated life of the control gear shall be above 50000 hours.

E. Control gear shall have electrical insulation between primary and secondary sides. Secondary cables from the control gear to LED modules shall be provided by the LED supplier. Maximum length between control gear and LED module shall be as per manufacturer's recommendations.

F. LED control gear shall be protected against electric shock, accidental contact with live parts, short circuit, overload and shall be earthed (protection class I).

G. Dimmable control gear, where required, shall be compatible with the dimming system used.

H. Control gears shall be compatible with the lighting control system used such as; 1-10V, DALI, DMX, etc...

I. Control gear shall comply with IEC 61347-1, IEC 61347-2-13 and IEC 62384 and shall meet the limits of main harmonic content as defined in IEC 61000-3-2 and comply with radio interference suppression limits defined in BS EN 55015 and immunity requirements of IEC 61547.

Part 3 EXECUTION

3.1 Installation

A. Generally: Install fixtures level, aligned and parallel or square to building lines and at uniform heights as shown on the Drawings or as approved by Engineer. Make final height adjustment after installation.

B. Fixture Support: Provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. and method of fastening for approval. Rigidly secure fixtures mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.

C. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

D. Stem Hangers: Provide two stem hangers for individually mounted pendant fixtures. Stems shall have suspension aligners and shall be of suitable length for suspending fixtures at required height.

E. Suspended Ceilings: If ceiling construction is unable to support weight of fixtures without strain or deformation, suspend fixtures directly from building structure.

F. Solid Ceilings: Coordinate dimensions of recesses in ceilings with exact fixture dimensions and structural elements.

G. Continuous Rows: Arrange fixtures so that individual fixture can be removed without dismantling remaining fixtures. Provide minimum spacing between fixtures.

H. Cover Plates: Install cover plates over fixture outlet box or opening in ceiling or structure when left unused.

I. Flush Recessed Fixtures: Install to completely eliminate light leakage within fixture and between fixture and adjacent finished surface.

J. J. Ventilation: Keep ventilation channels free after fixture is installed, if required by the design of the fixture. Ensure that the final circuit connection is adequately protected against heat transfer from fixtures.

K. Tightness: Ensure that enclosed fixtures are reasonably insect/dust tight when installed, and completely weather- proof for installations subject to weather conditions. Installation of fitting and termination of circuit wiring should not invalidate the ingress protection rating.

L. Lamps for Permanent Installation: Place new lamps in fixtures immediately prior to hand-over and when instructed by Engineer. Lamps used for temporary service shall not be used for final lamping of fixtures.

M. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.

END OF SECTION 16510

SECTION 16520

EXTERIOR LIGHTING

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SECTION 16520

EXTERIOR LIGHTING

Part 1 GENERAL

1.1 Submittals

A. Equipment Data: Submit data for approval including, but not limited to, the following:

1. Detailed literature, in English, for each type of luminaire or fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles, and any modification to a standard product if applicable
2. Detailed specification and drawings for each column type including shape, base/mounting flanges, bolts, nuts etc, cross-sections, design criteria and calculations, brackets, finishes, provisions for cabling, cut-out or circuit-breaker etc.
3. Photometric data for lighting calculations including polar curves, coefficients of utilization, efficiency and depreciation factors.
4. Materials and dimensions of luminaires and poles.
5. Certified results of laboratory tests for fixtures and lamps for electrical ratings and photometric data.
6. Certified results of laboratory tests for fixtures and lamps for photometric performance.

B. Shop and Construction Drawings: Submit Drawings for approval including, but not limited to, the following:

1. Layout of equipment in exact positions with mounting and construction details, concrete foundation dimensions and reinforcement, routing and sections of duct-banks and trenches, backfill and packing material, earthing rods etc.
2. Cabling and wiring diagrams, single line drawings, loads, phase distribution, protection and control, earthing and the like.
3. Calculations of illumination and glare levels, based on CIE methods.

C. Samples: Submit fully equipped sample of each fixture type, modified if required, together with color and texture samples of each fixture.

D. Installation instructions.

E. Coordination Drawings: Include work of all trades that shall be installed near lighting equipment.

F. Product Certificates: Signed by manufacturers of lighting fixtures certifying that products comply with requirements.

G. Dimming driver Compatibility Certificates: Signed by manufacturer of driver certifying that drivers are compatible with dimming systems and equipment with which they are used.

1.2 Quality Assurance

A. Fixture Design and Standards: The Specification and the Drawings are a guide to the selection of lighting characteristics and lighting fixtures, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, fixtures shall be manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the Schedule of Lighting Fixtures and complying with IEC 60598 and BS EN 55015.

B. Mockups: Provide lighting fixtures for in operation were required by the engineer

1.3 Extra Materials

A. Spare Parts: Provide extra fixtures and drivers up to 5% (or nearest whole unit with minimum four for each type).

1.4 Warranty

A. Manufacturer’s Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

B. Warranty Period: 5 year from date of substantial completion

Part 2 PRODUCTS

2.1 LED Fixtures

A. Fixtures shall be as per the selections made in the lighting schedules with applying the following points.

B. Light emitting diode shall be a solid-state device embodying a p-n junction, emitting optical radiation when excited by an electric current. It shall be part of the LED module which is supplied as a light source. Output color consistency shall be guaranteed and have a Color Rendering Index (CRI) greater than 90. LEDs shall have an efficacy of 100 lumens per watt as a minimum. Guaranteed rated life shall be above 50000 hours.

C. Housing shall incorporate an adequate heat sink which ensures the overall fittings and the LEDs are kept relatively cool,

D. The fixture shall be made with corrosion free materials,

E. All fixtures shall be provided with water proof connector IP-68, the connector shall be with number of inputs suitable to the approved wiring diagrams in the approved workshop drawings.

F. Electronic control gear for LED modules: high efficiency, high power factor, suitable for operation at the ambient conditions specified for the project. Control gear shall have constant output current or constant output voltage over the whole wattage range independent of mains supply fluctuations as shown on drawings and sufficient for operating the number and wattage of LEDs connected. Guaranteed rated life of the control gear shall be above 50000 hours.

G. Control gear shall have electrical insulation between primary and secondary sides. Secondary cables from the control gear to LED modules shall be provided by the LED supplier. Maximum length between control gear and LED module shall be as per manufacturer's recommendations.

H. LED control gear shall be protected against electric shock, accidental contact with live parts, short circuit, overload and shall be earthed (protection class I).

I. Dimmable control gear, where required, shall be compatible with the dimming system used. Control gears shall be compatible with the lighting control system used such as; 1-10V, DALI, DMX, etc...

J. Control gear shall comply with IEC 61347-1, IEC 61347-2-13 and IEC 62384 and shall meet the limits of main harmonic content as defined in IEC 61000-3-2 and comply with radio interference suppression limits defined in BS EN 55015 and immunity requirements of IEC 61547.

Part 3 EXECUTION

3.1 Installation

A. Install equipment to be readily accessible for operation, maintenance and repair.

B. Generally: Install fixtures level, aligned and parallel or square to building lines and at uniform heights as shown on the Drawings or as approved by Engineer. Make final height adjustment after installation.

C. Fixture Support: Provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. and method of fastening for approval. Rigidly secure fixtures mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.

D. Remote Mounting of Drivers: Distance between the driver and fixture shall not exceed that recommended by ballast manufacturer. Verify, with driver manufacturers, maximum distance between driver and luminaire.

E. Visual inspection is to include inspection of condition of each piece of equipment, quality of workmanship, alignment, perpendicularity, labeling and the like, all in conformance with the Specification.

F. Insulation resistance and continuity tests are to be carried out on each circuit and piece of equipment before energization, with circuit breakers in the open position and lamps not installed.

G. Operational tests are to be carried out on all circuit breakers and control gear, with lamps installed, including recording voltage at terminals of drivers of each circuit and at distribution panel or the like.

H. Performance tests are to be carried out after 100 hours normal operation, and are to include measurement of lighting and uniformity levels on required illuminated surfaces.

I. Other tests are to be carried out as required by the Engineer to verify conformity with the Specification.

J. Results of tests are to be recorded on site and signed by witnessing parties.

K. Provide instruments to make and record test results.

L. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:

1. Measure light intensities at night if specific illumination performance is indicated. Use calibrated photometers.
2. Check intensity and uniformity of illumination.
3. Check excessively noisy ballasts.

M. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.

N. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

O. For the applications with installation of uplighters in tiling/concrete areas, the water proof connector, shall be in adequate size to enter the up lighter cut hole.

END OF SECTION 16520

SECTION 16620

STRUCTURED CABLING

Part 1 GENERAL

1.1 Description

A. Local Authority Coordination: The Contractor shall coordinate with relevant service provider on their requirement for service entrance and entrance facilities. The provision of this requirement shall be facilitated by the Contractor in coordination with all relevant parties.

1.2 Submittals

A. Material submittals shall include for relevant catalogue cut sheets in color with options & part numbers / model number highlighted for each item, system philosophy, specification and regulation compliance and a schedule highlight location details. Relevant sample board and samples shall be submitted for approval.

B. The Material submittals by the Contractor shall include the following as a minimum:
   1. Detailed and comprehensive specification and regulation compliance schedule
   2. Schedule of material / equipment stating the Country of Origin.
   3. Relevant catalogue cut sheets in color with options & part numbers / model number highlighted for each item.
   4. Draft copy of the manufacturer's warranty.
   5. Relevant sample boards and individual samples as required shall be submitted for approval.

1.3 Labelling:

A. The Contractor shall submit a labelling and documentation strategy for Engineer approval. All labelling and identification shall suit the application and area being used and shall be to Engineer's approval. All equipment individual components, racks and cables shall be well identified with appropriate labelling and segregated in different colors for easy identification.

1.4 Shop Drawings:

A. Detailed layout drawings of IDF rooms and Server room/s. Scale 1:20 showing services required by others and provided to others. The drawings should include details of containment required, power supplies (wattage and outlet type) required, heat dissipation from equipment, ambient conditions required, etc. These drawings shall be signed & stamped by the respective service contractors as well as the Contractor.

B. Detailed rack elevation drawings of IDF rooms and Server room/s showing all the active & passive equipment being installed inside each rack. These drawings shall include power calculations per rack, heat dissipation per rack and any other relevant information that may be required or requested.

C. Detailed IT/ELV layouts Scale 1:50/1:100.
D. Schematic drawings of all systems showing connectivity details, integration, system topology and system components.
E. Relevant & detailed port / point schedules showing location and model as required by the Consultant.
F. Detailed elevations of all IT/ELV outlets & equipment / devices on wall (internal & external), ceiling (in-ceiling and ceiling fix), floor mounted, joinery, etc.

1.5 As-Built Drawings:

A. The Contractor shall provide the 'As-Built' drawings in advance of completion of the Works and as a condition precedent to the certification by the Consultant that the Works are complete. These 'As-Built' drawings shall reflect the works as installed

1.6 Test Plan:

A. The Contractor shall submit a detailed & comprehensive test plan listing the following; which shall be submitted prior to intended test date.

1. List of all the test equipment which will be used
2. Certifications of all the test equipment which will be used
3. Procedures for inspection and testing
4. Checklist for the above procedures
5. Intended test date

1.7 Field Test Reports:

A. The Contractor shall submit field test reports approved and signed Design Engineer for approval.

1.8 Operation and Maintenance Manual:

A. The Contractor shall provide Operation and Maintenance (O&M) manuals separately for each commissioned system in the project and in compliance to the following requirements.
    1. The O&M manual shall contain (as a minimum)
        a. System Design and Operations - which shall include General Safety Instructions, Function and Design of System, System Description, Operational and Technical details, Typical Physical Connectivity, Operations of each function of the system, etc.
        b. Maintenance – which shall include maintenance related Safety Instructions & Safeguards, Hardware & Software details required for maintenance, General Preventive Maintenance, Checklist for Preventive Maintenance, Corrective Maintenance, Trouble Shooting, Recommended Spare Parts, etc.
        c. Configuration – which shall include System Start-Up Procedure, Integration (if any) with other systems, Step-by-Step Configuration

(including server configuration and client configuration) as applicable, etc.

d. Schedule of Equipment – which shall include the schedule of all items (materials & equipment) supplied under the Contract
e. Data Sheets – which shall include Data Sheets of all components used / installed in the system including mounting kits, etc.
f. Drawings – which shall include Detailed Schematic Drawings, Layout Drawings and General Arrangement / Shop Drawings with respective registers for each of them.
g. Appendix of all User Manuals
h. Test Results – which shall include all the test results
i. Commissioning Documents – which shall include all commissioning performance details and measurements

2. Planned Preventive Maintenance Schedules for all commissioned systems and their component parts shall be submitted to the Consultant for approval.

3. List of recommended spare parts (and full contact addresses of Suppliers) for the operation of the systems for a period of two (2) years after the defects liability period.

1.9 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

B. Warranty Period: 5 years from date of Issuing Taking Over certificate

Part 2 PRODUCTS

2.1 General

A. The design intent is to provide a complete permanent certified Structured Cabling System (SCS) for the entire development using the pathways (coordinated with MEP) for Voice, Data & Video communications. This will include cables, enclosures, cabinets, outlets, conduits, wire ways, pull wires, support structures, etc.

B. <u>Type of Cabling to be utilized is CAT 6A.</u>

C. The color of CAT6A cables for Security Systems shall be different from that of the other ELV systems for clear separation and identification.

D. The entire SCS system (including but not limited to Racks / Cabinets, PDUs, Patch Panels, etc.) shall be from one manufacturer and all components shall be to the approval of Consultant.

E. Lengths and colors of all patch / mounting cords at outlet / workstation level and at IDF / Core switch shall be to Client/Consultant's and Operator's approval. A tabulated schedule highlighting typical usage along with sample board shall be submitted for approval prior to procurement. The sample shall include for necessary connectors, labelling and end outlets.

2.2 Copper Cables and Related Accessories

A. Cabling, The CAT6A cable must be suitable to transmit the following:
   1. The complete CCTV network comprising of all CCTV Cameras and the CCTV head end systems.
   2. 10 Gigabit, Gigabit Ethernet / Fast Ethernet / Ethernet Data Transmission.
   3. Wired and Wireless Internet.
   4. IP telephony.
   5. The horizontal CAT6A cabling provides physical connectivity between the work area device and network equipment in the IDFs. The Horizontal Cabling system consists of cabling, modular jacks, outlet faceplates, patch cables and patch panels.
   6. The horizontal CAT6A cable jacket color for Security Systems shall be Orange
   7. The horizontal CAT6A cable jacket color for Non-Security Systems shall be Purple.
   8. The horizontal CAT6A cabling shall be an unshielded twisted pair (U/FTP), four pair, and RJ45 copper solution able to support Gigabit applications up to 90 meters. The Horizontal Cabling system shall meet the Category 6 performance requirements defined in ANSI/TIA/EIA-568-C.
   9. In addition, the Permanent Link (patch panel to outlet), for every installed CAT6A cable link, shall comply with the following:
      i. Not exceed 80m cable length
      ii. 3dB headroom on NEXT

iii. At the IDFs, the cables shall be bunched in groups and neatly routed throughout and into IDF / TR Racks and terminated onto angled RJ45 patch panels or Flat patch panels with angled jacks. The cabling shall be supported throughout and secured via Velcro-type cable ties.

10. The horizontal CAT6A cabling shall be terminated on modular jack angled termination panels (patch panels) with each cable wire pair having a maximum amount of untwist of less than 13mm. The patch panels shall be made up of modular RJ45 jacks, with each jack able to be replaced individually.
11. CAT6A Patch Panels shall be capable of housing no fewer than 24 connectors. Each CAT6A patch panel shall use 1U of cabinet space and be located above the Active Components within the same cabinet.
12. The termination of the CAT6A cables shall be in rack mountable CAT6A jacks. The CAT6A cabling shall be installed in strict conformity with minimum bending radii and maximum stress capacities, all as per manufacturer's recommendation and in compliance to relevant standards.
13. Horizontal cables from IDFs cabinet to RJ45 outlets including outlets for data, voice, wireless access points, TV, etc. shall be via CAT6A cables with the following performance specifications and shall be terminated on the 8 pin RJ45 modular jacks provided at each outlet.
14. Termination at each CAT6A outlet shall be as per EIA/TIA 568B standard.
15. Performance / Cable Characteristics:
    i. CAT6A, U/FTP, LSZH, 23 AWG 100-ohm 4 pair indoor cable
    ii. Minimum dynamic / installation bending radius: 45.0 mm
    iii. Minimum static/installed bending radius: 23.0mm
    iv. Ambient installation temperature: 0 to 50 deg C
    v. Operating temperature range: -20 to 60 deg C
    vi. The end-to-end CAT6A U/FTP system shall have a 4-connector channel certification from an independent third-party lab to ISO / IEC standards
    vii. Tested to 350 MHz on CAT6A & 500 MHZ for CAT6A
    viii. 3dB headroom on NEXT
    ix. Compliance to and exceeds requirement of ISO/IEC 11801; IEC 61156-5; EN 50288; EN 50173; TIA/EIA 568-D.2-1
    x. Supports 10Base-T Ethernet, 100Base-T Fast Ethernet; 1000Base-T Gigabit Ethernet, 10 Gigabit Ethernet; 155 MBit ATM; 622 MBit ATM; 1.2 GBit ATM; future Class E applications
    xi. Certified to IEC 60332-1 (Flame retardant)
    xii. Certified to IEC 60754-2 (Determination of Acidity)
    xiii. Certified to IEC 61034-2 (Determination of Smoke Density)
16. Each cable shall be tested for and certified as fully PASSED by the manufacturer for electrical performance and transmission characteristics in full compliance to the limits and other parameters set by ISO / IEC standards.
17. Deliver full end to end Class E solution
18. When configured in worst-case 100-meter 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
19. Cable sheath colour for Non-Security Systems: PURPLE
20. Cable sheath color for Security Systems: ORANGE

B. Jacks and Connectors:

1. Modular RJ45, non-keyed, terminated with 110-style Insulation Displacement Connectors (IDC); high impact metallic housing; suitable for and complying with same standard as specified horizontal cable; ISO, IEC, TIA & EN standards compliant.
2. All modular jacks shall have a minimum of 50 micro-inches of gold plating over a nickel base.
3. U/FTP modular jacks shall be RJ45 jacks having tool-less insulation displacement contacts for cable terminations, and integral stain relief on the sheath of the cable. The jacks must utilize the TIA/EIA T568B pin out connector scheme and be appropriately color coded. All modular jacks must meet a minimum of EIA/TIA CAT6A hardware specifications as detailed in the EIA/TIA standard.
4. Each modular jack to be equipped with integral/hinged dust cover. Alternatively the jack dust cover may be fitted on the outlet faceplate. All dust covers must be installed at both ends of the terminated cable
5. The modular RJ45 jacks shall be matching color to that of the faceplate / patch panel and have permanent labelling.
6. Blank port inserts shall be provided for any unused ports on the data faceplates.
7. Performance: 500 mating cycles.
8. Voice and Data Jacks: 8-position modular jack, color-coded for both T568A and T568B wiring configurations.
9. Jack Panel shall be Angular or, Modular & with Integral label holder. Flat jack panel with cable manager is acceptable for wall mounted racks. Flat Jack Panels with Angular Jacks can be used instead of Angular Panels.
10. Color to match associated accessories i.e., face plate and jack panel.

C. CAT6A Patch Cords / Mounting Cords:

1. Factory-fabricated 4-pair cable assemblies with 8-position modular connectors terminated at each end. Compliance to and exceeds requirement of ISO/IEC 11801; IEC 61156-5; EN 50288; EN 50173; TIA/EIA 568-C.2-1.
2. It will be the responsibility of the Contractor to supply and install all the required patching for the entire Structured Cabling System. The patching shall be in coordination with the other suppliers for port connectivity.
3. All patch cords shall be provided with insertion loss tests for individual cords.
4. Patch cords of appropriate length, subject to a minimum of 1m shall be provided for all CAT6A termination ends in the IDFs, Security Control Room & Server Rooms.
5. Mounting cords of appropriate length, subject to a minimum of 2m length shall be provided for all CAT6A wall outlet ends to connect various field devices like PCs, Printers, WAP (Wireless Access Points), IP Phones, cameras, etc.
6. Performance/Cable Characteristics:
    i. CAT6A, Unshielded Twisted Pair, LSZH, 23 AWG
    ii. 100 ohm screened 4 pair RJ 45 patch cord
    iii. With cable boots and tangle-free latches on RJ45 plugs

iv. Provide 10% of installed patch cords as attic stock
v. Ambient installation temperature: 0 to 50 deg C
vi. Tested for high speed multimedia transmission
vii. Tested to 350 MHz on CAT6A & 500 MHZ for CAT6A
viii. 3dB headroom on NEXT
ix. Deliver full end to end CAT6A performance
x. Rugged construction
xi. Provide self-latching high reliability RJ 45 (ISO 8877) 8 pin modular connectors, factory crimped
xii. Fully matched with other components for maximum and compatible performance
xiii. External strain relief
xiv. Compliance to and exceeds requirement of ISO/IEC 11801; IEC 61156-5; EN
xv. 50288; EN 50173; TIA/EIA 568-C.2-1
xvi. Supports 10Base-T Ethernet, 100Base-T Fast Ethernet; 1000Base-T Gigabit Ethernet, 10 Gigabit Ethernet; 155 MBit ATM; 622 MBit ATM; 1.2 GBit ATM; future Class E applications
xvii. Certified to IEC 60332-1 (Flame retardant)
xviii. Certified to IEC 60754-2 (Determination of Acidity)
xix. Certified to IEC 61034-2 (Determination of Smoke Density)
xx. Each cable shall be tested for and certified as fully passed by the manufacturer for electrical performance and transmission characteristics in full compliance to the limits and other parameters set by TIA CAT6A standards
xxi. When configured in worst-case 100 meter 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.

7. The patch cords / mounting cords shall have independent third-party certification to ISO / IEC standards.
8. Patch cords colours should be used to differentiate amongst various vendors/systems in all Patch Cabinets

D. Racks / Cabinets

1. IDF Rooms, Server Room, Security Control Room and other relevant rooms shall be provided with suitable and approved equipment racks / cabinets in the space provided.
2. The IDF locations shown on the schematic and layouts are tentative and is for reference purposes only. Contractor shall ensure to locate the IDF and relevant racks appropriately to comply with the maximum cable length of 85 meter to the furthest outlet.
3. All IT / ELV racks will be EIA/ECA-310 standard 19 inch (482.6 mm) wide and powder coated.
4. All IT / ELV racks in the project shall be covered under 25-years warranty by the manufacturer against rusting, peeling of paint / powder coating, etc.
5. All cage nuts and screws shall be from the same manufacturer as the racks / cabinets and the complete SCS system.
6. All riser cables including Fiber, CAT3, horizontal CAT6A cables will be terminated in the racks. All active components like switches, routers, firewalls, wireless access point controllers, AV / BGM head end, etc. shall be installed within racks subject to Consultant's approval. Exposed wiring will not be permitted.
7. Required quantity of racks shall be provided by the Contractor to house all components based on the outlet count and other required parameters at the IDF Rooms, Server Room/s, and AV Room/sand Security Control Room/s.
8. Rack in the Landing Room/s and the CCs shall be based on the latest guidelines of the lead Telecommunication Service Provider and shall also be approved by them. All materials installed shall be pre-approved by them. An approval copy shall be provided along with the material submittal.
9. 8. IDF locations and rack sizes are indicative. The Contractor shall ensure to include for appropriately sized racks and of enough quantities to cater to all active and passive Data / Voice outlets. Active switches, splitters, ONTs, cable organizers and cable patch panels shall also be included to suit the above requirement.
10. Racks as a minimum, shall be EIA standard 42U for the server room (800 x 1000) and 42U for IDF (800 x 800), IP 30 rated 19" quick mounting light weight anodized aluminum rack, black color on castor wheels. The racks shall be fully enclosed, lockable, ventilated and modular type. Rack design should allow for right or left swing. The racks and all accessories within (including PDUs, Fan Trays, etc.) shall be from the same manufacturer as the structured cabling system.
11. The front door of the rack shall be reinforced, perforated & split type. Whilst the rear door shall be perforated and split type. The front and rear door shall be installed with euro locks for safety.
12. All racks in the server room shall have unique locks / keys. i.e. no single key should be able to open multiple (more than one) racks.
13. Racks shall be accessible from front and rear side.
14. All components installed within the rack including inline rack UPS shall be rack mountable type and suitable for the purpose. Color of the rack / cabinet shall be black.

15. Racks shall be provided with required ventilation fan for heat dissipation. The Contractor shall submit details of fan selection based on the equipment heat dissipation for Client/Consultant/Operator's approval.
16. All racks in the IDF Rooms, Server Room/s and Security Control Room/s shall be provided with a minimum of 2 PDUs. Each PDU shall have 8, integrally mounted 13A red non-standard D-earth pin switched (double pole) socket outlets, each with a minimum 10A, 6kA protection MCB. Each device's power supply connection shall be from an independent socket outlet.
17. The racks shall be provided with 25mm² clean earth terminals. Provide earthing / grounding connection via minimum single core 25 sq.mm earth wire to the building clean earth bar.
18. Provide surge protection device to protect all the components in the rack.
19. The IT/ELV Contractor shall submit a rack elevation drawing clearly highlighting the components installed, connection details for each and every rack in the project. The drawing shall be supported by a schedule highlighting the RJ45 outlet count, backbone cabling details and other components.

E. Communications Outlets
    1. A. Outlet Boxes:
        i. Provide depth as required to accommodate cable manufacturer's recommended minimum conductor bend radius.
    2. Wall Plates:
        i. Comply with system design standards and UL 514C.
        ii. Accepts modular jacks/inserts.

    3. All keystone jacks used in wall outlets shall be of tool free type.
    4. Keystone jacks shall be of maximum 28.5 mm depth so that it will fit into the standard 32 mm back box.
    5. The keystone jacks shall have independent third-party certification to ISO / IEC standards.
    6. Wall Plate Material/Finish - Flush-Mounted Outlets
        i. A matching faceplate with a complete set of mounting screws for the outlets. All visible screws to match the finish of their faceplate. The color of the faceplates shall match the electrical power outlets. Painted surfaces shall be by electrostatic powder coating process.
        ii. Type of faceplate shall be as per the approved model of wiring accessory and as approved from the engineer/interior designer

Part 3 EXECUTION

3.1 Installation - General

A. Install pathways with the following minimum clearances:
    1. 1220 mm from motors, generators, frequency converters, transformers, x-ray equipment, and uninterruptible power systems.
    2. 300 mm from power conduits and cables and panel boards.
    3. 125 mm from high frequency lighting fixtures.
    4. 150 mm from hot water pipes, and steam pipes.
B. Other
    1. Use proprietary trays and accessories from a single manufacturer in the same application. The manufacturer shall have standard components for all parts of the cable tray installation including for bends, T-junctions, corners, risers, reducers.
    2. Installed to manufacturer's recommendations.
    3. Where routes are not specifically shown, locate the trays as approved.
    4. All sections of the cable tray installation shall be appropriately earthed.

3.2 Containment

A. Arrange conduit to provide no more than the equivalent of two 90 degree bend(s) between pull points.
B. Conduit Bends: Inside radius not less than 10 times conduit internal diameter.
C. Arrange conduit to provide no more than 100 feet (30 m) between pull points.
D. Do not use conduit bodies.
E. Conduits concealed or exposed in wall chases or embedded in floor slabs or installed in inaccessible locations shall be of PVC/GI type(as applicable for project), and are to be complete with a draw cords to enable the pulling in of cables.
F. Conduits shall interface with the underside of cable trays. Conduits shall be appropriately secured to the underside of the cable tray using either the conduit manufacturer or cable tray manufacturer's proprietary components.
G. Junction boxes shall be provided at each conduit bend or change in direction and at every 10m interval along straight runs (or greater as per BICSI standards).
H. Conduits and fittings are to comply with the following:
    1. Use inspection-type fittings only in accessible locations and where exposed to view;
    2. Provide straight long runs, smooth and free from rags, burrs and sharp edges;
    3. Install conduits in parallel runs with right angle changes of direction;
    4. Bends shall be made where possible with easy sweeps. Bends of 90 degrees shall be made with a radius of not less than three (3) times the external diameter of the conduit. Conduit shall not be installed under mechanical stress sufficient to cause deformation. The number of 90 degree bends between boxes in any single conduit shall be limited to no more than two (2).
    5. Solid elbows shall not be used.
    6. Inspection fittings shall not be cast into concrete or installed in rendered walls or other inaccessible locations.
    7. Conduits shall not be less than 25mm diameter.
    8. Draw cords installed with 1m of cord coiled at each end of the run;

9. Use polypropylene cord, or insulated stranded earth wire, 2.5mm2 minimum size;
10. Provide draw-in boxes at intervals not exceeding 30 m in straight runs, and at changes of level or direction;
11. Seal other ducts and conduits after cable installation.

I. Flexible Conduits:
   1. Flexible conduit may be used where sweep bends are required and for final connections. Flexible conduits shall only be used following approval.
   2. Flexible conduit shall not be used for straight runs or chased into walls.
   3. Fittings for use with flexible conduit shall be compatible with the conduit systems and shall be suitable for terminating onto rigid conduit where required.
   4. Allowance shall be made for any differences between the cable carrying capacities of rigid and flexible conduits. Install the next larger size of flexible conduit if necessary, to maintain the equivalent required cable capacity.

3.3 Outlet Boxes:

A. Coordinate locations of outlet boxes as required for installation of telecommunications outlets provided under this section.
B. Mounting Heights: as indicated on drawings and interior elevations
C. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
D. Provide minimum of 600 mm horizontal separation between flush mounted outlets boxes installed on opposite sides of fire rated walls.
E. Unless otherwise indicated, provide separate outlet boxes for line voltage and low voltage devices.
F. Locate outlet boxes so that wall plate does not span different building finishes.
G. Locate outlet boxes so that wall plate does not cross masonry joints.

3.4 Cabling

A. General:
   1. Do not over-cinch or crush cables.
   2. Do not exceed manufacturer's recommended cable pull tension.
   3. When installing in conduit, use only lubricants approved by cable manufacturer and do not chafe or damage outer jacket.
   4. Maximum cable pulling tension as defined by TIA/EIA shall be followed during installation.
   5. Install cables in a workmanlike manner parallel to walls, floors and ceilings, as applicable.
   6. Install cables in a manner to eliminate any possibility of strain on the cable itself or on cable terminations.
   7. Do not embed cables directly in plaster, concrete, mortar or other finishes.
   8. Install cables a safe distance from items liable to become hot.
   9. Bending radii are to be more than the maker's recommendation and in all cases not less than six times the overall cable diameter.
B. Cables on trays:
   1. Fix cables neatly to the tray, wherever possible, in a single layer and install parallel with the tray edge.

2. Install cables such that spare space capacity of not less than 40% of each tray is provided.
3. Install cables at fixed intervals not exceeding 1200mm by means of Velcro or hook-and-loop type fasteners.

3.5 Testing and Commissioning

A. Test must be done by Fluke device to achieve the following measures (minimum)
B. Test backbone cables after termination but before cross-connection.
C. Test backbone cables for DC loop resistance, shorts, opens, intermittent faults, and polarity between connectors and between conductors and shield, if cable has overall shield.
D. Test operation of shorting bars in connection blocks.
E. Category 6A: Perform near end cross talk (NEXT) and attenuation tests.
F. Category 6A: Perform tests for wire map, length, attenuation, NEXT, and propagation delay.
G. Measuring network capacity and POE detection.

3.6 Spare Parts / Attic Stock

A. The Contractor shall include for and provide 5% spares for all SCS components used.
B. The Contractor shall provide a list of recommended spare parts along with the full contact details including addresses of Suppliers; for the operation of the IT / ELV systems for two (2) years period from the end of defects liability period.

END OF SECTION 16620

SECTION 16770

VIDEO SURVEILLANCE

Part 1 GENERAL

1.1 Submittals

A. Material submittals shall include for relevant catalogue cut sheets in color with options & part numbers / model number highlighted for each item, system philosophy, specification and regulation compliance and a schedule highlight location details. Relevant sample board and samples shall be submitted for approval.

B. The Material submittals by the Contractor shall include the following as a minimum:
   1. System operation philosophies
   2. Detailed and comprehensive specification and regulation compliance schedule
   3. Procurement and certificate of conformity schedule
   4. Schedule of material / equipment stating the Country of Origin.
   5. Video storage capacity calculations
   6. Relevant catalogue cut sheets in color with options & part numbers / model number highlighted for each item.
   7. Draft copy of the manufacturer's warranty.
   8. Relevant sample boards and individual samples as required shall be submitted for approval.

1.2 Method Statements:

A. Method statements for installation including installation check list, quality reports and manufacturer's Installation Instructions indicating application conditions, limitations of use stipulated by product testing agency, instructions for storage, handling, protection, examination, preparation, installation, and operation of product.

B. Method statements for testing and commissioning including relevant reports and the equipment to be used. This shall include for both factory test activities/reports, on-site and off-site testing activities as well as the T&C minimum tests listed in this specification. The testing and commissioning components shall be to the requirements of the manufacturer, local regulations and relevant standards.

1.3 Labelling:

A. The contractor shall submit a labelling and documentation strategy for approval. All labelling and identification shall suit the application and area being used and shall be to Consultant's approval. All equipment individual components and cables shall be well identified with appropriate labelling and segregated in different colors for easy identification.

1.4 Shop Drawings:

A. Detailed layout drawings of Service room/s. Scale 1:20 showing services required by others and provided to others. The drawings should include details of containment required, power supplies (wattage and outlet type) required, heat dissipation from equipment, ambient conditions required, etc. These drawings Shall be signed & stamped by the respective service contractors as well as the Main/MEP Contractor.

B. Detailed IT/ELV layouts Scale 1:50/1:100.

C. Sectional elevations, typical installation details and rack console and equipment details. This shall be submitted both in AutoCAD and Visio format, in color.

D. Schematic drawings of all systems showing cabling details, integration, system topology, cabling details and system components.

E. Relevant & detailed equipment schedules showing location and type as required by the Consultant.

F. Details of typical benchmark installations for all equipment of systems showing wall elevations (internal & external), ceiling (in ceiling and ceiling fix), floor mounted, joinery, etc.

G. Detailed elevations of all IT/ELV outlets & equipment / devices on wall (internal & external), ceiling (in-ceiling and ceiling fix), floor mounted, joinery, etc.

1.5 As-Built Drawings:

A. The Contractor shall provide the 'As-Built' drawings in advance of completion of the Works and as a condition precedent to the certification by the Consultant that the Works are complete. These 'As-Built' drawings shall reflect the works as installed

1.6 Test Plan:

A. The Contractor shall submit a detailed & comprehensive test plan listing the following; which shall be submitted prior to intended test date.

1. List of all the test equipment which will be used
2. Certifications of all the test equipment which will be used
3. Procedures for inspection and testing
4. Checklist for the above procedures
5. Intended test date

1.7 Field Test Reports:

A. The Contractor shall submit field test reports approved and signed Design Engineer for approval.

1.8 Operation and Maintenance Manual:

A. The Contractor shall provide Operation and Maintenance (O&M) manuals separately for each commissioned IT / ELV system in the project and in compliance to the following requirements.

1. The O&M manual shall contain (as a minimum)
    a. System Design and Operations - which shall include General Safety Instructions, Function and Design of System, System Description, Operational and Technical details, Typical Physical Connectivity, Operations of each function of the system, etc.
    b. Maintenance – which shall include maintenance related Safety Instructions & Safeguards, Hardware & Software details required for maintenance, General Preventive Maintenance, Checklist for Preventive Maintenance, Corrective Maintenance, Trouble Shooting, Recommended Spare Parts, etc.
    c. Configuration – which shall include System Start-Up Procedure, Integration (if any) with other systems, Step-by-Step Configuration (including server configuration and client configuration) as applicable, etc.
    d. Schedule of Equipment – which shall include the schedule of all items (materials & equipment) supplied under the Contract
    e. Data Sheets – which shall include Data Sheets of all components used / installed in the system including mounting kits, etc.
    f. Drawings – which shall include Detailed Schematic Drawings, Layout Drawings and General Arrangement / Shop Drawings with respective registers for each of them.
    g. Appendix of all User Manuals
    h. Test Results – which shall include all the test results
    i. Commissioning Documents – which shall include all commissioning performance details and measurements

2. Planned Preventive Maintenance Schedules for all commissioned IT / ELV systems and their component parts shall be submitted to the Consultant for approval.
3. List of recommended spare parts (and full contact addresses of Suppliers) for the operation of the IT / ELV systems for a period of Five (5) years after the defects liability period.

1.9 Warranty

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

B. Warranty Period: 5 year from date of Issuing Taking Over certificate

Part 2 PRODUCTS

2.1 General

A. The entire work shall be carried out to the requirements and approval of Consultant/Client & relevant Authorities as applicable. The scope of works includes for the development of design, supply, installation, testing and commissioning of the entire CCTV Surveillance system. The scope also includes for obtaining the approval of shop drawings and installation (including testing and commissioning) from the Consultant, Client & as applicable.

B. The system shall consist but not limited to the following:
   1. Network Video Recorders
   2. Video storage/Bandwidth calculations shall be submitted for approval.
   3. Video surveillance monitors
   4. Equipment Racks and cable management
   5. IP CCTV Cameras, housings, lenses on POE connection
   6. Structured Cabling System (Passive)
   7. Active Data Network Equipment
   8. CCTV Rack and Rack Mounted UPS unit

C. The security video system shall be an IP network-based, fully distributed digital video system. The security video system shall have a dedicated local area network (LAN), as a transmission medium for video and POE to CCTV cameras.

2.2 Camera

A. 3 Megapixel Camera, 2.8-12mm Lens The IP Camera shall be supporting the following:
   1. P-Iris Motorized, varifocal lens with autofocus
   2. Features: Auto Gain Control, Day/Night, Motion Detection Tracking, On Screen Display Menu, ONVIF, Privacy Masking, Vandal Resistant, Weather Resistant, Wide Dynamic Range
   3. Camera Signal: Network IP
   4. Connection Type: Wired
   5. Infrared Distance: 0~60 Feet
   6. Resolution: 3 Megapixel
   7. Lens Type: Varifocal
   8. Lens Size: 2.8-12mm
   9. Mount Type: Ceiling, Wall
   10. Compression Method: IntelliZip, MJPEG, H.264, H.265
   11. Durability: Vandal Resistant, Weather Resistant
   12. Voltage: 24vAC, PoE
   13. Electronic Shutter: 1/4-1/10000
   14. Minimum Scene Illumination Color: 0.03 Lux, B/W: 0.001 Lux
   15. Operating Temperature: -40ºF to 122ºF (-40ºC to 50ºC)
   16. Power Consumption: 15W
   17. Privacy Zone: 9 Zones
   18. Protocols: TCP/IP, IPv4, IPv6, TCP, UDP, HTTP, FTP, DHCP, WS-Discovery, DNS, DDNS, RTP, RTCP, TLS, Unicast, Multicast, NTP, SMTP, WS-Security,

IEEE 802.1x, PEAP, SSH, HTTPS, SOAP, WS-Addressing, CIFS, SNMP, UPNP, RTSP, LLDP

19. Weatherproof IP44
20. Motion Detection Tracking: 3 Zones
21. IR Distance: 25m/82.02ft
22. Auto Gain Control
23. Day/Night
24. Motion Detection Tracking
25. On Screen Display Menu
26. Privacy Masking
27. Wide Dynamic Range
28. ONVIF

2.3 Network Video Recorder

A. The network video recorder shall be supporting the following:

1. Video Recording Throughput 40 Mbps1
2. Memory 4 GB
3. OS Drive 500GB 2.5" SATA
4. Network Interface 2 x GigE, 8 x PoE (802.3af)
5. Video Storage 2 TB
6. Power Supply 180W : 24V @ 7.5A Internal
7. Max BTU 630
8. Max Total Camera 8
9. VideoEdge Client Yes
10. Max # of Video Intelligence 1 channel
11. Monitor Interface 1 VGA
12. Chassis 1U
13. Included Accessories USB Mouse and Keyboard

2.4 Data Switch

- If not mentioned in the data network Bills of Quantities, POE data switches shall be provided with the NVR solution to connect all cameras.
- Be capable of providing Power over Ethernet (PoE) to all devices via each individual port connection.
- The switch shall support 24 RJ-45 10/100/1000 ports , UP link to be ready for 4 No. fiber optic connection (any type suitable for connection with the data network)
- The switch to be manageable type.
- The switch shall have the capacity to allow for future expansion of 20% minimum
- Power supply units shall be sized to suit the loads of each switch and its connected devices

Part 3 EXECUTION

3.1 Installation

A. Install products in accordance with manufacturer's instructions.

B. Cameras cables shall be installed with extra care to eliminate any expected damage due to short bending radius.

3.2 Field Quality Control

A. Prepare and start system in accordance with manufacturer's instructions.

B. Adjust cameras to provide desired field of view and produce suitable images under all service lighting conditions.

C. E. Program system parameters according to requirements of Owner.

D. Test for proper interface with other systems.

3.3 Testing and Commissioning

A. All system components shall only be tested in totally dust free and protected conditions and only after the approval of the installation works by the Client/Owner/Engineer

B. As a minimum the following testing and commissioning activities shall be carried out to the approval of the engineer.

1. Visual Inspection
2. Compliance on location and type of equipment
3. Circuit continuity and Insulation resistance test
4. Self-testing / Self Diagnostic testing
5. Functional testing
6. Manual and Automatic with simulation of all alarms

3.4 Cleaning

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION 16770