

SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 **SCOPE OF WORK**

Work under this section shall include the supply, installation, testing and delivery in perfect running conditions of the electrical installations for subject project.

These installations comprise, but are not limited to, the following chapters:

Main Distribution Boards (MDB)

Lighting Panels (LPs)

Motor & Power Panels (MSPs & PPs)

Complete electrical installations for all lighting, sockets, and power outlets

HVAC and mechanical power.

Lighting fixtures

Telephone system.

Data System

Fire Alarm System

Intrusion Alarm System

Closed Circuit Television System (CCTV)

Videophone System

Earthing System

Lightning protection system and surge arresters

Uninterruptable Power Supply (UPS)

The supply shall include all the equipment, accessories and other materials not enumerated in these specifications but found necessary for the completion and perfect functioning of the installations.

Work shall be executed in a first-class work-manlike manner in accordance with these specifications, the drawings and notes indicated therein, the instructions of the Engineer, the provisions of the Bill of Quantities delivered in place and tested to the full satisfaction of the Engineer.

1.02 CONCEPT OF DESIGN

The characteristics of the electric supply shall be as follows :

Low voltage network : 3 phase, 4 wire - 50Hz
 380V between phases.
 220V between phases
 and neutral with a solidly earthed neutral.

The necessary electric power for the needs of the project shall be supplied equipped by the local power authorities.

All embedded conduits in concrete or in floor paving screed shall be PVC conduits and all surface-mounted conduits shall be heavy duty rigid PVC conduit unless otherwise mentioned.

All junction, derivation and outlet boxes shall be bakelite type or rigid PVC material.

All outlet boxes for switches and sockets shall be bakelite type or rigid PVC material.

All feeders shall be on cable trays in the false ceiling or in the shaft.

All feeder and derivation light points shall also run in floor screed or above false ceiling or in ceiling skirting.

The loading of circuits shall be as shown on drawings with no contradiction to the local practice in Lebanon and in full compliance to the LIBNOR Codes & requirements.

Separate circuits shall be provided for : a) Lighting and socket outlets. b) Air conditioning unit or exhaust fan.

The lighting design shall have a cross-section of 2,5 mm² and a circuit breaker of (1 x 10 A + N) – Minimum wire size shall be 2.5 mm².

The convenience socket outlet and exhaust fan shall have a cross section of 4mm² and a circuit breaker (1 x 16 A + N) unless otherwise mentioned on drawings.

All work pertaining to the telephone system shall be in accordance with these specifications and shall meet all applicable rules and regulations of the local authorities.

The fire alarm system shall be as approved by local civil defense & LIBNOR regulations as laid out for connection with break glasses, optical smoke and heat detectors, manual stations, indoor and outdoors alarm bells and automatically operated fire alarm panel with repeater panel. Furthermore the connection with the fire fighting system shall be provided.

In case of an alarm, the alarm bells or horns of this building shall sound. At the same time, the alarm shall be indicated optically and acoustically on the operator's panel.

After the cause of alarm has been checked, a push button shall be operated for general alarm. The call to the fire brigade must be made by automatic phone dialer.

Earthing systems shall be TNS and in accordance with the requirements of the standards and codes mentioned in these specifications. The resistance of every earthing system shall be inferior to five (5) ohms.

Lightning protection system to be in according to the drawings, requirements of the standards and codes mentioned in these specifications. The system shall include One Early Streamer Emission air terminals, 2 flat down conductors, 2 earth pits, all in full compliance with NFC-17-102.

Surge arresters to be in according to the drawings and in full compliance with the relevant IEC codes. The system shall include a type 1&2 surge arresters at both sides of Mains and generator, and one type 2 surge arrester at each panel as shown on drawings. Low current surge arresters to be installed at all low current systems.

All the equipment shall be fit for continuous work in the heaviest conditions in Beirut.

1.03 GENERAL ELECTRICAL REQUIREMENTS

ACTUAL ROUTE OF CABLES AND CONDUITS

The location of conduits, cables, switchboards, cable trunking, etc ... is shown on the drawings approximately, therefore the actual route of cables and conduits may differ from the plans according to the details or the building construction and the conditions of execution of the installation.

The Contractor shall supply and install at his expense all secondary materials and special fittings found necessary to overcome the interference and to apply the modifications on the route of cables and conduits that are found necessary during the work to the complete satisfaction of the Engineer.

DRILLING AND CUTTING

The Contractor shall have to do all drillings and cutting of walls or other parts of the building for the complete proper installation of the conduits, cables, switchboards and other parts of equipment.

Beams, girders and other principal structural members shall not be cut or drilled unless permission has been granted by the Engineer.

If such drilling and cutting is made on finished surfaces, any marring of the surface shall be made good by repair or replacement at the Contractor's expense.

1.04 LOW VOLTAGE SYSTEM

GENERAL REQUIREMENTS

A. SCOPE OF WORK

Work described here under shall apply to the supply and installation of all materials and execution of all works necessary for the extra low voltage systems in the project, namely, telephone system, data system, fire & intrusion alarm systems, paging system, and CCTV system.

The supply shall include all the equipment, accessories and other materials not enumerated in these Specifications but necessary for the completion and perfect functioning of the systems. All to be executed in accordance with these Specifications, the drawings and notes indicated therein and the instructions of the Engineer, delivered complete in place and tested to the full satisfaction of the Engineer.

The Contractor shall coordinate the works of the extra low voltage system with the other installations to avoid any interference or damage to any of the systems or installations.

B. STUDIES TO BE PREPARED BY THE CONTRACTOR

These Specifications indicate the operation requirements of all the extra low voltage systems as well as the various types of materials to be used and their characteristics.

The Contractor shall prepare, according to the systems he is offering, all the wiring diagrams, the number and sizes of wires and cables necessary for the perfect functioning of each system.

Full selectivity, discrimination and coordination study shall be provided between consecutive breakers based on their characteristic curves.

These distribution circuits shall have enough capacity to fulfill the operation requirements under the heaviest load conditions.

No claim could be formulated by the Contractor under pretext of insufficiency of certain choices of Specifications indicated herein for the complete functioning of any of the systems required.

The above mentioned layouts and wiring diagrams shall be presented to the Engineer for approval prior to the ordering of the materials.

1.05 SUMMARY

A. This section specifies administrative and procedure requirements regarding electrical work. Additional requirements are specified in various sections of Division 16 and also may be required during the execution of work due to project conditions.

B. Requirements of this section shall include, but not be limited to, the following:

1. Submittals.
 2. Coordination drawings (shop drawings).
 3. Record documents (as built drawings).
 4. Maintenance manuals.
 5. Electrical installations.
 6. Cutting and patching.
 7. Temporary power and lighting.
- C. The requirements of this section do not supersede or take precedence over any provision of the General Conditions and Supplementary General Conditions, and should any discrepancy become apparent between these requirements and the General Conditions and Supplementary General Conditions, the Contractor shall notify the Engineer, in writing, and the Engineer shall interpret and decide such matters in accordance with the applicable provisions of the General Conditions and Supplementary General Conditions.

1.06 QUALITY ASSURANCE

- A. Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.
1. Locally manufactured products of foreign approved makes and of similar quality shall be approved by the Engineer. The Engineer shall be the sole judge to determine whether the product is of the same quality or not.
 2. Code Requirements:

Comply with the latest applicable standards of the following unless specified otherwise under each section:

 - The equipment, materials and installation shall satisfy the following:
 - The specifications and technical conditions described in the present book of specifications.
 - All electrical works shall be in accordance with LIBNOR Code while shall have precedence whenever available.
 - The General Specifications for Electrical Installations of the Local Authorities (based on IEC).
 - The recommendations of the "International Electro-Technical Commission (I.E.C.)".
 - Requirements of the client (FDC).

Tests after the completion of the installation shall satisfy the requirements of the standards mentioned above and as mentioned here after.

1.07 SUBMITTALS

A. Definitions: The required submittals of this division, in addition to the definitions of the General Conditions, and elsewhere in the contract documents, are further categorized for convenience as follows:

1. Product data shall include manufacturer's latest standard printed literature such as manufacturers installation instructions, catalog cuts, color charts, rough-in diagrams, wiring diagrams, and performance curves on materials, equipment and systems for this project. Product data shall include references to applicable specification section and item number. Product data shall be in addition to the required shop drawing submittals.
2. Shop drawings shall include specially prepared technical data with diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, plans, sections, details, measurements, not in standard printed form. Shop drawings shall be in addition to the required product data and shall indicate applicable specification section and item numbers.
3. Samples shall include physical examples of materials; in complete units for visual inspection. Samples shall indicate applicable specification section number and item numbers within that section.
4. Certificates shall include statements of applicability, certifying reports from governing agencies, industry standards, and testing agencies and applicable certificates specified in each section of the specification.
5. Test and Inspection reports shall include reports specified to be required in each section of the specifications.

B. Coordination and Sequencing

- a. Coordinate preparation and processing of submittals with the construction schedule and progress so that the Work will not be delayed.
- b. Coordinate and sequence submittals for Work and Work interfaced with other Work so that the processing of submittals will not be delayed by the lack of required coordination between submittals.
- c. The obligation to coordinate the Work indicated on any submittal material with other trades and with field conditions is the responsibility of the Contractor. No claim will be allowed for Work that may have to be moved or replaced based on a claim that the work was placed in accordance with dimensions indicated on an approved submittal.
- d. No claim for an extension of Contract Time will be approved because of Contractor's failure to coordinate submissions.

C. Shop Drawings

Before starting the work, the Contractor shall submit to the Engineer for his approval, the execution of shop drawings (4 copies to be submitted) for the entire installation, especially the transfer stations, the main connections and junctions, the final route of cables and conduits and the details of the switchboards, panels, exact location of all electrical outlets & device and any other part of the installation required by the Engineer. The Engineer reserves the right to alter or modify these plans if they are found to be insufficient or not complying with the established technical standards or if they do not afford the most satisfactory performance or accessibility for repairs.

Three sets of operating and maintenance instructions covering completely the operation and maintenance of electrical systems and automatic control equipment shall be furnished to the owner.

Where necessary, one set of operating and maintenance instructions for each electrical equipment shall be framed behind glass and hung where directed.

Where necessary, three sets of lubrication charts and manuals for each item of equipment shall be furnished to the owner.

At the end of the work, the Contractor shall present three sets of as-built drawings of the whole installation, with all details required by the Engineer, and with the technical data of all installed equipment.

D. Product Data

- a. Submit product data as called for under "Submittals" in each individual specification section.
- b. Product data shall be submitted in sextuplicate for review. The Contractor shall indicate on copies of the literature the actual materials being submitted for review when literature contains selections.

E. Samples

- a. Submit two (2) samples of each material (unless a different quantity is specified) as called for under "Submittals" in each individual section of the specifications.
- b. Samples shall be delivered where directed by the Engineer. Sidewalk delivery of samples will not be accepted.

1.08 COORDINATION DRAWINGS

- A. Prepare coordination drawings in accordance with provisions of the Contract Documents detailing major elements, components, and system of electrical equipment and materials in relationship with other systems, installations and

building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installation are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
 - a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
 - d. Equipment connections and support details.
 - e. Sizes and location of required concrete pads and bases.
2. Indicate scheduling, sequencing, movement and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations and details to indicate penetrations in floors, walls and ceilings and their relationship to other penetrations and installations.

1.09 RECORD DOCUMENTS

- A. Prepare record documents (as built drawings) in accordance with the provisions of the Contract Documents. In addition to the requirements specified in Division 1, indicate installed conditions for:
 1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 3. Approved substitutions, Contract Modifications and actual equipment and materials installed.

1.10 INSTRUCTION MANUALS

The supplier shall prepare and produce instruction manuals in both Arabic and English languages for the use, operation and the maintenance of the supplied equipment and installations.

1.11 MATERIALS OF THE SAME KIND

All materials of the same kind of service shall be identical and made by the same manufacturer.

1.12 TEST CERTIFICATE

The supplier shall submit test certificates where required. These shall be issued by an internationally recognized inspection office certifying that all equipment materials,

construction and functions are in agreement with the requirements of these Specifications and accepted Standards.

1.13 **TEST AND ADJUSTING**

After the wiring systems are completed, it shall be tested for all controls and defects. Any defects appearing shall be remedied before any apparatus, is installed.

Tests, both electrical and physical, shall be made of the various materials, equipment and installation comprising the electrical system.

After the entire installation has been completed all necessary adjustments shall be made until all Performance requirements are met.

PART 2 - PRODUCTS

(NOT USED)

BASIC ELECTRICAL REQUIREMENTS (16010) (CONT'D)

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions at the job site where electrical work is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

- A. The Engineer's drawings issued with these specifications show the approximate location of electrical apparatus; the exact locations are subject to the approval of the Engineer. The general run of feeders, branches and conduits are indicated on the drawings. It is not intended that the exact routing of circuits or locations of conduit be determined there from.
- B. The contractor shall submit a priced list of manufacturer's recommended spare parts sufficient for two years of normal operation.

3.03 INSTALLATION

- A. Sequence, coordinate and integrate the various elements of electrical systems, materials and equipment.
- B. Coordinate electrical systems, equipment and material installation with other building components & existing work.
- C. Verify dimensions by field measurements.
- D. Arrange for chases, slots and openings in other building components during progress of construction, to allow for electrical installations.
- E. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
- F. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
- G. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
- H. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.

- I. Install systems, materials and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.
- J. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
- K. Install electrical equipment to facilitate servicing, maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- L. Install access panels or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors" and Section 16050 "Basic Electrical Materials and Methods."
- M. Employer Furnished Equipment
 - 1. Install and connect designated motor and control equipment furnished by the Employer.
 - 2. Connect designated equipment furnished by the Employer requiring an electric power supply.
- N. Operation of Defective Equipment: The Employer reserves the right to operate operable defective equipment until it can be removed from service for correction by the Contractor.

END OF SECTION

SECTION 16110

RACEWAYS

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide labor, materials, equipment and services, and perform operations required for installation of Raceways and related work as indicated on the drawings or specified herein.
- B. Work Included: The work of this section shall include, but not be limited to, the following:
 - 1. Electrical metallic tubing (EMT)
 - 2. Flexible metal conduit.
 - 3. Liquid-tight flexible metal conduit.
 - 4. Rigid metal conduit.
 - 5. Rigid PVC conduit.
- C. Related Work Specified Elsewhere
 - 1. Basic Electrical Requirements - Section 16010.
 - 2. Basic Electrical Materials and Methods - Section 16050.

1.02 SUBMITTALS

- A. Submit the following in accordance with the requirements specified under "Submittals" of Section 16010.
 - 1. Product Data: Submit manufacturer's technical product data, including specifications and installations, for each type of raceway system required. Include data substantiating that materials comply with requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- Arnould (France).
- Decoduct (UAE).
- Allied Tube & Conduit (USA)
- EGA Tube (UK)
- Or any approved equal

2.02 MATERIALS

A. Conduit and Tubing

1. Provide metal conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) for each service indicated.
2. Rigid PVC: Conduit-heavy gauge normal impact unmodified rigid PVC and shall conform to UL 651 and meet NEMA TC-2 and WC-1094 Conduits shall be resistant to heat, suitable for a continuous service temperature of 70 degrees C., and shall be corrosion-proof, non combustible, gas and watertight, acid-proof. Thin wall rigid PVC conduit shall not be permitted.
3. Rigid Steel Conduit: Rigid steel, zinc-coated, threaded type conforming to FS WW-C-581, ANSI C80.1 and UL 6. Provide zinc coating fused to inside and outside walls.
4. Flexible Metal Conduit: FS WW-C-566 and UL 1. Formed from continuous length of spirally wound, interlocked zinc-coated strip steel.
5. Liquid-Tight Flexible Metal Conduit: Liquid-tight flexible metal conduit; constructed of single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanized inside and outside; coat with liquid-tight jacket of flexible polyvinyl chloride (PVC) conforming to UL360.
6. Electrical Metallic Tubing (EMT): FS WW-C-563, ANSI C80.3 and UL 797.
7. EMT Fittings: FS W-F-408, compression type, plated malleable iron or steel.
8. Conduit Straps and Supports: Hot dipped galvanized cast malleable iron or structural steel with hot dipped galvanized nuts and bolts.
9. Conduit Bushings: Insulated bushings for conduits 3/4 and larger. Provide lay-in type lugs on grounding bushings.
10. Expansion Fittings: Malleable iron-hot dipped galvanized end fittings with grounding strip and flexible tube and covered with neoprene tubing for rigid steel conduit in concrete. The use of aluminum material is prohibited.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions at the job site where work of this section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this section with the work of related trades so as not to delay job progress.
- C. Provide templates as required to related trade for location of items.

3.03 INSTALLATION

- A. Installation of Raceways
 - 1. Install raceways as indicated; in accordance with manufacturer's written installation instructions, and in compliance with the applicable electrical code. Install units plumb and level, and maintain manufacturer's recommended clearances.
 - 2. Coordinate with other work including wires/cables, boxes, and panel work, as necessary to interface installation of electrical raceway and components with other work.
- B. Installation of Conduits
 - 1. Install all conduits concealed or exposed as follows:
 - a. Conduit sizes shall be in accordance with applicable electrical codes, minimum size 3/4" (20 mm). Mechanically fasten together metal conduits, enclosures, and raceways for conductors to form continuous electrical conductor. Connect to electrical boxes, fittings and cabinets to provide electrical continuity and firm mechanical assembly.
 - b. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat surfaces with corrosion inhibiting compound before assembling, Burndy "Penetrox" or T&B Kopr-"Shield".

- c. Install miscellaneous fitting such as reducers, chase nipples, 3-piece unions, split couplings, and plugs that have been specifically designed and manufactured for their particular application. Install expansion fitting in raceways every 200 feet linear run or wherever structural expansion joints are crossed.
 - d. Use roughing-in dimensions of electrically operated unit furnished by supplier. Set conduit and boxes for connection to units only after receiving review of dimensions and after checking location with other trades.
 - e. Provide nylon pull cord in empty conduits, with ends secured to blocks to prevent accidental removal. Provide each end of the pulling cord with a linen tag identifying the termination. Test conduits required to be installed, but left empty, test with ball mandrel. Clear any conduit which rejects ball mandrel. Pay costs involved for restoration of conduit and surrounding surfaces to original condition.
2. Conduit Installation: Provide rigid PVC conduit where embedded in concrete, masonry, under floor or earth. Follow requirements in other areas as follows:
- a. Use heavy duty rigid PVC conduits above false ceiling. Exposed low current cables to be 30 cm minimum from adjacent power conduits/cables.
 - b. Use rigid steel conduit for exposed conduit installations other than above false ceiling, unless otherwise noted.
 - c. Use flexible conduit in movable partitions and from outlet boxes to recessed lighting fixtures, and final 24 inches of connection to control items subject to movement or vibration, and in cells of precast concrete panels.
 - d. Use liquid-tight flexible metal conduit for final 24 inches of connection to motors in damp or wet location.
 - e. Use Liquid-tight flexible steel galvanized conduit in the following conditions:
 - 1) Exterior location.
 - 2) Moist or humid atmosphere where condensate can be expected to accumulate.
 - 3) Corrosive atmosphere.
 - 4) Subjected to water spray or dripping oil, water or grease.

- e. Cut conduits straight, properly ream, and cut threads for heavy wall and intermediate steel conduit deep and clean.
- f. Field-bend conduit with benders designed for purpose so as not to distort nor vary internal diameter.
- g. Make changes in direction of horizontal telephone conduit runs 1 inch or larger with minimum 36 inches radius long sweep elbow or bends.
- h. Not more than the equivalent of two (2) quarter bends (180 degrees total) are permitted for telephone, data and telecommunication conduit runs between terminations.
- i. Size conduit to meet applicable electrical codes.
- j. Fasten conduit terminations in sheet metal enclosures by 2 locknuts, and terminate with bushing. Install locknuts inside and outside enclosure.
- k. Conduits are not to cross pipe shafts, or ventilating duct openings.
- l. Keep conduits a minimum distance of 6 inches from parallel runs of flues, hot water pipes or other sources of heat.
- m. Support riser conduit at each floor level with clamp hangers.
- n. Use of running threads at conduit joints and terminations is prohibited. Where required, use 3-piece union or split coupling.
- o. Complete installation of electrical raceway before starting installation of cables/wires within raceways.
- p. Install conduit so as not to cut or run through structural members, cable holes or cable slots, except by special written permission of the Engineer.
- q. Concealed Conduits
 - 1) Encase conduits installed under floors on grade in minimum 2" concrete.
 - 2) Install underground conduits minimum of 24" below finished grade.

- r. Conduits in Concrete Slabs
 - 1) Place conduits between bottom reinforcing steel and top reinforcing steel.
 - 2) Place conduits either parallel, or at 90 degrees, to main reinforcing steel.
 - 3) Separate conduits by not less than diameter of largest conduit to ensure proper concrete bond.
 - 4) Conduits crossing in slab must be reviewed for proper cover by the Engineer.
 - 5) Embedded conduit diameter is not to exceed 1/3 of slab thickness.
- s. Install conduits as not to damage or run through structural members. Avoid horizontal or cross runs in building partitions or side walls.
- t. Conduit Fittings
 - 1) Construct locknuts for securing conduit to metal enclosure with sharp edge for digging into metal, and ridged outside circumference for proper fastening.
 - 2) Install insulated type bushings for terminating conduits 3/4" and larger. Bushings are to have flared bottom and ribbed sides. Upper edge to have phenolic insulating ring molded into bushing.
 - 3) Bushing of standard or insulated type to have screw type grounding terminal.
 - 4) Miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split coupling, and plugs to be specifically designed for their particular application.

C. Installation of Raceways and Wireways

- 1. Mechanically assemble metal enclosures, and raceways for conductors to form continuous electrical conductor, and connect to electrical boxes, fittings and cabinets as to provide effective electrical continuity and rigid mechanical assembly.
 - a. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat surfaces with corrosion inhibiting compound before assembling.

- b. Install expansion fittings in raceways wherever structural expansion joints are crossed.
- c. Make changes in direction of raceway run with proper fittings, supplied by raceway manufacturer. No field bends of raceway sections will be permitted.
- d. Properly support and anchor raceways for their entire length by structural materials. Raceways are not to span any space unsupported. Do not support raceway from ductwork.
- e. Use boxes as supplied by raceway manufacturer wherever junction pull or device boxes are required. Standard electrical "handy" boxes, etc. shall not be permitted for use with surface raceway installations.

END OF SECTION

SECTION 16111

CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
 - 1. "Basic Electrical Requirements"
 - 2. "Basic Electrical Materials and Methods"

1.2 SUMMARY

- A. This section includes metallic cable trays. Types of cable trays in this section include the following:
 - 1. Ventilated (perforated) bottom.
 - 2. Ladder.
- B. Related Sections: The following Division Section contains requirements that relate to this section.
 - 1. Division 7 section "Fire Stopping".
 - 2. Division 16 section "Supporting Devices".

1.3 SUBMITTALS

General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:

- 1. Product Data: Manufacturer' catalogues and data for cable tray products and accessories.
- 2. Shop Drawings: Layout floor plans and elevations showing cable tray system. Designate components and accessories including clamps, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings. Show accurately scaled components and spatial relationships to adjacent equipment. Show tray types, dimensions, and finishes.
- 3. Factory Test Reports: Certified copies of factory test reports performed in conformance with Standard approved on cable trays of types and size specified for this project.
- 4. Field Test Reports: in compliance with "Field Quality Control" Article of this section.
- 5. Maintenance data for inclusion in "Operating and maintenance Manual".

PART 2 - PRODUCTS

2.1 MANUFACTURERS (Local manufacturers strictly prohibited)

- A. Approved Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include but are not limited to the following:
1. Wiremold
 2. Vergokan.
 3. Tallmega
 4. Cooper B-Line Inc
 5. ABB
- or approved equal

2.2 CABLE TRAYS, GENERAL REQUIREMENTS:

- A. Cable tray systems shall be of indicated types, sizes, and standard classes and shall be complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adaptors, hold-down devices, grommets, and blind ends as required and indicated.
- B. Cable tray products shall have rounded edges and smooth surfaces.
- C. Except as otherwise indicated, provide metal cable trays, with splice plates, bolts, nuts and washers for connecting units; capable of supporting concentrated loads of 90kg at any point, over and above cable load.
- D. Provide cable tray covers, where indicated; construct of metal and finishes which mate and match cable trays.
- E. Provide cable tray supports and connectors, including bonding jumpers, as indicated and as recommended by cable tray manufacturer.
- F. Galvanizing: is to be in accordance with ASTM B633, applied after fabrication.
- G. Sizes: trays and ladders are to be standard metric sizes, 300, 600 and 900 mm wide, and at least 2,44 m length of section, minimum thickness: 1.5 mm. Size of tray or ladder is to be determined by number and sizes of cables in accordance with the Regulations and/or as shown on the Drawings. Tray or ladder is to have strength and rigidity to provide support for cables contained within. Deflection between supports is not to exceed 1/350 under full loading capacity.
- H. Earthing Connector: for plastic coated trays or ladders, provide earthing connector on each coupling between adjacent sections and at distances not exceeding 30m

2.3 MATERIALS AND FINISHES:

- A. Cable Trays, Fittings, and Accessories: Steel, hot-dipped galvanized after fabrication.

2.4 CABLE TRAY ACCESSORIES:

- A. Covers: Solid type, of same materials and finished as cable trays.
- B. Barrier Strips: Same materials and finishes and finishes as cable trays.

2.5 SUPPORTS AND CONNECTOR:

- A. Cable tray supports and connectors, including bonding jumpers shall be as recommended by cable tray manufacturer.
- B. Bolts and screws shall be cadmium plated or electrolytically galvanized.

2.6 FASTENERS FOR SUPPORTS:

- A. Fasteners to connect cable tray supports to the building structure (at distances not exceeding 75cm apart) shall be as follows:
- B. Expansion Anchors: Carbon steel wedge or sleeve type.
- C. Toggle Bolts: All steel springhead type.
- D. Powder-Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.

2.7 FIRE STOPPING:

- A. General : Materials shall be UL listed and labeled and FM approved for fire ratings consistent with penetrated barriers.
- B. Sleeves: Schedule 40, welded, black steel pipe sleeves. Sizes as indicated or minimum NEC size for cable or cable group to be installed.
- C. Sealing Fittings: Suitable for sealing cables in sleeves or core drilled holes.
- D. Two-Part Sealant: Formed-in-place sealant as specified in paragraph "Fire-Resistant Joint Sealers" in Division 16 Section 16050, "Basic Electrical Materials and Methods".

PART 3 - EXECUTION

3.1 Installation of cable tray systems:

- A. Install cable trays in accordance with equipment manufacturer's written instruction.
- B. Remove burrs and sharp edges of cable trays.
- C. Conform to manufacturer's recommendations for selection and installation of supports.
- D. Strength of each support including fastenings to the structure shall be adequate to carry present and future load multiplied by a safety factor of at least four or the calculated load plus 90 kg (200 lbs), whichever is greater spacing of supports is not to exceed 0.75 m.
- E. Installation of supports shall be in accordance with cable tray manufacturer's written instruction and recommendations.
- F. Fastening Supports: Unless otherwise indicated, fasten cable tray supports securely to the building structure as specified in Division 16 Section "Supporting Devices".
- G. Support at Connections to Equipment: Where cable trays connect to equipment, provide flanged fittings fastened to the tray and to the equipment. Support the tray separately. Do not carry the weight of the tray on the equipment enclosure.
- H. Thermal Contraction and Expansion: Install expansion connectors in cable tray runs that exceed the following length:
 - 1. Steel Tray: 52.5 m (175 feet).
 - 2. Spacing and gap settings for expansion connectors shall not exceed recommendations of approved applicable standards.
- I. Direction Changes: Make changes in direction of cable tray with standard cable tray fittings.
- J. Locate cable tray above piping except as required for tray accessibility and as otherwise indicated.
- K. Firestopping: Where cable trays penetrate fire and smoke barriers including walls, partitions, floors, and ceilings, install fire-stopping at penetrations after cables are installed.

3.1 Installation of cable tray systems (CONT'D)

- L. Sleeves For Future Cables: Install capped sleeves for future cables through fire stopped cable tray penetrations of fire/smoke barriers.
- M. Working Space: Install cable trays with sufficient space to permit access for installing cables.
- N. Barriers: Where trays carry conductors of different systems, such as power, communications, and data processing, or different insulation levels, use separate cable trays. In case of absolute necessity, where an Engineer's approval is required install barriers to separate the systems.

3.2 GROUNDING

- A. Electrically ground cable trays and ensure continuous electrical conductivity of cable tray system. Use tray as an equipment ground conductor for itself only, not for connected equipment.

3.3 WARNING SIGNS:

- A. After installation of cable trays is completed, install warning signs, on or in proximity to cable trays, where easily seen by occupants of space.

3.4 FIELD TESTING:

- A. Earthing: Test cable trays to ensure electrical continuity of bonding and grounding connections.
- 1. Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof-load for fastener. If fastening fails test, replace fastener and retest until satisfactory results are achieved.

3.5 CLEANING AND FINISH REPAIR:

- A. Upon completion of installation of cable trays, inspect trays, fittings, and accessories. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.
- B. Galvanized Finish: Repair damage with a zinc-rich paint recommended by the tray manufacturer.
- C. PVC or Paint Finish: Repair damage with matching touch-up coating recommended by the tray manufacturer.

END OF SECTION

SECTION 16116

**DISTRIBUTION, SUB-DISTRIBUTION AND
FINAL BRANCH CIRCUIT PANELBOARDS**

1. **GENERAL**

ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 16010 of the Specification.

DESCRIPTION OF WORK: panelboards for distribution and sub-distribution of electric power and for protection of circuits, including fixing and supporting materials and materials for termination of feeders, sub-circuits and branch circuits.

STANDARDS: panelboards generally are to comply with the requirements of IEC 439, Factory-Built Assemblies of Low Voltage Switchgear and Control Gear.

DESIGNATIONS: panelboards are designated on the Drawings and in the Schedules as follows:

LP:

final branch circuit panelboards, power panelboards and sub-distribution panelboards respectively, for secondary lighting and power distribution with branch miniature circuit breaker (MCB) and main moulded case circuit breaker (MCCB) protection unless otherwise shown on the Drawings.

MSP & PP:

distribution panelboards for power distribution with MCCB protection on main incoming and outgoing feeder circuit breakers (all MCCB unless otherwise noted on drawings).

SCHEDULES indicate the designation and required type of panelboard using the following criteria:

- type of construction (MCB or MCCB), referring to type of branch circuit breakers
- voltage, number of phases and wires
- branch circuit breaker trip rating and wire size
- main circuit breaker trip rating and frame size (maximum continuous rating) for MCCB
- short-circuit interrupting capacity (IC) in kA
- special arrangement or provisions.

EQUIPMENT DATA: submit data for approval including, but not limited to, the following:

- manufacturers' catalogues indicating specific equipment selected
- types of panelboards and circuit breaker characteristics including duties and ratings
- compensation at and above 40 deg. C ambient conditions and corresponding temperatures within the enclosures

dimensions of panels and specific contents of each panelboard

integrated equipment tabulations for coordinated short-circuit series combinations of circuit breakers.

TESTS AND CERTIFICATES: submit complete certified manufacturer's type test and routine test records in accordance with the Standards.

SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

exact composition of each panelboard, indicating busbar rating, frame or continuous rating and trip ratings of circuit breakers

typical installation details of panelboards, indicating main feeder and branch circuit conduit connections, terminal provisions, tags, labels, mounting methods and materials used.

ELECTRICAL CLOSETS are to be checked for clearances, spaces and ventilation, for the installation of proposed equipment, prior to starting construction.

APPROVED MANUFACTURERS: obtain panelboards from one of the following:

A. Schneider (France)

B. Moeller (Germany)

or other equal and approved.

2.1 DISTRIBUTION, SUBDISTRIBUTION AND FINAL BRANCH PANELBOARDS

2.1.1. GENERAL REQUIREMENTS

RATED INSULATION VOLTAGE is to be in accordance with the respective Standards.

PANELBOARDS are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 144, and are to be factory designed and assembled. Indoor panels to be steel type with glass window.

EARTHING BAR is to be provided in every panelboard.

PROTECTION is to be fully rated throughout the systems.

SERIES (CASCADE) COORDINATED PROTECTION (integrated equipment short-circuit ratings) will not be acceptable.

CIRCUIT BREAKERS are to be non-fused type.

CIRCUIT BREAKER ARRANGEMENT: panelboards are to have one main incoming circuit breaker and the required number of branch circuit breakers, arranged as shown on the Schedules, including spare circuit breakers and spaces for future expansion. Three-phase panelboards are to be designed for sequence phase connection of branch circuit devices.

BRANCH CIRCUIT NUMBERING: on 3-phase panelboard schedules, circuits 1 and 2 are to 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.

2.1.2 PANELBOARD ENCLOSURES

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.

CONSTRUCTION: box, trim and doors where required, are to be electro-galvanized sheet steel of gauges not less than specified and in accordance with the Standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the Standards, but are not to be less than 100 mm on all sides. Enclosure is to have predesigned angles or threaded end studs to support and adjust mounting of interior panelboard assembly.

TRIMS are to cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims are to 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 are to be oval-head, countersunk and flush. Trims for flush mounted panelboards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panelboards are to be exactly sized to form flush fit to box.

DOORS are to have concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high are to have vault-type handle and multiple point latch mechanism. Locks are to be keyed alike.

FINISH: inner and outer surfaces of cabinet/boxes, trims, doors etc. are to 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, ageing and corrosion and of standard grey colour to the approval of the Engineer.

DIRECTORIES under glassene, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors is specified. Directories are to be typed to identify panelboards and clearly indicate circuit number and description of load.

OUTDOOR ENCLOSURES are to be heavy duty sheet steel cabinets, minimum 1.5 mm thick, fully weatherproofed (IP 55), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

2.1.3. BUSBARS

TYPE: one piece, 98% pure electrolytic copper, based on maximum total temperature rise of 40 deg. C over an ambient of 50 deg. C at full continuous rating. Bolted or clamped contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminium is not to be used for busbars or panelboard parts.

DESIGN: busbars are comb type with protective cover for unused parts. Busing and blank plates are to allow installation of future circuit devices, where indicated on the Drawings.

RATING: busbar rating is to be at least equal to main-circuit breaker frame size. Where no main circuit breaker is required, busbars are to have main lugs or disconnect switch, with nominal rating equal to standard circuit breaker frame sizes, and as shown on the Drawings.

SHORT-CIRCUIT DUTY: busbars are to carry maximum short-circuit duty of main protective device, which is to be at least maximum short-circuit at point of application for one second, without showing any signs of degradation.

NEUTRAL BAR is to be solid and fully insulated from cabinet or box. One solderless box type set-screw connector is to 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 is to be fully sized and rated as for phase busbars.

EARTHING BAR is to be copper, brazed to panelboard cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

2.1.4. MOULDED CASE CIRCUIT BREAKERS (MCCBs)

TYPE: tested to approved standards, totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded 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 overcurrent conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws, suitable for copper or aluminium conductors.

CIRCUIT BREAKER TRIP UNITS: unless otherwise specified or shown on the Drawings, circuit breakers up to and including 600/630 A frame size, are to be thermal-magnetic type, having bi-metallic inverse time delay overcurrent element for small overloads and instantaneous magnetic overcurrent trip

element for operation under short-circuit conditions on each pole. Circuit breakers 250 A and larger are to have adjustable instantaneous trips. Where solid state electronic trip circuit breakers are required these are indicated in the Schedules suffixed with the letter e.

2.1.5. MINIATURE CIRCUIT BREAKERS (MCBs)

- A. TYPE: thermal magnetic non-adjustable type, tested in accordance with BS 3871, Part 1.
- B. MINIMUM SHORT-CIRCUIT BREAKING CAPACITIES for 6 - 100 A MCB : 10 kA at 240/415 V a.c.
- C. CONSTRUCTION: MCBs are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panelboard enclosure and humidities up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg. C. MCBs and combinational devices are to be modular, of unified profile and mounted to a standard DIN rail.
- D. OPERATION: under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at 7 - 10 times normal rated current (type 3 characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milli-seconds.

2.1.5. MINIATURE CIRCUIT BREAKERS (MCBs) (CONT'D)

- F. RATINGS: preferred rated currents are to be 6, 10, 15, 20, 25, 30, 40, 50, 60, 80 and 100 A, calibrated at 40 deg.C, available as 1, 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg.C, and loading is not to exceed 70% of circuit breaker rating.
- G. RESIDUAL CURRENT DEVICES for earth leakage protective circuit breakers are to 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 are to be available for all ratings of 2-pole and 4-pole circuit breakers.
- H. AUXILIARIES, where required or shown on the Drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.

2.1.6. MOULDED CASE SWITCH (MCS)

MOULDED CASE SWITCH: non-automatic on/off switching device of equal construction to equivalent circuit breaker, having no overcurrent or fault protective elements, but marked with maximum current withstand and voltage rating.

2.2. PANELBOARD ASSEMBLIES

2.2.1. DISTRIBUTION PANELBOARDS (DP or PP)

- A. To have voltage rating 600 V a.c., 240 V d.c., conforming to IEC 439 form 2b and BS 5486: Part 1, class 3 (or UL listed, and meeting U.S. Federal Specification WP-115, Type 1, Class 1), surface mounted to wall, without doors (unless otherwise shown on the Drawings), suitable for ratings of main breaker and busbars ranging from 225 A to 1200 A, 3-phase, 4-wire (or 3-wire where specifically indicated), suitably and orderly arranged for any selected combination of branch MCCBs ranging from 150 A to 1200 A frame size and short-circuit interrupting ratings as shown on the Drawings. Circuit breakers smaller than 250 A frame size, where indicated, may be grouped on an integral sub-assembly mounted to main
- B. CONSTRUCTION: sheet steel, minimum 1.5 mm thick for cabinet/box and door. Fronts are to be single or twin covers to shield circuit breakers, terminals and live ends.
- C. INTERIOR OF PANELBOARD is to be pan assembly consisting of galvanized sheet steel chassis minimum 1.5 mm thick, folded, flanged and reinforced, with busbars vertically arranged and mounted on moulded insulators.
- D. MOULDED INSULATORS are to have minimum temperature rating of 130 deg. C and insulation grade of 3.5 kV for one minute.
- E. CIRCUIT BREAKERS are to be mounted in twin arrangement (except for larger circuit breakers) and bolted rigidly to copper cross and centre bus connectors.

2.2.2. FINAL BRANCH CIRCUIT, POWER AND SUB-DISTRIBUTION

PANELBOARDS - GENERALLY

ARRANGEMENT: to comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker. Single and multi-pole circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.

INDOOR ENCLOSURE: sheet steel, minimum 1.0 mm thick for box/cabinet and minimum 1.5 mm thick for front shield, trim and door. Fixings for flush trim are to be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) are to be at least 100 mm wide. Larger gutters are to be provided where tap-off insulated split connectors are required. Knockouts are to be provided in top or bottom of enclosures and are to provide a neat and uniform conduit/cable terminal arrangement.

FINAL BRANCH CIRCUIT PANELBOARDS - TYPE MCB (LP panels)

- A. **INTERNAL ASSEMBLY:** Both European DIN rail type and American busbar type configuration are approved. Locally manufactured panelboards are strictly prohibited. Panel to 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 is to be complete with neutral terminal block, earthing bar and one-piece insulated bolt-on/comb-type phase busbar. Busbars are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards. 25% spare space to be provided with full size busbars.
- B. **SPN TYPE PANELBOARDS** are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.
- C. **SPN TYPE MAIN CIRCUIT BREAKER** is to be double-pole MCB, with or without earth leakage device (RCD), as shown on the Schedules.
- D. **SINGLE-POLE AND DOUBLE-POLE MCBs** for 240 V service, are to have trip ratings between 6 A and 50 A, with ICs as shown on drawings.
- E. **TPN TYPE PANELBOARDS** are to 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 MCB or MCCB main incoming, as shown in the Schedules or on the Drawings.
- F. **TRIPLE-POLE BRANCH CIRCUIT BREAKERS** are to have trip ratings between 6 A and 100 A, with IC as shown on drawings.
- G. **TPN TYPE PANELBOARD MAIN CIRCUIT BREAKERS** are to be MCB or MCCB, 100A continuous current rating, with trip range from 25 A to 100 A, or 225 A MCCB with trip range 70 A to 225 A, with/without RCD as shown on the Drawings.
- H. **SHORT-CIRCUIT RATING:** TPN panelboards may only have an integrated equipment (series) short-circuit rating.

3. FIELD AND INSTALLATION WORK

3.1. INSTALLATION

FIXING GENERALLY:

Align, level and securely fasten panelboards to structure

Fix surface mounted outdoor panelboards at least 25mm from wall ensuring supporting members do not prevent flow of air

Do not use connecting conduits to support panelboards

Close unused openings in panelboard cabinets.

PANELBOARD INTERIORS: do not install in cabinets until all conduit connections to cabinet have been completed.

WIRING INSIDE PANELBOARDS: to be neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections are to be split and bolted type, fully insulated.

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

PROTECTION: treat concealed surfaces of recessed cabinets with heavy field application of water-proof compound prior to installation.

GENERALLY: carry out sample tests, as required by the Engineer, on panelboards after installation, to verify short-circuit capability of circuit breakers and busbars. Inspect conditions within panelboards and verify insulation conditions by use of a megger.

CIRCUIT BREAKERS: tests are to include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by the 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.

3.1.2. INSPECTION AND TESTS ON SITE

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.

ROUTINE TESTS ON SITE are to be carried out, in accordance with the Standards, on all panelboards assembled from standardized components of the manufacturer outside the works of the manufacturer.

END OF SECTION

SECTION 16120

WIRES AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Section, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
 - 1. "Basic Electrical Requirements."
 - 2. "Basic Electrical Materials and Methods"

1.2 SUMMARY:

- A. This Section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.
- B. Extent of electrical wire and cable work is indicated by drawings and schedules.
- C. Types of electrical wire, cable, and connectors specified in this section include the following:
 - 1. Single core copper conductor/cables
 - 2. Multicore copper conductor/cables
 - 3. Fixtures wires.
 - 4. Control and signal cables.
- D. Applications of electrical wire, cable, and connectors required for project are as follows:
 - 1. For power distribution circuits.
 - 2. For lighting circuits.
 - 3. For appliance and equipment circuits.
 - 4. For motor-branch circuits.
 - 5. For signal and control circuits where not specified required otherwise under other sections of the specification.
- E. Related Sections: The following Sections contain requirements that relate to this section:
 - 1. Division 16 Section "Electrical Boxes and Fittings" for connectors for terminating cables in boxes and other electrical enclosures.

1.3 SUBMITTALS:

- A. Product Data: submit manufacturer's data on electrical wires, cables and connectors.
- B. Field Test Reports: indicating and interpreting test results relative to compliance with performance requirements of testing standards.

1.4 QUALITY ASSURANCE:

- A. Regulatory Requirements: Comply with provisions of the statutory laws having jurisdiction and local codes of practice applicable to the job site/host country.
- B. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.
- C. Manufacturers: Firms regularly engaged in manufacture of electrical wire and cable products of type and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- D. IEC Compliance: Comply with IEC requirements as applicable to construction, insulation and color coding of electrical wires and cables.
- E. NFPA Compliance: Comply with applicable NFPA requirements pertaining to cables and cable installations.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Deliver wire and cable properly packaged in factory-fabricated type containers, wound on factory reels.
- B. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.
- 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

Wire and Cable

Liban Cable.

2.2 WIRES AND CABLES

- A. General: Unless otherwise specified or shown on the Drawings, cables and other feeders are to have copper conductors. Cable conductors are to be stranded for sections 4 mm² and above, based on IEC 228 Class 2. Signal and control cables are to have solid conductors unless otherwise specified. Flexible cords are to have finely stranded conductors. Conductors of single core cables 25 mm² and above are to be compacted. Multi-core cables 35 mm² and above are to be sectoral shape.
1. Conductor Sizes: are to be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted.
 2. Building Wiring Insulation: in the absence of a national code/regulation, insulation is to be color coded or otherwise identified as follows:
 - a. Neutral is to be light blue or white or black.
 - b. Protective earth is to be green or green/yellow striped.
 - c. Phase colors are suggested as red, yellow, dark blue for 380/220V systems.
- B. LV Wires:
1. Single Core PVC Insulated Wires: unless otherwise specified single conductor wires for wiring in conduit are to have annealed copper conductors, generally with concentric strands and insulated with flame retardant, moisture and heat resistant PVC/E to IEC 227 suitable for wet locations and for conductor temperature of 85 deg. C. Wires are to be 450/750 V grade.
- C. LV Cables:
1. Multi-Core PVC Insulated Cables (0.6/1 KV): to have annealed, copper conductors, insulated with PVC/E to IEC 227, flame retardant, moisture and heat resistant, suitable for wet locations and conductor temperatures of 85 deg. C, laid up, bedded with suitable filler and sheathed with PVC.
 2. Multicore XLPE insulated Feeder Cables (0.6/1 KV): Single core annealed copper conductors, XLPE insulated, for conductor temperature of 90 deg. C, laid up and bedded with suitable non-hygroscopic material compatible with the insulation and PVC over sheathed, color black. Armoured cables are to have single layer of galvanized steel wire applied helically over extruded PVC bedding (which may be an integral part of filling) and over sheathed with PVC, color black. PVC oversheaths are to be type ST2 to IEC 502.
 3. Flexible Cable for Connection to appliances, window fans, pendants etc.: is to be 300/500 V grade, three or four core, with tinned finely

stranded copper wires, EPR insulated, twisted and sheathed with chlorosulphonated polyethylene (CSP compound) and with strengthening cord.

4. High Temperature Cable: solid or stranded plain annealed copper conductors to BS 6360 (in sizes up to 4 mm²), extruded silicon rubber insulation (0.6 mm radial thickness), aluminum/PVC laminate and PVC composite sheath with tinned earth continuity conductor/drain wire. Cable is to be rated 300/500V, capable of accepting voltage surges up to 5 KV, to operate continuously at 150 deg. C. and for short durations at 200 deg. C. It is to be certified to have passed IEC 331 and IEC 332 flame resistance and fire retardant tests.

D. Control and Signal Cables

1. Multicore PVC Insulated Control Cables: 0.6/1 KV rating, solid, 2.5 mm² or stranded 4 mm² plain circular copper conductors, with heat resistive PVC/E to IEC 227, rated for 85 deg. C, of 7,12,19,24,30 or 37 cores. Cores are to be laid up together and filled with non-hygroscopic material, PVC over sheathed, to form compact and circular cable for use in switchgear, control gear and generally for control of power and lighting systems.
2. PE Insulated Control and Signal Cables: for use on data systems, are to be generally 300 V rating, polyethylene insulated, color coded, tinned copper conductors (0.6 mm diameter), twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075 mm bare copper shielding tape and provided with drain wire and overall PVC sheath.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRES AND CABLES:

- A. General: Install electrical cables, wires and wiring connectors as indicated, in compliance with applicable requirements of the Regulations/codes applicable, and IEC, NFPA, and in accordance with recognized industry practices.
- B. Co-ordinate: wire/cable installation work including electrical raceway and equipment installation work, as necessary to properly interface installation of wires/cables with other work.
- C. Run d.c. wiring in separate conduits than a.c. wiring.
- D. Use pulling compound or lubricant, where necessary; compound used must not deteriorate conductor or insulation.
- E. Use pulling means including, fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway.
- F. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.

- G. Keep conductor splices to minimum. In case of splices, these are to be inside splice boxes, pull or junction boxes.
- H. Install splice and tap connectors which are compatible with conductor material.
- J. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in recognized standards.
- K. Pull cables simultaneously where more than one cable is being installed in the same raceway.

3.2 FIELD QUALITY CONTROL:

- A. Prior to energization of circuitry, check installed wires and cables with megohm meter to determine insulation resistance levels to ensure requirements are fulfilled.
- B. Prior to energization, test wires and cables for electrical continuity and for short-circuits.
- C. 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

SECTION 16135

ELECTRICAL BOXES AND FITTINGS

PART 1 -GENERAL

1.01 SUMMARY

- A. Provide labor, materials, equipment and services, and perform operations required for installation of electrical boxes and fittings and related work as indicated work as indicated on the drawings and specified herein.

- B. Work Included: The work shall include, but not be limited to, the following:
 - 1. Outlet boxes
 - 2. Junction boxes
 - 3. Pull boxes
 - 4. Floor boxes
 - 5. Poke-throughs
 - 6. Knockout closures.

- C. Related Work Specified Elsewhere
 - 1. Basic Electrical Requirements - Section 16010
 - 2. Basic Electrical Materials and Methods - Section 16050
 - 3. Grounding - Section 16450

1.02 QUALITY ASSURANCE

- A. Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.
 - 1. Code Compliance: Comply with electrical codes as applicable to construction and installation of electrical wiring boxes and fittings.
 - 2. UL Compliance: Comply with applicable requirements of UL 50, UL 514-A, and UL 886 pertaining to electrical boxes and fittings where applicable. Provide electrical boxes and fittings, which are UL-listed and labeled.
 - 3. NEMA Compliance: Comply with applicable requirements of NEMA Stds/Pub Nos. OS1, OS2 and Pub 250 pertaining to outlet and device boxes, covers and box supports.

1.03 SUBMITTALS

- A. Submit the following in accordance with the requirements specified under "Submittals" in Section 16010.
 - 1. Product Data : Submit manufacturer's data on electrical boxes and fittings.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Outlet Boxes: Provide galvanized coated flat rolled sheet-steel outlet wiring boxes, of shapes, cubic inch capacities and sizes, including box depths as required, suitable for installation at respective locations. Construct outlet boxes with mounting holes and with cable and conduit-size knockout openings in bottom and sides. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding.
1. Concrete box shall be 4 inches octagon with a removable backplate and 3/8 inch fixture stud, if required. Depth of box shall allow for a minimum of 1 inch of concrete to be poured above the backplate.
 2. Lighting fixture box shall be 4 inches octagon with 3/8 inch fixture stud. For suspended ceiling work, 4 inches octagon with removable backplate where required, and two parallel bars for securing to the cross-furring channels.
 3. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, wallboard hangers, box extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used to fulfill installation requirements for individual wiring situations.
 4. Device Boxes: Provide galvanized coated flat rolled sheet-steel device boxes of shapes, cubic inch capacities and sizes including box depths as required, nominal 4" square minimum 2-1/8" deep as required, suitable for installation at respective locations. Construct device boxes for flush mounting with mounting holes, and with cable-size knockout openings in bottom and ends, and with threaded screw holes in end plates for fastening devices. Provide cable clamps and corrosion-resistant screws for fastening cable clamps, and for equipment type grounding. Multi-device boxes shall be of the multi-gang type, minimum 2-1/4" deep. Gangable "switch" boxes are not acceptable.
 5. Device Box Accessories: Provide device box accessories as required for each installation, including mounting brackets, device box extensions, switch box supports, gang box covers, plaster ears, and plaster board expandable grip fasteners, which are compatible with device boxes being utilized to fulfill installation requirements for individual wiring situations.
- B. Raintight Outlet Boxes: Provide corrosion-resistant cast-aluminum, raintight outlet wiring boxes Type FS or FD and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, cast aluminum face plates with spring-

hinged watertight caps suitably configured for each application, including face plate gaskets and corrosion-resistant plugs and fasteners, no overlapping edges.

C. Junction Pull and Splice Boxes: Provide galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws and washers. Boxes installed outdoors to be fabricated of aluminum. Provide cover gaskets for boxes installed outdoors or in wet or damp locations.

1. Where size of box is not indicated, size to permit pulling, racking and splicing of the cables.
2. Braze a ground connector, suitable for copper cables to the inside of the box.
3. Junction Box - Sidewalk Type: Cast iron, hot dipped galvanized with threaded conduit entrance hubs, flanged, reinforced checkered cover, gaskets, with pry bar slots and countersunk stainless steel screws.
- 4) Nonmetallic Boxes: Nonmetallic boxes rigid PVC shall be used only with rigid PVC conduit. It shall be constructed so as to prevent contact between the conductors in the box and the supporting screws.

It shall be made of high impact PVC and it shall be supplied as the same make of the rigid PVC conduit.

Boxes shall conform to Federal Specifications W-J805.

D. Knockout Closures: Provide corrosion-resistant box knockout closures, offset connectors, of types and sizes to suit respective installation requirements and applications.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.

B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades, so as not to delay job progress.

C. Provide templates as required to related trade for location of items.

3.03 INSTALLATION

- A. Install electrical boxes and fittings as indicated; in accordance with manufacturer's written instructions, applicable requirements of the applicable electrical code and in accordance with recognized industry practices to fulfill project requirements.
- B. Obtain exact location of outlets from the drawings of interior details and finishes. Refer any condition that would place an outlet box in an unsuitable location to the Engineer.
- C. Mount outlet boxes for similar equipment in the same or similar areas at uniform heights. Where mounting heights are not indicated, locate outlet as required for the equipment connected thereto or as directed by the Engineer.
- D. Provide blank plates on outlet boxes in which no device is installed.
- E. Provide rain tight cast boxes for surface mounted weatherproof switches and receptacles.
- F. Provide pull and/or splice boxes where indicated on the drawings or required to facilitate pulling of wires and cables.
- G. Support boxes located above hung ceilings independently of the ceiling. Fasten boxes to the structure by bar hangers or other supports as approved by the Engineer.
- H. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.
- I. Provide weathertight outlets for interior and exterior locations exposed to weather or moisture.
- J. Provide knockout closures to cap unused knockout holes where blanks have been removed.
- K. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring. Where mounted in removable partition panels, install outlets to permit removal of panels without removing the outlet box.
- L. Avoid installing boxes back-to-back in walls. Provide not less than 6 inches separation/
- M. Do not install aluminum products in concrete.
- N. Position recessed outlet boxes accurately to allow for surface finish thickness.
- O. Set floor boxes level and flush with finish flooring material.

- P. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry.
- Q. Provide insulation at the rear of outlet boxes installed within exterior walls to prevent condensation within the boxes.
- R. Mounting Heights for Devices: The mounting heights for electrical outlets measured from the finished floor to the centerline of the outlet, shall be in accordance with the following, unless otherwise shown on the interior design or electrical drawings. Long dimensions of devices shall be vertical unless otherwise specified or shown on the drawings.
1. Wall Light Switches: 110 cm.
 2. Wall Receptacles 30 cm.
 3. Wall Exit Fixtures: Bottom of fixture 5 cm. above door frame.
 4. Wall Mounted Telephone Outlets: 30 cm.
 5. Wall Telephones: 110 cm.
 6. Fire Alarm Pull Station: 140 cm.
 7. Fire Alarm Audio or Audio/Visual Alarms: Bottom 5cm. above door frame.
- S. Provide electrical connections for installed boxes.
- T. Subsequent to installation of boxes, protect boxes from construction debris and damage.
- U. Grounding: Upon completion of installation work, properly ground metallic electrical boxes and demonstrate compliance with requirements.

END OF SECTION

SECTION 16195

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide labor, materials, equipment and services, and perform operations required for installation of electrical identification and related work as indicated on the drawings and specified herein.
- B. Work Included: The work shall include, but not be limited to, the following:
 - 1. Electrical power, control and communication conductors, conduits, and boxes.
 - 2. Operational instruction and warnings.
 - 3. Danger signs.
 - 4. Equipment/system identification signs and painting.
 - 5. Manhole covers.
- C. Related Work Specified Elsewhere
 - 1. Basic Electrical Requirements - Section 16010
 - 2. Basic Electrical Materials and Methods - Section 16050.

1.02 QUALITY ASSURANCE

- A. Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.
 - 1. Code Compliance: Comply with applicable electrical code requirements to installation of identifying labels and markers for wiring, cables, distribution boards, circuits, breakers, boxes, conduits, and all electrical equipment.

1.03 SUBMITTALS

- A. Submit the following in accordance with the requirements specified under "Submittals" in Section 16010.
 - 1. Product Data: Submit manufacturer's data on electrical identification materials and products.

1.03 SUBMITTALS

- 2. Samples: Submit samples of each color, lettering style and other graphic representation required for each identification material or system.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, provide single selection for each application.

- B. Color-Coded Conduit Markers
 - 1. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, extending 360 degrees around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretensioned snap-on.

 - 2. Colors: Unless otherwise specified or required by governing regulations, provide white markers with red letters.

- C. Cable Conductor Identification Bands: Provide manufacturer's standard vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, either prenumbered plastic coated type, or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

- D. Engraved Plastic-Laminate Signs: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in size and thicknesses indicated, engraved with engraver's standard letter style of sizes and wording indicated, black face and white core plies (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
 - 1. Thickness: 1/6 inch, except as otherwise indicated.

 - 2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.

PART 3 - EXECUTION

- A. Lettering and Graphics: Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturer or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.

3.01 EXAMINATION

- A. Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades, so as not to delay job progress.

3.03 APPLICATION AND INSTALLATION

- A. General Installation Requirements
 - 1. Install electrical identification products as indicated, in accordance with manufacturer's written instruction, and requirements of the applicable electrical code.
 - 2. Coordination: Where identification is to be applied to surfaces which require finish, install identification after completion of painting.
 - 3. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.
- B. Conduit Identification: Where electrical conduit is installed in spaces with mechanical piping which is identified by color-coded method, apply color-coded identification on electrical conduit in manner similar to piping identification. Except as otherwise specified, use white as coded color for conduit. IN shafts al conduits to be labeled every 3m maximum.
- C. Equipment/System Identification
 - 1. Install engraved plastic-laminate signs on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication/control/signal system, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2" high lettering on 1-1/2" high sign (2" high where 2 lines are required), white lettering in black field. Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work.
 - a. Panelboards, electrical cabinets and enclosures
 - b. Access panel/doors to electrical facilities.

2. Install signs at locations indicated or specified. Where not otherwise indicated at location for convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.
3. Plates for receptacles on emergency circuits shall be painted red.
4. Receptacles on emergency circuits shall have nameplates with white letters on red background giving the panelboard and circuit number to which it is connected..
5. Provide a nameplate with 1/4 inch white letters on black background, mounted on outside of panelboard trims with nomenclature as indicated on drawings.
6. Provide a nameplate with 1/4 inch white letters on black background, mounted on the outside of local disconnects, starters, control devices, pushbuttons, selector switches and pilot lights identifying the equipment served and/or their function.
7. Provide a red dot self-adhesive identification affixed to the visible trim of lighting fixtures connected to emergency circuits.
8. Provide a typed directory card inserted behind a clear plastic covering within a frame on the inside face of panelboard door identifying circuit utilizations and locations and wire and cable color coding for each voltage system.

END OF SECTION

SECTION 16330

GENERAL LIGHTING INSTALLATIONS

1. GENERAL

ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Section 16010 of the Specification.

DESCRIPTION OF WORK: complete indoor and outdoor lighting installations including fixtures, control gear, mounting provisions, accessories and connection to circuit wiring and to corresponding lighting control equipment. Work shall also include KNX system related to façade lighting & key pad for control.

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 are to 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 598 and CISPR 15. Only fixtures backed up with software package calculation shall be approved.

DESIGN LAYOUT: fixture layout has been determined from photometric data of specified fixtures to achieve desired level and uniformity of illumination. Reflected ceiling plans are to 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 are to be located in coordination with final equipment layout so that illumination is as intended by the design.

EQUIPMENT DATA: submit data for approval including, but not limited to, the following:

- A. Detailed literature on each fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles
- B. details of changes to standard fixtures for adaptation to condition of installation and to the Specification
- C. photometric data for lighting calculations including polar light distribution curves, coefficient of utilization, glare classification, efficiency, depreciation factors etc.

SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

- A. 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
- B. installation details including suspension and mounting provision
- C. purpose made fixtures or lighting assemblies with full details
- D. wiring details, circuit and panelboard references, special lighting control arrangements etc.

SAMPLES: submit fully equipped sample of each fixture type, modified if required, together with color and texture samples of each fixture. (Lighting fixtures to be coordinated with ID design & submit accordingly)

2. FIELD AND INSTALLATION WORK

INSTALLATION

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 the Engineer. Make final height adjustment after installation. Proper drainage shall be provided for all outdoor in ground fixtures as per manufacturer recommendations.

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.

STEM HANGERS: provide two stem hangers for individually mounted pendant fixtures. Stems are to have suspension aligners and are to be of suitable length for suspending fixtures at required height.

SUSPENDED CEILINGS: if ceiling construction is unable to support weight of fixtures without strain or deformation, suspend fixtures directly from building structure.

SOLID CEILINGS: coordinate dimensions of recesses in ceilings with exact fixture dimensions and structural elements.

CONTINUOUS ROWS: arrange fixtures so that individual fixtures can be removed without dismantling remaining fixtures. Provide minimum spacing between fixtures.

COVER PLATES: install cover plates over fixture outlet box or opening in ceiling or structure when left unused.

FLUSH RECESSED FIXTURES: install to completely eliminate light leakage within fixture and between fixture and adjacent finished surface.

VENTILATION: keep ventilation channels free after fixture is installed, if required by the design of the fixture.

EARTH metal frames of fixtures as described in Section 219 of the Specification.

TIGHTNESS: ensure that enclosed fixtures are reasonably insect/dust tight when installed, and completely weather- proof for installations subject to weather conditions.

LAMPS FOR PERMANENT INSTALLATION: place new lamps in fixtures immediately prior to hand-over and when instructed by the Engineer. Lamps used for temporary service are not to be used for final lamping of fixtures.

3. INSPECTION AND TESTS ON SITE

VISUAL INSPECTION: check neatness of installation, uniformity of equipment and nameplates etc.

ILLUMINATION MEASUREMENTS: to be taken at selected locations, to determine level and uniformity.

OPERATION: check lighting installations for operation including control and regulation equipment.

ELECTRICAL DATA: measure power factor, current and voltage at start for installations with discharge lamps.

3.1 KNX (EIB) work to include all facade lighting & related control.

A. The EIB system shall be installed by competent mechanics and checked out by competent technicians regularly employed by the manufacturer of the equipment.

B. Single source responsibility of the EIB contractor shall include supervision of installation, calibration, programming and checkout of the stand-alone subsystems, as well as the complete operation of the EIB.

REFERENCED STANDARDS, CODES AND ORDINANCES

A. It is the responsibility of the EIB contractor to be familiar with all codes, rules, ordinances, and regulating of the Authority Having Jurisdiction and their interpretations, which are in effect at the site of the work.

B. The latest issue of applicable standards and recommended practices of the EIBA (European Intelligent Bus Association) in effect shall form a part of the specification to the extent each agency's relative standards or recommended practices apply to the

Systems and its components as specified herein.

C. The EIB contractor shall be solely responsible for compliance with all health and safety regulations, performing this work in a safe and competent manner, and use industry accepted installation procedures required for the work as outlined in these documents.

D. All systems equipment, components, accessories, and installation hardware shall be new and free from defects and shall be as per the latest EIB/KNX as set by NF or VDE where applicable. All components shall be in current hand and shall be a standard product of the system or device manufacturer. Refurbished or reconditioned components are unacceptable.

Each component shall bear the make, model number, device tag number (if any), and the listing label as applicable. All Systems components of a given type shall be the product of the same manufacturer.

TOOLS AND INSTRUMENTS: provide tools and instruments required for normal routine inspection, maintenance and testing as appropriate for type of system supplied.

PART 2 – PRODUCTS

2.1 MANUFACTURERS OR APPROVED EQUAL:

1. Gira (Germany)
2. Berker (Germany)

GENERAL DESCRIPTION OF SYSTEM

A. The Low Voltage Programmable Lighting Control System shall be designed & developed in accordance with the European Installation Bus technology to cover lighting in common areas as shown on drawings

B. A two-wire bus cable shall link in parallel all sensors (push buttons, brightness sensors, motion sensors, timers, etc.) and actuators (on/off controllers, dimming controllers, ...etc.) to each other. The bus cable shall be a twisted pair, screened & shielded with solid conductors and shall be capable of handling information exchange and supplying power to the bus devices. Separate power supply to any of the sensors and actuators shall not be acceptable. The bus cable shall be laid in the building in the form of a linear, star or tree structure similar to the power mains. Systems requiring fixed wiring configurations shall not be acceptable.

C. The system shall be completely de-centralized and programmable. The programming shall be implemented via a PC or notebook computer located anywhere in the system and having access level passwords. Programming via local system switches or with no password security shall not be acceptable. Any device in the system shall be accessed for programming from the PC location without having to manipulate the device locally.

D. Each device in the system shall be addressable via a software programmable physical address. Any device in the system shall communicate with any other device via software programmable group addresses (telegrams). Each individual device will

respond to only those group addresses for which they are programmed to do so. There shall be an EEPROM storing the physical address, group addresses & other software parameters for every device, thus making it intelligent. No centralized processors or centralized memory storage devices shall be permitted.

E. It shall be possible to program any of the devices on-line at the working site without affecting any of the system devices or the system operation as well as off-line prior to dispatch of the material to site.

F. The entire system shall consist of bus lines each consisting of up to 64 devices. Two consecutive lines shall be connected to each other via line couplers that act as network filters and also provide communication between devices in different lines. In the event of failure of a device in one line, only the control functions controlled by that device shall be affected and all other devices shall continue to operate as normal. Any system with routers / couplers that require separate power supply shall not be acceptable.

G. The power supply module feeding power to the network shall consist of a built in backup power to compensate short voltage interruptions of up to 200 ms. This back-up power shall enable the system to put all actuators in a fail-safe position (either on or off or as it is) in the event of power failure.

H. The diagnostic modules shall scan the system for any faults in the bus wiring and display an alarm LED in the event of faults in the wiring.

I. Each of the devices shall have a built-in push button along with a LED. The LED shall lit in the event the push button is pressed and if there is power to the device, thus depicting that the device is communicating in the system.

J. In the event of power failure or bus wiring failure each of the system devices (switching modules and dimming controllers...etc.) shall be programmed to attain a fail safe position (controlled circuits to become "On", "Off" or "As it is, Last status")

K. All devices in the system shall be compliant to CE and IEC standards and should be manufactured in accordance with the EMC and the low voltage guidelines. Full compliance with EIBA standards and guidelines is a must. All devices shall be EIBA certified.

END OF SECTION

SECTION 16425

MAIN DISTRIBUTION BOARDS

1.1 GENERAL

ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Section 16010 of the Specification.

DESCRIPTION OF WORK: main distribution board(s) (MDBs) for low voltage (LV) distribution, ancillary mounting frames, fittings, cable termination accessories and supports.

STANDARDS:

- A. MDBs panels to be manufactured in accordance to IEC 439-1, Factory-Built, and in full compliance with form 2B otherwise as indicated on drawings. **ALL MDB, MCC & PP panels to be partially type tested.**
- B. Circuit breakers are to comply with IEC 947-2 as specified.
- C. Other components, where not otherwise specified, are to comply with the relevant IEC standards.
- D. Board / panel builder shall submit calculation sheets for heat dissipation within enclosure verifying that adequate ventilation is provided (natural and / or forced) with no derating of components inside enclosure.

EQUIPMENT DATA: submit for approval detailed description of main distribution boards and major components supported by manufacturer's catalogues, indicating compliance with the Standards, 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 busbars, isolating, earthing, interlocks, control devices, indicating and metering instruments etc.

TESTS AND CERTIFICATES: submit complete manufacturer's routine test records, in accordance with the local & IEC Standards.

EMERGENCY DISTRIBUTION BOARDS (16425) (CONT'D)

SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

plans and elevations with indication of built-on equipment, exact dimensions and weights

arrangement of boards inside rooms allocated, indicating spaces and clearances

arrangement of equipment inside board

one-line diagram of power system showing current ratings of switchgear and busbars and types and locations of protective gear (relays, instruments, CTs, VTs etc.)

schematic and elementary diagrams of control circuits

foundation details, grouting holes, installation details

arrangement of incoming and outgoing feeders, terminal fittings, instruments, busbar connections etc.

Tightening torque levels of all bolts related to breakers as per breaker's supplier data Sheet. (Torque levels to be submitted for approval)

TECHNICAL LITERATURE: submit the following for approval prior to placing orders for equipment manufacturer:

schedule of circuit breakers application, indicating type, range, features and characteristics, short-circuit ratings, time-current curves etc.

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 pointstest methods on site and references.

SPARE PARTS: provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the following:

one set of fixed and moving contacts for every type of replaceable (consumable) contact set

one operating motor and/or coil for each type of electrically operated circuit breaker

two sets of each type of indicating lights, fuses, LEDs etc.

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.

APPROVED MANUFACTURERS: obtain main distribution board from one of the following:

For components:

Moeller (Germany)

Schneider (France)

For enclosures

A. Eaton (USA)

B. Logstrup (Denmark)

C. Cubic (Denmark)

D. Prisma (France)

2. PRODUCTS AND SYSTEMS

EMERGENCY DISTRIBUTION BOARDS AND ACCESSORIES

2.1. GENERAL REQUIREMENTS

2.1.1. **GENERALLY:** Main distribution boards are to be dead-front type, metal enclosed, multi-cubicle, floor mounted, free standing, 600 V class of service switchboards, with fixed or draw-out switchgear, manually or manually and electrically operated, as shown on the Drawings, with matching vertical sections to form a continuous integral and rigid structure. All accessories to be of the same manufacturer matching the original type tested certificate, with 25% spare space to be provided with all proper accessories (Basbars,...)

2.1.2. **GENERAL CONSTRUCTION:** rigidly framed and bolted, with electro-galvanized sheet steel enclosures, minimum thickness 2 mm, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating, grey color (RAL 7032 or ANSI 61) to approval. Panels to be to be vermin, dust and rodent proof, IP42 protection to IEC 144 for indoor installations, with adequate lifting means and base-frames and capable of being moved into position and directly bolted to floor without additional sills.

- 2.1.3. VENTILATION: compartments are to be ventilated, where required, by approved methods complying with the Standards.
- 2.1.4. FASTENINGS between structural members are to be bolted.
- 2.1.5. EXTENSION of structure and busbars is to be possible at either end of switchboard.
- 2.1.6. ARRANGEMENT is to permit incoming and outgoing busbars and cables to enter enclosure as indicated on the Drawings and connect at respective terminals without inconvenience to installation or maintenance, according to form 4 of IEC 439-1.
- 2.1.7. REMOVING CIRCUIT BREAKERS: suitable arrangements and equipment are to be provided for extracting, lifting and unloading switchgear from enclosures as appropriate for type of switchgear.
- 2.1.8. SPARE AND SPACE POSITIONS are defined as follows:
spare position : fully equipped enclosure with switchgear
space position : fully equipped enclosure ready to receive switchgear.
- 2.1.9. BUSBARS: to be site rated for normal current as shown on the Drawings or at least site rated to same rating of main circuit breaker frame size, and braced for a symmetrical rms short-circuit duty equal to or higher than main circuit breaker interrupting duty, for minimum of one second unless otherwise specified or shown on the Drawings. Busbars are to be Rigid copper, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to maximum 50 deg. C above average ambient temperature of 35 deg. C outside enclosure. Connections and buswork are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance.
- 2.1.10. CONNECTIONS from busbar to switchgear are to be rated to carry full continuous current rating of switchgear frame and are to be insulated.
- 2.1.11. FULL SIZE NEUTRAL is to be continuous through all sections. Neutral bus is to be insulated and separate from earth bus and connected to it with removable links.
- 2.1.12. EARTH BUS is to 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.
- 2.1.13. BOARD TYPE: board(s) are to be of the Front accessible wall aligned, with fixed main circuit breaker sections (type and rating as shown in schedules) and fixed group mounted outgoing MCCB distribution section(s) as per form 4A or as per drawings with all needed separation.

- 2.1.14. **FIXED MAIN CIRCUIT BREAKER SECTION** is to individually accommodate main circuit breaker, main cable entry with terminal fitting assembly and metering compartment. Where required an additional cable pull section is to be provided, depending on actual configuration shown on the Drawing. Where placed against a wall, accessibility is to be possible from front and sides or only from front of section.
- 2.1.15. **FRONT ACCESSIBLE FIXED GROUP-MOUNTED FEEDER MCCB DISTRIBUTION SECTIONS** are to rear align with main section(s) and be of uniform depth, with all devices removable from the front and mounted on a panelboard type base. Construction is to allow all connections and maintenance to be made without rear access. Cables are to be accommodated in extra wide vertical gutters. Sides, top and rear are to be covered with removable screw-on plates having formed edges all around. Front plates are to be sectionalized and removable, covered by trims, and secured by self-tapping screws

2.1 Power Circuit Breakers (ACBs)

Air circuit breakers to be installed as shown on drawings & in accordance to IEC 947.

2.2.1- Type:

Encased in high strength, high temperature resistant, molded plastic insulating materials, for normal operation at 70°C within enclosure, to approve standards, manually operated of normal functions, and automatically tripped under over current conditions. Trip power is to derive from main power circuit, with sufficient tripping energy to reliably trip circuit breaker.

2.2.2-Construction:

Manually or manually and electrically operated, as shown on the drawings, with two-step, spring charged, stored energy mechanism, quick-make, quick-break type, electrically and mechanically trip-free, to prevent maintaining circuit breaker closed against over current condition whether under manual or automatic operation. Electrically operated circuit breakers are to have integrally mounted, spring charging motor mechanism.

Both manually or manually and electrically operated circuit breakers are to have mechanical built-in charging lever and are to include open and close direct acting push buttons. Stored energy provision is to allow open/close/open sequence of operation without use of external energy. Safety feature is to allow discharging stored energy without closing circuit breaker. Circuit breaker is to have are quenching device on each pole and replaceable arcing contacts.

2.2.3- Rating:

3-pole, 600V class, with continuous current rating (frame size) as shown on the drawings, ranging between 400A and 4000A (400, 800,1200,1600, 2000, 2500, 3000, and 4000A), fully rated (100%) for service under worst site conditions. Breakers are to be rated for a symmetrical rms service short-circuit breaking capacity as shown on the drawings, to IEC 947-2 sequence II (rated service short-circuit breaking capacity) at specified voltage and frequency, meeting IEC 947-2, sequence I, II, III and IV tests (for circuit breakers of utilization category B), tested in an enclosure substantially the same as the enclosure in which they are to be installed.

2.2.4- Trip Unit:

Trip Unit is to be totally enclosed, solid state device, interchangeable for compatible frame sizes, luggable into front of circuit breaker, tamper-proof and with transparent, sealable cover. Trip unit is to be direct-acting, current transformer operated, with flux transfer shunt trip that requires no external power. It is to have adjustable ampere setting (0.5 – 1.0 times sensor rating) with adjustable long-time delay, short-time pick-up and short-time delay, earth-fault pick-up and time delay and over-ride instantaneous discriminator. Current setting range is to be by replaceable elements within the maximum frame size rating.

2.2 Power Circuit Breakers (ACBs) (CONT'D)

Once removed, circuit breaker is to remain in the trip-free position. Earth-fault trip is to be adjustable, range up to maximum 1200A. with adjustable time delay between 0.1 and 0.5 seconds. Short time delay is to be adjustable in steps, 2-10 times sensor rating, with settable or adjustable time band having maximum fixed delay of 0.2 seconds. Selective over-ride protection is to allow full sensitivity up to interrupting capacity of circuit breaker.

2.2.5- Position Indicators:

Position indicators are to be positive with trip indication target. Target indicator is to be mechanical and is to give indication even when control power has been lost.

2.2.6- Circuit Breaker Accessories:

Circuit Breaker Accessories are to include the following:

- Pad-locking or key-locking provisions for all positions (disconnected, test, connected, closing blocking, open).
- Overload, short-circuit, and ground fault trip LEDS.
- Trip indicator and reset button.
- On/off pilot lights
- Shunt-trip coil and closing solenoid for remote control.

2.2.7- Auxiliary Contacts:

Auxiliary Contacts are to include N.O. and N.C. contacts on switchgear as required, plus 2 N.O. and 2 N.C. spare contacts.

2.2 MOULDED CASE CIRCUIT BREAKERS (MCCBs)

2.2.1 MCCBs GENERALLY are to be thermal-magnetic type for ratings below 600 A frame size, unless otherwise shown on the Drawings. MCCBs 400 A and larger are to be electronic solid-state trip type. All circuit breakers are to be 3-pole unless otherwise shown on drawings.

2.2.2 CONSTRUCTION: totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials, for normal operation at 70 deg. C within enclosures, to approved standards, provided with quick-make, quick-break, trip-free switching mechanism manually operated by front toggle type handle and automatically tripped under overcurrent conditions. Multi-pole breakers are to have common integral trip

bar for simultaneous operation of all poles. Contacts are to be non-welding silver alloy with arc quenching metallic devices of approved construction. Cable terminals are to be solderless anti-turn box lug or clamp type with set screws suitable for copper or aluminium cables.

- 2.2.3 **THERMAL OVERCURRENT TRIPS** are to be compensated to allow for ambient temperature higher at breaker than at protected circuit or device. Compensation is to be applicable between 25 and 50 deg. C. In case of adjustable thermal settings, range of adjustment is not to exceed maximum trip rating shown on the Drawings.
- 2.2.4 **ELECTRONIC TRIP CIRCUIT BREAKERS** are to have solid state trip units with long time delay setting range at least between 0.5 and 1.0 times maximum trip rating, 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 are to be insensitive to changes in ambient temperature between -20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified, and is to be adjustable between 0.2 and 0.6 normal phase current pick-up with maximum time delay of 0.2 seconds, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.
- 2.2.5 **TRIPPED POSITION:** when tripped automatically by overcurrent condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.
- 2.2.6 **INTERCHANGEABLE TRIPS:** circuit breakers larger than 250 A are to have interchangeable thermal and magnetic top units and breakers with frame 400A and larger to have electronic trip units.
- 2.2.7 **SEALING:** non-interchangeable trip circuit breakers are to have sealed covers. Circuit breakers with interchangeable trips are to have trip unit covers sealed to prevent tampering.
- 2.2.8 **CIRCUIT BREAKER RATINGS** are to be non-current limiting, fully rated (100%) with continuous duty at site conditions, and with frame size and interrupting capacity to IEC 947-2, sequence II (rated service short-circuit breaking capacity), and maximum trip rating as shown on the Drawings. Interrupting capacities at specified voltage and frequency are to meet IEC 947-2 test sequence I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability).
- 2.2.9 **ACCESSORIES:** circuit breaker design is to allow addition of electrical operator, control and interlocking functions, under-voltage release, shunt-trip coils, alarm and auxiliary switches, padlocking devices, key-lock devices, and the like. Such accessories are to be provided where shown on the Drawings.

2.1. METERING INSTRUMENTS

Digital Power-Metering: Microprocessor-Board with suitable for 3 or 4 wire system and with the following features:

- 1- Switch selectable digital display of the following values with maximum tolerances as indicated:
 - a. Phase currents, Each phase $\pm 1\%$.
 - b. Phase to phase voltages, 3 phases $\pm 1\%$.
 - c. Phase to Neutral voltage, 3 phases, $\pm 1\%$.
 - d. Megawatts: $\pm 2\%$.
 - e. Megavars: $\pm 2\%$.
 - f. Power factor : $\pm 2\%$.
 - g. Frequency $\pm 2\%$.
- 2- Flush or Semi-flush for all metering devices.

For each EDSB, PP, DP provide one digital power meter for all electrical measures.

- 2.1.1. CURRENT TRANSFORMER (CT): indoor dry type, rated secondary current 5 A. Rated primary current, core size and accuracy are to be determined in accordance with nominal current of plant protected, short-circuit level and burden.

2.2. WIRING

- 2.2.1. ARRANGEMENT: wiring is to be modularly and neatly arranged on master terminal boards with suitable numbering strips and appropriate cartridge type fuses where required.
- 2.2.2. CONNECTIONS are to be made at front of terminal board and with no live metal exposed.
- 2.2.3. METAL CASES of instruments, control switches, relays etc. are to be connected, by bare copper conductors not less than 2.5 mm² section, to nearest earthing bar.
- 2.2.4. 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 are to be used in proximity to higher temperature components and as flexible cable.
- 2.2.5. FERRULES: wires are to be fitted with numbered ferrules of approved type at each termination.

3. FIELD AND INSTALLATION WORK

3.1. INSTALLATION

- 3.1.1. 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.

- 3.1.2. **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.
 - 3.1.3. **BUILT-IN ITEMS:** ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.
 - 3.1.4. **EQUIPMENT:** install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.
 - 3.1.5. **SUPPORTS AND TERMINATIONS:** install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables. All circuit breaker bolts to be tightened in according to torque level as specified by circuit breaker manufacturer.
 - 3.1.6. **RELAYS:** set in accordance with manufacturer's instructions and in accordance with an approved scheme.
 - 3.1.7. **MAKE GOOD** damaged 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 the Engineer.
- 3.2. **INSPECTION AND TESTS ON SITE**
- 3.2.1. **EQUIPMENT:** inspect equipment upon delivery to Site and report any damage to the Engineer.
 - 3.2.2. **SWITCHGEAR:** inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.
 - 3.2.3. **TESTS:** after installation and before handover, carry out all tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including insulation resistance tests and operational tests.
 - 3.2.4. **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.
 - 3.2.5. **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.

- 3.2.6. INSTANTANEOUS TRIP ELEMENTS: test by high current primary injection, using high-current primary injection test-sets and report all readings.
- 3.2.7. ROUTINE TESTS ON SITE are to be carried out on every main distribution board in accordance with the Standard specified (IEC 439 or BS 5486: Part 1) 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 the Engineer.

END OF SECTION

SECTION 16440

WIRING DEVICES AND DISCONNECTORS

PART 1 GENERAL

1.1 Related Documents

Drawing and general provisions of the Contract, including General Conditions, Conditions of Particular Application and Division-1 Specification Sections, apply to work of this section.

1.2 Summary

This section shall cover various types of receptacles, connectors, switches and finish plates

Submittal

Submit the following according to the Conditions of the Contract and Division 1 Specification Sections:

- **Product Data:** Data shall be submitted for each product specified in this section, with catalog clippings and manufacturer technical specifications.
- **Samples** Provide three (3) samples for each device which shall be used and for all relevant accessories (cover, plates). Color selection and technical features shall be complied with the requirements of codes and of the Engineer.
- **Operation and Maintenance Data:** Provide operation and maintenance data for materials and products specified in this section.

1.4 Quality Assurance

Products shall be supplied from one manufacturer.

Manufacturer shall be regularly engaged in manufacture of electrical devices, sizes, and ratings. These products have been in satisfactory use and in service for not less than 2 years. Products shall be complied with requirements of local codes and IEC Standards.

PART 2 PRODUCTS

2.1 Manufacturers

Approved manufacturers subject to compliance with requirement. Wiring devices shall comply fully with the relevant Local, and International Standards.

All types shall be of the same manufacturer to provide consistent appearance and finish.

2.1 **Manufacturers (Cont'd)**

Rated voltage and ampere should be indicated on all wiring devices, fixed screen shall be installed to separate live parts in case of multi-phase exists in one box.

Approved Manufacturer

- Legrand Arteor White
- Or approved equal

2.2 **Wiring Devices**

2.2.1 **Boxes and Fittings**

Boxes shall be provided with means for securely terminating conduits.

Heavy-molded rigid PVC boxes shall be provided with brass insert threads and fixed lugs to receive cover screws.

Round boxes shall not be used where conduits or connectors requiring the use of locknuts or bushings are to be connected to the side of the box.

2.2.2 **Plates**

Plates shall be of square or rectangular shape to adequately cover corresponding outlet boxes and be designed to fit the electrical devices, Various samples shall be submitted for approval and/or selection by the Engineer.

Fixing screws shall be chromium plated, polished. Screw head shall suit the plates.

Combination (multi-gang) plates shall be provided for grouped outlets and devices as detailed on the Architectural or Electrical Drawings.

Plates for socket outlet shall match switch plates in each particular area.

The Contractor shall supply a unified standard type socket (receptacle) outlet for the whole project, preference shall be given to French or German type sockets.

Socket outlet shall be rated 15 amp, 16 amp, 20 amp, 30 amp, as noted on drawings and 250 volts with two rounded poles plus earth, 20 mm spacing. The earth terminal of each socket shall be effectively connected to the earth continuity conductor, phase and neutral conductors to the respective terminals.

Socket outlet shall have a moulded plastic or porcelain base and be designed to fit the appropriate plate as required or as approved, before execution, by the Engineer.

Sockets above desks in guest rooms for client use to be multi-standards type.

2.2.3 **Socket (Receptacles) Outlets**

Contacts shall be self-adjusted and have a non-expanding size limiting entry, to prevent permanent distortion.

Where duplex socket outlets are shown on Drawings, two of this type of socket shall be mounted under one common plate.

Weatherproof socket outlets shall be mounted in the box specified with a gasketed, weatherproof cast-metal cover plate, with individual cap over each socket outlet opening and stainless steel mounting screws. Caps shall be tightly closed with stainless steel springs when socket outlet is not in use.

Door bell push button shall be with label holder.

Outlets for internal use shall generally be of the insulated pattern ivory finish, color to be selected by Engineer. In utility and workshop areas metal clad enclosures and finishes shall be used.

Outlets for exterior use shall be weatherproof pattern enclosed in Glassfibre Reinforced Plastic (GRP) or galvanized metal boxes.

Terminals for 220 V outlets shall each be capable of receiving and satisfactorily connecting two (2) conductors (solid or stranded), each of 4 mm² minimum.

Contact pressure with conductors shall preferably be by clamp plate rather than by pinch screw.

Socket outlets for flush fitting shall be mounted in appropriate recessed box.

Socket outlets and their enclosures shall be complete with necessary terminals for the connection of circuit protective conductors as required by the IEE Regulations and IEC latest edition.

Boxes providing enclosure and/or mounting for socket outlets shall be PVC if concealed or galvanized steel if exposed complete with conduit entries.

2.2.4 **Power Outlets:** Industrial. pattern socket outlets shall comply with IEC 309-2 and shall be fitted with a switch interlock and fuse. Unless specifically detailed, 3 phase with neutral and earth , 380 V sockets shall be fitted. Rating of power socket and number of poles shall be according to the Drawings and/or data sheets.

Power sockets shall be IP 55, made of high tech polymer material, water resistant and supplied with its compatible plug. Earth pole shall be 6 h for all kind of power sockets.

2.2.5 **Load Break Switches (LBS) or Disconnect Switch**

Load break switches shall be provided and installed as shown on Drawings and on wiring schedules.

Electrical characteristics of load break switches such as Ampere rating and number of poles shall be as indicated on Drawings, wiring schedules and/or as herein specified: Ratings have to be readjusted by the Contractor and approved by the Engineer before ordering if the served load is different than that shown in wiring schedules.

The LBS shall be a non-fusible, single-throw, as indicated on Drawing, provided with arc quenching devices on each pole, making it capable of interrupting at least six times the normal switching current.

Switches shall effectively interrupt the power supply for all line conductors where it exists, and simultaneously disconnect the supply for control circuits.

The operating mechanism shall be quick-make, quick-break with the external operating handle mechanically interlocked with the enclosure cover.

Interlocks shall make it necessary for the switch to be in the "OFF" position for normal access to the inside of the enclosure. Switch shall have means of by-passing the interlocks.

Any LBS shall be so placed that gravity shall not tend to close when approved for use in the inverted position, it shall be provided with a locking device that will ensure that the blades remain in the open position when so set.

Indication to the position of the switch shall be positive and clearly indicated on the cover.

Enclosure shall be EEC type IP40 for general purpose application, unless otherwise noted and IP65 for weatherproof installations unless otherwise required.

Enclosure shall have provisions for locking the operating handle in the "OPEN" and "CLOSED" positions.

2.3 **Touch-up Paint**

The surface of all wiring devices shall be of the manufacturer's finish according to location and the Engineer approval.

2.4 **Factory Inspection and Testing**

Prior to shipping, all units shall be inspected and shop tested to assure proper operation and compliance of the wiring devices with the requirements of specifications. The inspection and testing shall be in accordance with equipment standards. In addition, all tests shall be complied as specified in the specification sections describing the devices.

PART 3 **EXECUTION**

3.1 **Installation**

3.1.1 **General:** Flush-mounted boxes shall be cast in concrete walls and grouted into hollow walls. Metal boxes threaded to raceways in exposed installations shall be separately supported.

Boxes installed in concealed conduit or raceway systems shall be set flush with the finished surfaces. The location of all boxes shall be easily accessible and any

interference with mechanical equipment or structural features shall be relocated as directed by the Engineer.

- 3.1.2 **Sockets**: The sockets shall be located and installed as shown on the Drawings. The location shall be easily accessible. Receptacles shall be so installed that the neutral (grounded) pin is always on the left side or top side, when viewed facing the installation.
- 3.1.3 **Switches**: Local wall switches near doors, shall be located at strike side of doors as finally hung, whether so indicated on Drawings or not.

A junction box shall be placed in the back of each wall mounted switch or socket outlet.

If thickness of wall does not permit such an installation, adjacent position shall be accepted.

The switches shall be installed as shown on the approved Drawings. Where more than one switch is shown for one indoor outlet box, the switches shall be installed under one plate. Toggle switches for lighting, except for 3-way and 4-way switches shall be installed so that the contacts are closed when the handle is in the up position.

Switches shall be mounted with longer dimension vertical and operating handle in upward position when in the "ON" position.

Single pole switches shall switch the (phase) wire circuit. Neutral wire shall not run through switches provided with a neutral shunt or bridge.

- 3.1.4 **Device Plates**: Device plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. device plates shall be installed vertically with an alignment tolerance of 0.16 mm (1/16 inches).
- 3.1.5 **Mounting Height**: The mounting height of wall-mounted outlet and switch boxes; measure between the bottom of the box and the finished floor, shall be as specified and as approved by Engineer.

3.2 **Grounding**

Grounding system shall be installed as required by the drawings, and as specified herein. Neutral conductors of the wiring system shall be grounded at the transformer secondaries and at the panelboards, the grounding connections shall be made as indicated on Drawings, and as required by the IEC Code.

Devices grounding connections shall be made by means of screw-type pressure connectors to the box's frame and receptacle ground pin in accordance with the IEC Code.

3.3 **Field quality Control**

Provide checking, adjusting and testing operations on the wiring devices installation including the following:

Check: All wire terminals shall be checked to assure tight connections, electrical continuity and for short circuit.

Operate each device at least 6 times. All wiring services shall be clean before energizing.

- Adjust: Adjust wiring devices to operate in the indicated and required sequence.
- Testing: The tests shall be performed to detect wrong connections, short circuits, continuity,

Test wiring devised for proper polarity and ground continuity.

Replace damage or defective components.

END OF SECTION

SECTION 16452
EARTHING SYSTEM

1. GENERAL

- 1.1. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Section 16010 of the Specification.
- 1.2. DESCRIPTION OF WORK: complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TNS system arrangement, including:
 - transformer neutral earthing.
 - main earthing terminals or bars.
 - exposed conductive parts of electrical equipment.
 - extraneous conductive parts.
 - standby generator neutral earthing.
- 1.3. REGULATIONS AND STANDARDS: carry out work in accordance with the following:
 - 1.3.1. IEC publications 364-3 and 364-4-41 Electrical Installations in Buildings
 - 1.3.2. latest edition of IEE Regulations for Electrical Installations in Buildings - London.
- 1.4. DEFINITIONS OF TERMS used on the Drawings and in the Specification are as follows:
 - 1.4.1. EARTH: conductive mass of the Earth whose electric potential at any point is conventionally taken as zero
 - 1.4.2. EARTH ELECTRODE: conductor or group of conductors in initial contact with, and providing electrical connection to, Earth
 - 1.4.3. EXPOSED CONDUCTIVE PART: any part which can be readily touched and which is not a live part, but which may become live under fault conditions
 - 1.4.4. EXTRANEIOUS CONDUCTIVE PART: any conductive part not forming part of the electrical installation such as structural metalwork of a building, metallic gas pipes, water pipes, heating tubes etc. and non-electrical apparatus electrically connected to them i.e. radiators, cooking ranges, metal sinks etc. and non-insulating floors and walls.

- 1.4.5. **PROTECTIVE CONDUCTOR:** conductor used for some measure of protection against electric shock and intended for connecting together any of the following parts:
- exposed conductive parts
 - extraneous conductive parts
 - earth electrode(s)
 - main earthing terminal or bar(s)
 - earthed point of the source(s)
- 1.4.6. **ELECTRICALLY INDEPENDENT EARTH ELECTRODES:** earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other(s)
- 1.4.7. **MAIN EARTHING TERMINAL OR BAR:** the terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.
- 1.4.8. **EQUIPOTENTIAL BONDING:** electrical connection to put exposed and extraneous conductive parts at a substantially equal potential.
- 1.4.9. **EARTHING CONDUCTOR:** protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.
- 1.5. **EQUIPMENT DATA:** prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for earth rods, connecting clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits and tools etc., and samples of conductors as requested.
- 1.6. **SHOP AND CONSTRUCTION DRAWINGS:** submit drawings for approval including, but not limited to, the following:
- A. exact location of earth pits, rods and details of installation and connections.
 - B. exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.
 - C. cross sectional area of all earthing, protective and bonding conductors.
 - D. layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

- 1.7. APPROVED MANUFACTURERS: obtain materials from one of the following:

Kingsmill	(England)
Copperweld	(U.S.A.)
Furse	(England)
OBO Bettermann	(Germany)
Wallis	(UK)

or other equal and approved.

2. PRODUCTS AND SYSTEMS

EARTHING SYSTEM (TYPE TT)

2.1. GENERAL REQUIREMENTS

- 2.1.1. COMPONENT PARTS of earthing system are to include the following:

earth electrode (rods, tapes etc.)

main earthing terminals or bars

earthing conductors

protective conductors

equipotential bonding conductors

electrically independent earth electrodes for special systems

accessories and termination fittings, bonding, welding kits and other materials.

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

2. PRODUCTS AND SYSTEMS (CONT'D)

- 2.1.3. RING TYPE EARTH ELECTRODE is to consist of earthing conductors, in a closed loop, buried in exterior wall foundations underneath the water-proofing, or alternatively at 0.6 m around the perimeter of the building foundations, as shown on the Drawings, to which all earthing conductors are to be connected. Insulated connection flags into the building, of same material as earthing conductors, are to be located at positions of service entrance and main switchboard rooms, terminating in bolt-type earth points (studs) or test-links for connection of main earth bar(s). Additional earth rods

connecting with the earth ring are to be provided, as necessary, to bring down earth electrode resistance to an acceptable value.

- 2.1.4. FUNCTIONAL EARTH ELECTRODE is to be provided separately from, but interconnected to, other earth electrode(s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.
- 2.1.5. ALTERNATIVE EARTH ELECTRODE: other types of earth electrode may be used, after approval, including:
- A. cast iron pipes with special surround material
 - B. plate(s)
 - C. tape mats (strips).
 - D. MAIN EARTHING BAR is to be provided at point of service entrance or main distribution room, and as described in the Specification or shown on the Drawings, to which all earthing conductors, protective conductors and bonding conductors are to be connected. Two insulated main earthing conductors are to be provided, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 120 mm² or as otherwise required by the particular Section of the Specification.
 - E. TESTING JOINTS (TEST LINKS) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar and earth electrode.

2. **PRODUCTS AND SYSTEMS (CONT'D)**

- F. PROTECTIVE CONDUCTORS are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes. Selection of sizes is to be in accordance with Table 54F of IEE Regulations.
- G. PROTECTIVE CONDUCTORS are not to be formed by conduit, trunking, ducting or the like. Where armoured cable is specified and armour is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.
- H. CONTINUITY OF PROTECTIVE CONDUCTORS: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive

parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/or brazing to continuous protective conductors which are to be insulated by moulded materials.

- I. EARTH FAULT LOOP IMPEDANCE: for final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on overcurrent occurs within 0.4 seconds, and for final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds. Use appropriate tables and present same for approval by the Engineer (IEE Regulations: Tables 41A1 and 41A2, Appendix 7 and Regulation 543).
- J. SUPPLEMENTARY EQUIPOTENTIAL BONDING: all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armour are to be connected to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor is not to be less than half that of the protective conductor connected to respective earthing terminal, and minimum 4 mm².
- K. IDENTIFICATION: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labelled in accordance with the Regulations, as follows:
- L. SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE.
- M. IDENTIFICATION: protective and earthing conductors are to be identified by combination of green-and-yellow colors of insulation or by painting bar conductors with these colors, as approved.
- N. IDENTIFICATION: source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labelled 'neutral earthing'.

2.2. TRANSFORMER SUBSTATION EARTHING

Not applicable

2.2. TRANSFORMER SUBSTATION EARTHING (BY EDL)

- 2.2.1. TRANSFORMER NEUTRAL
Not applicable

- 2.3. EARTHING OF MAIN DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES
- 2.3.1. MAIN EARTHING BAR is to be provided in main distribution room and connected to earth electrode by two insulated conductors (minimum 120 mm²) via testing joints.
- 2.3.2. EARTHING BARS OF MAIN DISTRIBUTION BOARDS are to be connected, by bare earthing conductor, directly to main earthing bar at main distribution room and by protective conductor run with incoming feeder from respective supply point.
- 2.3.3. DISTRIBUTION, LIGHTING AND POWER PANELBOARDS are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main distribution board earthing bar.
- 2.3.4. SOCKET OUTLETS are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.
- 2.3.5. FINAL RING SUBCIRCUITS: protective conductor of every final ring subcircuit is to be in the form of a ring having both ends connected to earth terminal at origin of circuit in panelboard.
- 2.3.6. LIGHTING FIXTURES AND OTHER EXPOSED CONDUCTIVE PARTS of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panelboards.
- 2.4 GENERATOR PLANT EARTHING
- 2.4.1. GENERATOR NEUTRAL
- Connected to earthing system.
- 2.4.2. EXTRANEOUS CONDUCTIVE PARTS including steel frames, battery racks, day-tank, pumps and piping are to be connected by bare copper earthing conductors to main earth bar in compliance with bonding regulations.
- 2.4.3. Lightning Arresters are to be connected to the bus bar of the panel it is protecting, distance between arrester & earth bar plus distance between arrester & main breaker of panel should be < 0.5m.
- 2.5. MECHANICAL PLANT ROOMS AND FIXED MACHINERY
- 2.5.1. MAIN EARTHING BAR OR LOOP is to be conveniently located in mechanical plant rooms, and connected by earthing conductors to exposed conductive parts of motor control centre at its earthing bar, and to motors, switches and other electrical equipment etc. at their

earthing terminals, using 20 x 2 mm bare copper strips or 35 mm² bare copper conductor (minimum size) or as required to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200 deg. C. Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.

2.5.2. MAIN EARTHING BAR OR LOOP is to be connected at two extremely separate points to earth electrode, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.

2.5.3. MOTOR AND OTHER EQUIPMENT EARTH TERMINALS are to be connected also by protective earth conductors of each branch circuit to earth terminal/bar at motor control centre, panel or distribution unit.

2.6. ROAD LIGHTING (when applicable).

2.6.1. EARTHING CABLES: separate protective earthing cables for lighting column circuits are to be run with power circuit, terminated at LV supply position in lighting control panel and looped into column earthing terminals. Every column is to be bonded via an earthing bolt to a single 14 mm diameter copper covered steel rod, 2.5 m long, driven into ground adjacent to column. Bonding is to be 16 mm² stranded bare copper conductor.

2.6.2. CONNECTIONS between rods and earthing conductors are to be made by the Cadweld process producing a fused joint. Bolted connections may be used for connection to removable items of equipment only.

2.7. MATERIALS AND PRODUCTS

2.7.1. EARTH ROD: Non Corrosive stainless steel, 20 mm diameter, 3 m length, extendible as necessary to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.

2.7.2. BURIED EARTH CONDUCTORS: bare annealed Non corrosive stainless steel strip conductors 25 x 2.5 mm, or annealed stranded stainless steel 95 mm² cross-section.

2.7.3. TAPE MATS: where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4 m

apart, welded together by exothermic welds to form a grid. Tape is to be 25 x 2.5 mm strip conductor.

- 2.7.4. EARTH PIT: precast, square or circular section concrete handhole (minimum 450 mm internal diameter), with concrete cover, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod where connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth Pit - Do Not Remove'.
- 2.7.5. EARTHING CONDUCTORS: insulated or bare copper conductor as described in the Specification for the particular application.
- 2.7.6. TESTING JOINTS (TEST LINKS): copper, stainless steel or copper alloy as applicable, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.
- 2.7.7. PROTECTIVE CONDUCTORS: single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming part of a multi-core cable, color coded.
- 2.7.8. MAIN EARTHING BAR: hard drawn copper, 40 x 4 mm where formed into a closed loop, and 50 x 6 mm where open ended. Earth bar is to be labelled 'Main Earth Bar' and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.
- 2.7.9. PROTECTIVE BONDING CONDUCTORS: bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in sub- section 1 hereof.
- 2.7.10. EARTHING ACCESSORIES: copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross-section and current carrying capacity. Connectors and clamps are to be bolted type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.

3. FIELD AND INSTALLATION WORK

3.1. INSTALLATION

- 3.1.1. CONTINUITY: ensure that complete earthing system is electrically continuous and mechanically secure.
- 3.1.2. EARTH RODS: while sitting earth rods, ensure that resistance areas associated with individual rods do not overlap. Earth rods are to be

located at a distance greater than 600 mm from foundations of buildings. Where rock is encountered, a hole of sufficient size is to be drilled before lowering the rod. Conductive filler such as Marconite or Bentonite or equal filler that will not corrode, is to be provided around the rod.

- 3.1.3. BURIED EARTHING CONDUCTORS are to be laid at a depth not less than 0.8 m from ground surface.
 - 3.1.4. EARTHING CONDUCTORS are to follow shortest path between earth rods and main earthing terminals or bars, and are to run in PVC conduit (duct) fastened to building structure by approved supports and extending 0.2 m above level, and are to be protected against mechanical damage and corrosion.
 - 3.1.5. PROTECTIVE CONDUCTORS: separate protective conductors, which are not part of a cable, are to be fixed on same support or drawn into same conduit as circuit conductors.
 - 3.1.6. PROTECTIVE BONDING: remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.
 - 3.1.7. PROTECTION AGAINST CORROSION: protect bolted connections against corrosion either by filling with vaseline or coating with a special anti-corrosion compound and proper capping.
 - 3.1.8. CONNECTIONS: earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.
 - 3.1.9. CONNECTIONS: where earth connections between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound, or by wrapping with protective tape to exclude moisture.
 - 3.1.10. LIGHTNING ARRESTERS are to be directly connected to earth bar of the panel it is protecting, following the shortest path (distance between arrester and earth bar plus distance between arrester and main breaker < 0.5 m).
- 3.2. TESTS ON SITE AND RECORDS
- 3.2.1. COMBINED RESISTANCE of earth electrodes is to be measured during dry season and checked against specified resistance.
 - 3.2.2. ELECTRICAL CONTINUITY of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.

- 3.2.3. EARTH FAULT LOOP IMPEDANCE of all circuits is to be measured and checked against calculated impedance figures.
- 3.2.4. OPERATION of residual current protective devices is to be checked.
- 3.2.5. RECORDS: submit the following:
 - A. scaled drawings, as-installed, showing actual layout and specification of all components of earthing system
 - B. nature of soil and any special earth arrangements etc.
 - C. date and particulars of soil conditioning method and agents if used
 - D. test conditions and results obtained

END OF SECTION

SECTION 16480

MOTOR STARTERS

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide labor, materials, equipment and services, and perform operations required for installation of motor starters and related work as indicated on the drawings and specified herein.

Work Included: The work shall include, but not be limited to, the following:

1. Combination motor starters.
 2. Fractional HP manual motor starters.
- C. Related Work Specified Elsewhere
1. Basic Electrical Requirements - Section 16910
 2. Circuit and Motor Disconnects - Section 16170.
 3. Electrical Identification - Section 16195.
 4. Motor Control Centres - Section 16482.

1.02 QUALITY ASSURANCE

- A. Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.
1. Electrical Code Compliance: Comply with applicable electrical code requirements of the authority having jurisdiction.

1.03 SUBMITTALS

- A. Submit the following in accordance with the requirements specified under "Submittals" in section 16010.
1. Product Data: Submit manufacturer's and installation instructions on motor starters.
 2. Shop Drawings: Submit shop drawings of motor starters.
 3. Wiring Diagrams: Submit power and control wiring diagrams for motor starters. Differentiate between portions of wiring, which are manufacturer-installed, and portions, which are field-installed.

1.04 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and equipment specified herein in manufacturer's unopened containers, with manufacturer's name and point of origin on each container.
- B.
· Deliver materials and equipment and handle as to prevent the inclusion of foreign materials and the damage of materials by water or breakage.
- C. Store materials and equipment in clean dry place and assume responsibility and security for materials and equipment. Take precautions for protection from detrimental conditions.

1.05 SEQUENCING AND SCHEDULING

- A. Sequence motor starter installation work with other work to minimize possibility of damage and soiling during remainder of construction period.

1.06 MAINTENANCE

- A. Maintenance Data: Submit maintenance data and parts list for each motor starter and component; including "troubleshooting" maintenance guide. Include that data, product data and shop drawings in a maintenance manual; in accordance with requirements of Section 16010.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide motor starters of one of the following (for each type and rating of motor starter):
 - 1. Schneider
 - 3. Moeller.
 - 4. Katko.
 - 5. Or approved equal

2.02 MATERIALS AND EQUIPMENT

- A. Disconnect Type
 - 1. Disconnects shall be of the molded case circuit breaker, bolt-on type as specified.
- B. Motor Starters
 - 1. Except as otherwise indicated, provide motor starters and ancillary components which comply with manufacturer's standard materials, design and construction in accordance with published product information and as required for installation.

2. Equipment shall be the product of one manufacturer, unless located in a hazardous location, to insure standardization of spare parts, operation and maintenance.
3. Where motors furnished by the Contractor (subject to Engineer's approval) differ from the ratings indicated, the Contractor shall provide the required adjustments to wiring, conduit, disconnects, starters and protection as required.
4. Provide externally manually reset type thermal overload protection in each phase, located within the starter, and selected on the basis of the actual full load nameplate current rating of the motor, taking into account the reduction in current if capacitors are installed downstream of the overload protection.
5. Provide an individual control power transformer within each motor starter for motors, operating at voltages above 120 volts. Secondary voltage of the control power transformer shall be 120 volts, fused on one side and grounded on the other side. Do not connect switching contacts in the grounded side of the control circuits. Rating of the control transformers shall be adequate for imposed control devices 120 volts operating coils, pilot lamps, relays, etc. Provide primary fuse protection where required by the applicable electrical code.
6. Provide a minimum of two normally open and two normally closed auxiliary contacts (two convertible contacts are acceptable) in addition to a normally open "seal-in" contact. Where the required number of auxiliary contacts (spare plus active) cannot be mounted on the starter contractor, provide control relays within the starter enclosure.
7. Starters shall be enclosed. Enclosures shall be as requirements of IEC for indoor and outdoor, unless otherwise noted. Where installed in hazardous location, enclosures shall be suitable and as approved for the class, division and group in the classified area.
8. Minimum size of starter shall be as per requirements of IEC.
9. Starter contacts shall be as requirements of IEC rated. Where starters are utilized with high efficiency, high power factor motors, contacts shall be suitable for the higher than usual inrush currents associated with these motors.
10. Provide combination magnetic full voltage (across-the-line) single speed non-reversing starters unless otherwise indicated.
11. Motor starter panel enclosures and breakers shall abide by applicable paragraph of specifications in section 16116.

Motor Starters shall be built and sized in accordance with NEMA Industrial Control Standards, ICS-1970 or IEC 947 or approved equal.

Starters shall be non-reversing, magnetic type unless otherwise indicated or specified.

All starters shall be equipped with necessary control contact for connection to BMS.

Contactors shall have their contact easily accessible for inspection and maintenance.

It shall not be possible to remove the arc-quenching chamber when the contactor is energised.

The arc-quenching chamber shall be fully enclosed in order to prevent the escape of hot gases.

It shall be impossible to operate the main and auxiliary contacts manually by means of the position indicator.

Auxiliary switches shall be equipped with fail-safe linkage in order to exclude false signals.

The rated withstand voltage shall be 600 V and the test voltage shall be 3000 V for 1 minutes (IEC 9471).

The insulation class coil shall be "B" according to VDE 0660.

All starters shall comply with coordination type 2 per IEC 947-4-1 when installed in MCC, MSP, or PCP.

All starters shall be provided with thermal cutout devices in each phase calibrated for close protection of the motors against overloads. These devices shall trip the starters in case of overload and shall not allow it to be reset except manually. The thermal overload relays shall be adjustable from 90 to 110% of nominal rating. A single calibration adjusts all three legs. The overload relay shall be ambient compensated.

All motors 10 HP and larger shall have their starters equipped with integrated multiple function solid state motor protection for:

- Thermal overload
- Assymetry/ phase failure
- High overload/stalling

Motor starters larger than 20 hp. shall also have earth fault protection integrated within the solid state motor protection unit.

THE STARTER SHALL BE PROVIDED WITH AUXILIARY CONTACTS FOR THE CONNECTION OF SIGNALING, INTERLOCKING AND OTHER CIRCUITS AS REQUIRED FOR

THE CONTROLS.(AT LEAST 2 NO. + 2 C) AND AS REQUIRED BY BUILDING MANAGEMENT SYSTEM.

Unless otherwise indicated, all starters shall be provided with START-STOP pushbuttons, and RED & GREEN pilot lights, all located on the starter front cover. An overload reset button shall be provided inside the cover. Pushbuttons shall be momentary contact or maintained type as applicable to the function of control.

Starters shall have horsepower ratings at least equal to ratings of motors they serve.

Voltage of control circuit shall not exceed 220 volts.

Starters shall be electrically held in, providing inherent undervoltage release.

Starters when not part of a motor control center and are located indoors shall be encased in a NEMA 1 gasketed dust-proof enclosure, unless otherwise indicated.

"Star-delta" starters if any shall have additional "Star" and "Delta" contactors which shall be electrically and mechanically interlocked to close the motor in "Delta" connection with the supply after the "Star" contactor has opened. A timing device shall be fitted to provide and adjust time in "Star" before changing over to the Delta connection.

"Star-Delta" Starters shall provide close transition.

Schematic wiring diagram of all starters shall be provided on the interior of starter front cover.

Auto-transformer type starter shall not be approved.

C. Motor circuit protective device

Motor circuit protective devices shall comply with IEC standards 957-1 and 957-2. Alternative proposals to ratings shown on drawings based on manufacturers recommendations shall be subject to the Engineer's Approval. The Contractor shall in any case be responsible to assure that the circuit protective devices shall carry the starting current with no tripping, and if reducing trip rating results in a reduction in frame size, the Contractor shall make sure that the new rating withstands the available short circuit current.

D. Control Panel

Control panel of individual air handler units shall consist of individually mounted combination starters and shall also include all additional control and instrumentation devices as described under corresponding clause in mechanical section.

E. Combination Starters

Combination Starters shall comprise motor starters as specified hereinbefore and a moulded case circuit breaker in a NEMA 1 enclosure unless otherwise indicated. The circuit breaker may be a magnetic only type in lieu of thermal magnetic to the approval of the Engineer.

Combination starters shall be manufactured by GE (USA), ABB

F. Solid-State Reduced Voltage Motor Starter (Soft Starter)

Solid state , soft starter shall be used where indicated on drawings and shall be quoted separately as an alternative to star-delta starter.

1. The solid-state reduced voltage motor controller shall consist of a power section, a one-piece printed circuit logic board and a field wiring interface terminal board.
2. The power section shall be three-phase, 50 Hz. and rated for the hp, current, and voltage as shown on the drawings. It shall consist of three sets of back-to-back phase controlled power semi-conductors. Maximum current limit shall be 500% for standard units.
3. Resistor/Capacitor snubber networks shall be used to prevent false firing of SCR'S due to dv/dt characteristics of the system.
4. Fan cooled units shall be supplied with thermal sensors on the heat sink to trip the control protective logic for over-temperature condition. Thermal sensors shall be rated 90 °C maximum.
5. The one piece logic board shall be mounted for easy testing, service and replacement.
6. Three-phase current sensing via current transformers for closed loop control to insure motor stability shall be provided.
7. The logic board shall used quick disconnect plug-in connectors for current transformer inputs, line-and-load voltage inputs, SCR gate firing output circuits and status panel.
8. The logic circuitry shall include as a minimum:
 - a. Short circuit electronic trip overcurrent protection. Time not to exceed ½ cycle.
 - b. Inverse time running overcurrent protection.
 - c. Auxiliary trip circuitry.

- d. Gate firing circuit lockout protection on trip.
 - e. Fault relay lockout protection.
 - f. 250%-500% current limit adjustment.
 - g. Minimum and maximum voltage adjustments.
 - h. Voltage stability adjustment.
9. The logic board soldering shall be treated with a conformal protective coating system.
10. The logic board shall include, as standard, current and motor slip sensing circuitry that continually monitor motor load and regulate motor voltage to minimize motor kWh energy consumption.
11. The solid-state logic shall provide phase sequence protection.
12. External interface circuitry shall include 220-volt or 1120 volt relay logic interface capability.
13. Tripped functions shall be designed to be cleared by removing power from the solid-state logic board.
14. Controllers for motors larger than 200 hp shall have additional features as follows:
- a. Dwell time at current limit with ramp continuation after acceleration.
 - b. Individual light emitting diodes (LEDs) to indicate run, undervoltage, phase loss, phase current unbalance, overcurrent trip, overtemperature, current limit, end of ramp and incorrect phase rotation.
 - c. Single-phase protection with built-in short time delay.
 - d. Undervoltage protection with built-in short time delay.
 - e. The power section shall have metal oxide varistor (MOV) type surge suppressors across the SCRs rated 10% above the SCR rated voltage. The power semi-conductors shall be rated with peak inverse voltage at least 2.5 times SCR rated line-to-line voltage. Data shall be made available on tolerances to incoming line voltage surges or line spikes. Data shall include both magnitude and time content of each spike (voltage peaks and volt-seconds) plus tolerance to repetitive surges.
 - f. 100%-120% full load running current trip adjustment.
 - g. 200%-500% current limit adjustment.

15. Two ground lugs shall be furnished, one for incoming and one for outgoing ground connections.
16. Power terminations shall consist of pressure type terminals for top or bottom entrance.
17. Enclosure
 - a. Enclosures shall not be less than 16-gauge steel. Type 12 enclosures shall be of welded construction with gasketed heat sink and doors.
 - b. Doors shall include plastic device holders for mounting up to six (eight for above 200 hp motors) operator devices.
 - c. External and internal steel surfaces to be painted shall be thoroughly cleaned and phosphatized prior to application of paint. They shall then be primed with a corrosion-resisting coating. Cabinet and door finish shall be manufacturer's standard.
 - d. Controllers for motors above 200 hp shall include the following:
 1. The operating handle of the disconnect, when supplied, shall always remain connected to the breaker or switch. The operating handle shall not be mouted on the door of the enclosure, but on the controller for safe "stand-aside" operation. The position of the operating handle will indicate ON or OFF position of switch or circuit breaker and include provision for padlocking in the OFF position.
 2. Interlock provisions shall prevent unauthorized opening or closing of the starter door with the disconnect in the ON position.
 3. The structure, when floor-mounted, shall be provided with adequate lifting means and shall be capable of being rolled or lifted into installation position and bolted to the floor.
 4. A door-mounted status panel shall provide individual light emitting diodes (LEDs) to indicate run, undervoltage, phase overtemperature, current limit, end of ramp and incorrect phase rotation.

G. Fractional HP Manual Starters

Fractional HP Manual Starters: Single-phase fractional HP manual motor starters, of sizes and rating indicated. Equip with manually operated quick-make, quick-break toggle mechanism; and with one-piece melting alloy type thermal units. Starter to become inoperative when thermal unit is removed. Provide starters with double break silver alloy contacts, visible from both sides of starter; green pilot lights, and switch capable of being padlocked-OFF. Enclose starter unit in IEC general purpose enclosure suitable for flush mounting in finished areas and surface mounting in non-finished areas. Where installed in

hazardous locations, enclosure shall be suitable and approved for the class, division and group in the classified area. Coat with manufacturer's standard color finish.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Verify measurements and dimension at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades, so as not to delay job progress.
- C. Provide templates as required to related trade for location of items.

3.03 INSTALLATION

- A. Install motor starters as indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices; comply with applicable requirements of the applicable Electrical Code, IEC standards, to insure that products fulfill requirements.
- B. Provide disconnect switches at motors where shown on the drawings or where required by the applicable electrical code.
- C. Install equipment at uniform heights with operating means at convenient heights above the floor.
- D. Wire motors, starters and controls in accordance with approved wiring diagrams. Do not use freehand field wiring diagrams or sketches.
- E. Examine motors for presence of moisture prior to installation. Refer any doubtful condition to Engineer for decision.
- F. Support starter enclosures independent of the connecting conduits.
- G. Do not use connecting conduits to support starter and/or control enclosures.
- H. Check control wiring for proper connection before energizing by "ringing" or "taking" out circuits.

- I. Refer to the Heating, Ventilating and Air Conditioning and Plumbing drawings and specifications for the manner of control, operation and monitoring of motors and other electrically operated equipment. Provide a motor starter for each motor and each electrically operated piece of equipment except where motor starters and controls are furnished by the manufacturer of the motor or piece of equipment. Motor starters shall be internally wired and connected to other motor starters and to controls to provide the required control operation and monitoring. Connect motor starters and controls furnished by the manufacturers of motors and other electrically operated equipment.
- J. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified applicable Electrical Code.
- K. Grounding: Provide equipment grounding connections for motor starter equipment as specified. Tighten connections to comply with tightening torques specified in IEC to assure permanent and effective grounding.

3.04 FIELD QUALITY CONTROL

- A. Prior to energizing motor starters, perform tests as specified in Section "Electrical Tests".
- B. Touchup scratched or marred enclosure surfaces to match original finishes.

3.05 ADJUSTING AND CLEANING

- A. Adjust operating mechanism, where necessary, for free mechanical movement.
- B. Touch up scratched or marred enclosure surfaces to match original finishes.

END OF SECTION

SECTION 16670

LIGHTNING PROTECTION SYSTEMS

1. **GENERAL**

Electrical work generally is to be in accordance with the requirement of sections 16010 of this specification.

1.1 Description of Work

Complete installation of the Lightning Protection System as shown on the drawings, consisting of: 1 early streamer emission air terminal, 2 flat down-conductors and 2 Earthing Systems.

1.2 Regulations and Standards

All work shall be carried out in accordance with the following:

- NFC 17-102

1.3 Submittals

Prior to installation, submit data for approval including, but not limited to manuals, catalogs, head radii protection, exact location of head, down-conductors and earthing system.

The contractor shall also submit drawings showing all details needed for the system, as well as location of each component of the system such as air terminal, down-conductors vertically and horizontally, earthing system.

A prior survey should be conducted to determine the air terminal head location, the down-conductor path on the building roof and side walls, as well as the earthing systems location and type.

2 Products & Systems

2.1 Air Terminal Head

a- General:

The air terminal head should be of the early streamer emission (ESE) kind and must be installed on the highest point of the supporting structure, it should always be the highest point within the area that it protects.

The protected area shall be as defined on the drawings.

The air terminal head and its down conductor through which lightning currents flows should be made of copper. The rod and the terminal tip should have a conductive cross-sectional area larger than 120mm²

b- Positioning:

The air terminal tip should be at least 4 meters higher than the area that any object it protects, including antennas, cooling towers, roofs, tanks, etc...

The down-conductor is attached to the air terminal conductor by a connecting system located on the support rod. This connecting system consists of a suitable mechanical device providing long-lasting electrical contact.

2.2 Down Conductors

a- General:

Down-conductor is designed to let the lightning current flow from the air termination systems to the earth termination system. The down-conductors should be installed outside of the structure.

Air terminal should be connected to the earthing system by at 2 down conductors as shown on the drawings with 2 earthing pits, with max 5 ohms resistivity in dry season.

Down-conductor should be installed on 2 different main walls. Down-conductors consists of PVC covered, flat cable copper 30x2mm or 25x3mm.

b- Routing:

The down-conductor should be installed in such a way that its path is as direct as possible. The down-conductor routing should take into account the earth termination location. It should be along the shortest path without sharp bends or upward sections. The bend radii should not be less than 20cm. For the diverting of down-conductors, bends formed edgewise should preferably be used.

The down-conductor should not be routed along or cross-electrical conduits. However, when electrical conduit crossing is unavoidable, the electrical conduit should be placed inside a metal screen, which extends 1m beyond the point of crossing. The screen should be connected to the down-conductor.

Routing round parapet walls or cornices should be avoided. Provisions should be made to ensure that down-conductor paths are as direct as possible. However, a maximum height increase of 40cm is permissible for passing over a parapet wall with a slope of 45° or less.

The down-conductors should be attached on the basis of three fixings per meter. The fixings should be suitable for the supports and their installation should not alter the roof water-tightness. The fixings should allow for possible thermal expansion of the conductors.

All the conductors should be connected together by means of clamps of the same material, or by solid rivets, soldering or brazing. Drilling through down-conductors should be avoided.

Down-conductors should be protected against the risk of impact by installing sleeves up to a height of 2m above ground level

c- External Cladding:

When the outside of a building or structure has a metal cladding or stone or glass curtain-walls, or in the case of a fixed cladding item, the down-conductor may be attached behind the cladding to the concrete wall or the load-bearing structure.

In such a case, the conductive cladding components and the supporting structure must be bonded to the down-conductor at the top and bottom ends.

As the lightning current has an impulse characteristic, flat conductor should be used instead of the round conductor as shown on drawings.

d- Test Clamp/Disconnect Terminal (or test terminal):

Each down-conductor should be provided with a test clamp used to disconnect the earth termination system for measuring. The test clamp should bear the term “lightning conductor” and the Symbol:

Approved Manufacturers

- Pouyet
- Duval Messien
- France Paratonnerres

or approved equal

3 Equipotential Bonding of Metal Parts & Internal Lightning Protection Installation

3.1. General

When lightning current flows through a conductor, differences of potential appear between this conductor and nearby earthed metal parts. Dangerous sparks maybe produced across the ends of the resulting open loop.

Depending on the distance between the ends of the open loop (down-conductor) and earthed metal part, equipotential bonding may or may not be achieved.

However, equipotential bonding is frequently preferred but not provided in some cases (flammable or explosive piping). The down-conductors are then routed further away than the safety distances. Safety distance is known as the minimum distance at which no dangerous sparks can be produced between a down conductor and a nearly earthed conductive mass.

The equipotential bonding should be provided wherever possible at the closest point by an equipotential conductor, a lightning arrester or a spark gap, between the down-conductor and the component to be put at the same potential and located on the structure, in the structure walls or inside the structure.

3.2 Equipotential Bonding of External Metal Masses

In most cases, a connection using an equipotential conductor is possible. If it is not possible or authorized by the local authorities, the connection must be made using a surge protective device as indicated on drawings for all low current systems.

a- Equipotential Bonding using an Equipotential conductor:

Equipotential bonding should be provided at the following locations:

- Above the ground and underground. All the structure earth terminals should be interconnected.

- Whenever the proximity requirements are not met: when $d < s$

In such a case, the acceptable equipotential conductors should be of the same type as those used to make down-conductor. They should be kept as short as possible. In the event of a lightning protection system separated from the structure to be protected, the equipotential bonding should be made at ground level only.

b- Equipotential Bonding using a Surge Protective Device:

An antenna or a small post supporting electrical lines should be bonded at the nearest to the down-conductor, via an antenna-mast spark-gap type surge protective device.

Note: Equipotential conductors should be used to connect internal metal parts to an equipotential bonding bar made and laid out in such a way as to allow easy disconnection for inspection purposes. The minimum cross-sectional area of such conductors should be 16mm² of copper. The equipotential bonding bar should be connected to a point as close to the structure earthing circuit as possible. For large structures, several equipotential bonding bars may be installed provided that they are interconnected.

Active conductors should be bonded to the lightning protection system.

3.3 Surge Arresters

Supply install & connect a complete internal lightning protection system including surge arresters as shown on drawings. Class 1/2 (100KA) lightning arresters shall be installed at incoming feeders of Lebanon Mains Power & generator set. Class 2 (40KA) lightning arresters shall be installed at each lighting panel, distribution panel, elevator panel and any other secondary panel as shown on drawings. 10KA lightning arresters shall be installed at each coaxial cable out of CCTV. 10KA lightning protection arrester shall be installed at each incoming telephone pair.

Approved Manufacturers:

- Dehn
- Obo Bettermann
- or approved equal

4 Earth Termination Systems

4.1 General

One earthing system shall be provided for each down-conductor.

To allow for the impulse characteristic of the lightning current and to enhance current draining to earth, while minimizing the risk of dangerous voltage surges within the protected volume, it is also important to pay attention to the earth termination system shape and dimensions and also to the earth termination resistance value.

Earth termination systems should meet the following requirements:

- The resistance value measured using a conventional equipment should be 10 ohms or less. This resistance should be measured on the earthing termination insulated from any other conductive component.
- The wave impedance or inductance value should be as low as possible in order to minimize the back-electromotive force which is added to the ohmic potential rise occurring during the lightning discharge. For this purpose, earth termination systems having a single excessively long horizontal or vertical component should not be used.

The use of a single vertical termination system deeply buried to reach a humid layer of soil is thus not advantageous unless the surface resistivity is particularly high.

It should however be noted that such drilled earth termination systems have a high wave impedance when the depth exceeds 20 meters. This calls for the use of a greater number of horizontal conductors or vertical stakes, which must always be perfectly interconnected from an electrical standpoint. Similarly, copper conductors should be preferred to steel conductors whose cross-sectional area required to achieve equivalent conductivity makes their use impracticable.

Earth termination systems should be made and laid out as stated above and in section 544 of standard NF C 15-100.

5 Anticorrosion Protection

5.1 General

The corrosion of metals depends on the type of metal used and on the characteristics of the metal environment. Factors such as fungus, soluble salts (electrolytes), degree of ventilation, electrolyte temperature and changes make the conditions highly complicated.

The contact of dissimilar metals associated with electrolysis phenomena due to the environment increases corrosion in more anodic or active metal and decreases corrosion in more cathodic or inert metal. Corrosion in more cathodic metal should be prevented. The electrolyte for this reaction maybe a humid soil or condensation retained in cracks.

5.2 Precautions & Measures to be taken

In order to reduce corrosion, it is necessary to:

- Avoid the use unsuitable metals in an aggressive environment.
- Avoid contacts between dissimilar metals which different galvanic couples.
- Use conductors of appropriate gauges and corrosion-resisting fasteners.
- Provide protective coatings in critical cases as appropriate to the external influences.

To meet the above requirements, the following precautions are given as typical examples:

- The minimum thickness or diameter of a conductive item should comply with standard mentioned in this specification.

- Copper/aluminium joints should be avoided wherever possible. If unavoidable, joints should be made using suitable two-metal connections.
- Copper is usually suitable for earthing, except under certain acid conditions, when exposed to oxygen or sulfate.
- When there are sulfuric or ammoniacal fumes, a coating may be used on the down-conductors.
- Conductor fasteners should be made of stainless steel or suitable synthetic material under corrosive environmental conditions.

6 Special Measures

An antenna on the roof of the premises increases the lightning stroke probability and is the first vulnerable item likely to receive the lightning discharge.

When this is an individual or collective radio broadcasting receiver antenna, complying with the standard, the antenna support mast should be connected through a surge protective device or a spark gap to the down-conductors of the installation by a standard conductor unless the antenna is outside the protected area.

A common support mast can be used under the following conditions:

- The common support mast consists of adequately strong tubes, which do not need guy lines.
- The air terminal is attached to the tip of the mast.
- The air terminal tip is at least 2m above the nearest antenna.
- The down-conductor is attached by a clamp which is fastened directly onto the rod.
- The antenna coaxial cable routed inside the mast antenna.
- It is preferable to route the coaxial cable through a metal tube.

7 Inspection & Maintenance

LPS maintenance is essential since a number of components may lose their effectiveness over time due to corrosion, weather, mechanical impacts, and lightning. The mechanical and electrical characteristics of an LPS should be maintained throughout the LPS life in order to meet the standard requirements.

7.1 Initial Inspection

Once the air terminal installation is completed, it should be inspected to make sure that it complies with the provisions of this standard.

The purpose of this inspection is to make sure that:

- The air terminal head is 4 meters or more above the entire protected area.
- The materials and the gauges used for the down-conductors are suitable.
- Sizes of down-conductors, head, earthing rod are according to standards.
- The down-conductors are routed, located and electrically bonded as required.
- All the installation components are firmly secured.
- The safety distance is respected and/or equipotential bonding are provided.

- The earth termination system resistance values are correct.
- The earth termination systems are interconnected.
- This inspection should be performed visually under the conditions stated in standards NF C 15-100, and NFC 17-102.

However, where a conductor is entirely or totally hidden, its electrical continuity should be tested. Such a test should conform to part 6 of standard NF C 15-100.

7.2 Inspection Procedure

A visual inspection should be performed to make sure that:

- No extension or modification of the protected structure calls for the installation of additional lightning protective measures.
- The electrical continuity of visible conductors is correct.
- All component fasteners and mechanical protectors are in good condition.
- The safety distance is respected and there are enough equipotential bonding and their condition is correct.
- Conductors size & installation.
- Air terminal type & installation.

Measurements should be taken to verify:

- The electrical continuity of hidden conductors.
- The earth termination system resistance values

END OF SECTION

SECTION 16740

TELEPHONE SYSTEM

PART 1 - GENERAL

1.1 **RELATED DOCUMENTS:**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Specification sections, apply to this Section.
- B. Division-16 Basic Electrical Requirements sections apply to work specified in this section.

1.2 **SUMMARY**

- A. Telephone system work is indicated by drawings and schedules, and is hereby defined to include, but not be limited to telephone wiring/cabling, private branch exchange, conducting and proper connection to local city telephone network.

2. **PRODUCTS**

2.1 **EPABX**

- A. PBAX to be electronic type fully IP supporting IP, Digital & analogue extensions, with 6 exterior lines & 24 interior lines, expandable type.

i- Type:

PABX must be compatible with the relevant public exchange equipment as existing. It shall be electronically exchanged, fully digital and stored program controlled. It shall facilitate an integrated voice/data system that is capable of transmitting voice and data simultaneously. PABX is to be designed for use as a standard telephonic exchange for all applications. It shall be possible to connect any combination of standard serial-pulse and DTMF telephones to the PABX, with manufacturer-made interface modules as necessary within the exchange and without the need to modify the assembly. All control functions shall be performed by latest technology of micro and mini processors. Full duplications should be provided for all control and service cards. PABX shall be provided with all needed analog licenses, IP, analog & digital ports, PRI media, music on hold, all needed gateways, full redundancy, auto attendant, hospitality messaging solution, and voice mail system. The IP telephony infrastructure shall be designed to sustain all kinds of security and virus attacks and support encryption of voice streams without impairing the connection or voice quality.

The Unified Communications (UC) component must provide a single identity & presence enabled communications and collaboration solution. The UC component should deliver rich communications across multiple media (telephony, email, voice-mail, IM, video & web conferencing), which are intuitive and accessible from anywhere on any device, integrated into business process and can be efficiently and securely deployed into existing customer environment.

The IP telephony & UC components must be tightly integrated to ensure it is possible to make and receive remote calls to/from any analogue, digital or IP phone and the public voice network, to provide remote call control between the desk phone and PC client and to provide telephone presence.

The system must support the following features without the need for any additional hardware:

- Account codes
- Administered connections
- Answer detection
- Authorization codes
- Automated attendant (full option)
- Automatic call distribution
- Automatic alternate routing
- Automatic camp-on
- Automatic circuit assurance
- Automatic number id
- Automatic recall
- Automatic route selection-basic
- Automatic transmission measurement system
- Call by call service selection
- Call detail recording
- Call log
- Centralized attendant service
- Classes of restriction
- Classes of service
- Code calling access
- Controlled private calls
- Delayed ringing
- Dial plan
- Dialed number id service
- Direct department calling
- Direct inward dialing
- Did call waiting
- Direct inward termination
- Direct outward dialing
- Extended trunk access
- Facility restriction levels
- Facility test calls
- Forced entry account codes
- Hunting
- Integrated system directory
- Least cost routing
- Modem pooling
- Multiple listed directory numbers
- Music on hold
- Night service (fixed & programmable)
- Off-hook alarm
- Off premises station
- Open system speed dial
- Password aging

- Power failure transfer station
- Recent change history
- Restriction features
- Fully restricted
- Miscellaneous trunk
- Toll/code
- Trunk
- Voice terminal
- Route advance
- Security violation notification
- Shared tenant service
- System speed dial
- System status report
- Time of day routing
- Timed reminder
- Trunk answer any station
- Trunk callback queuing
- Uniform call distribution
- Uniform dial plan
- Virtual extension
- Voice message system interface
- The system must support full attendancy features
- Call waiting
- Conference
- Display
- Intrusion
- Paging/code call access
- Priority queue
- Recall
- Operator at PABX can see that an office does not want to receive calls (Maximum privacy)
- Call converge
- Call forward busy
- Call forward busy inside
- Call forward programmable
- Call park
- Call pickup
- Call privacy
- Callback/ring again
- Caller ID
- Directories
- Do not disturb
- DTMF delivery
- Features access codes
- Intercom capability
- Visual message waiting indication
- Digital & analogue telephones must require single pair copper cables.
- Automatic server fail-over
- Provide all reports needed as per client's requirements

ii- Cabinet(s):

Exchange components are to be grouped in a modular, totally enclosed, sheet metal cabinet, corrosion resistant, with lockable front accessories, and the whole assembly is to fit into one integrated form. Cabinet(s) is to be dust and insect proof, and ventilation is to be provided as required for specified ambient conditions as well as air-conditioning facilities. All internal metal surfaces of the cabinet shall be protected against corrosion. All external metal surfaces shall be treated, prior to finishing, with metal spray galvanizing, plating, then primed treated to provide a first class base for epoxy point finish.

iii- Plug-in Equipment:

Electronic circuits and components, which are all solid state components, are to be plug-in card type. Equipment are to be assembled neatly in racks. Sensitive components are to have dust-protection covers.

Manufacturer: Alcatel, Siemens, Ericsson, Avaya or approved equal

2.2 CONNECTION MODULES

A. IDC (Insulation Displacement Contact) Modules will comprise the terminal blocks in the MDF and distribution frames (if needed). They will be of high reliability, and will have the following minimum specifications:

MDF size	or as shown on drawings
conductor diameter	0.4 to 0.8 mm
insulation diameter	0.7 to 1.5 mm
number of insertions	1000 times
maximum contact resistance	0.02 ohm
dielectric strength (60 Hz)	2000 V (r.m.s.)
minimum insulation resistance	10000 Mega-ohm, at 500 V (dc)

2.2 DISTRIBUTION COMPONENTS

B. Distribution Cabinets: distribution cabinets & MDF if needed to be of high professional quality, metal type, dust proof, IP42 minimum, corrosion resistant, wall mounted by screws, with tamper proof removable screw covers, cable holder rings, labelling plates, equipped with relevant connecting strips, and have efficient capacities to fully wire the complete incoming cable and outgoing ones.

C. Connecting Strips will have thermoplastic bodies, nickel plated brass connectors, galvanized screw terminals in both sides, wire guides, and will have the following electrical specifications:

range of conductor diameter	up to 1.2mm
dielectric Strength (50 Hz)	1500v (r.m.s.)
minimum insulation resistance	10000 Mega-ohm, at 500 V (dc)

D. CONDUITS AND RACEWAY are to be provided in accordance with the relevant Section of the Specification, and as shown on the drawing and in full compliance to PTT requirements.

2.3 CABLES AND OTHER ACCESSORIES

- A. Telephone Cables: will be CAT 6, UTP as per EIA/TIA.
- B. Telephone Cables will be Classified: according to their location in the network into two types: riser cables (main cables), and distribution cables. Riser cables will be outgoing from, and incoming to, the MDF; whereas distribution cables will include the cables outgoing from distribution frames (cabinets) to distribution boxes as well as those outgoing to telephone outlets whatsoever Belden, IBM, Alcatel or equal.
- C. Raceways: will include all conduits, cable trunking, and cable trays. Comply with the relevant sections of the Specifications.
- D. Fixing, Labeling, and Marking Accessories: fixing accessories will include cable ties, clamp ties, push mounted ties, marker ties. Labels and markers will be made of white plastic or polyester, durable type, subject to the approval of the engineer. Each label will indicate, according to an approved labeling designations, the cable-number, and the two distribution units where the cable is coming from and going to.
- E. Raceways: telephone cables are to run in dedicated raceways segregated from those where power cables are laid. Moreover, telephone cables will not share undivided trays or paths with any other type of cables. The installation, and fixation will be as per the relevant section of the specification, field and installation work, unless otherwise is indicated herein.
- F. Cable Laying: before the start of cable works, the site will be properly checked in order to ensure that the raceways, whatsoever, are clean and dry. Cables will be carefully unreeled from drums, and pulled-in/laid-on raceways according to the approved shop drawings and work procedure. Specialized rolls and tools will be used for cable works so as the cables will not be dragged on ground or surfaces. Cables are to run concealed above cable trays, and through embedded pipes. Under false floors; if any, they may be arranged above ground, subject to the approval of the engineer. All pipe ends, whether occupied or empty, will be perfectly sealed against dirt, parasites, rats, and insects. Sealing material, or elements will be according to every specific site condition, subject to the approval of the Engineer. After the network is satisfactorily completed and tested, cables will be tied to cable trays and labelled as necessary. For any cable, the maximum distance between two successive ties will not exceed five meters except for vertical riser cables where the maximum distance will be two meters. Cables will be labelled at every terminal location, every bent, before every distribution unit, and at every fan-out. Moreover, vertical main cables, along the riser, will be labelled at least twice in each floor.
- G. Cable Wiring: cables will be terminated at the distribution units where they will be held, fanned out properly, and wired to the terminal blocks or connecting strips. Wires will be tied into groups, in accordance with the order of pairs as per color code, and corresponding to the relevant connection modules (or strips). Wiring to the terminal blocks in MDF and distribution frames (cabinets) will be performed by standard IDC connection tools, no soldering will be needed, whereas the wiring of distribution cables to the terminal strips in distribution boxes may be completed by screw drivers.

- H. Jumper Wires: are to extend neatly between connection modules, moderately stretched, and guided by the specialized rings and hooks. No jumper will be left loose or imperfectly guided. The final arrangement of jumper wires within any cubicle will allow for an easy trace of any telephone line.
- I. Earthing: every cable, distribution unit, and equipment will be properly earthed as necessary and as recommended by manufacturers. Earthing system will ensure safety conditions and will eliminate noise effects. Earthing cables will be characterized by their green/yellow color. Provide interference-free earthing as necessary.
- J. Wireless Access Points (WAP) shall be of a modular design, enclosed in a housing listed for use in environmental return air spaces, permitting a dual radio configuration, with complete backward compatibility for legacy clients. WAP shall support IEEE 802.11b/g standards & 802.11a. WAPs shall support 5 dBi Omni-directional and 9 dBi directional patch antenna at a minimum. The WAPs should obtain power over the Ethernet (POE). All switches used shall be capable of providing POE for the corresponding WAPs.

3.2 **ON-SITE TESTS, AND INSPECTION:**

- A. Test Plans: all tests will be carried out according to a detailed test procedures which is submitted by the contractor and approved by the engineer. The tests will cover every aspect related to the specification of the material and their operation; including, but not limited to, visual inspections, insulation tests, measurements, and operation. All instruments to be used during the tests must have been calibrated and certified, by an authorized official laboratory, as complying with the specification of their manufacturers.
- B. On-Site Cable Tests: cables are to be tested to ensure that no damage have occurred to them during transportation to site and/or during the course of pulling-in and laying. A complete wire-to-wire continuity test is to be performed for every cable length. The contractor will have to replace any length where the electrical continuity is not verified for all wires. Then, a 10% sample of all cable lengths will be subject to an insulation test, according to the manufacturer specifications. Sampling will be random and as decided by the engineer. The contractor will have to replace a cable should its insulation resistance is below the minimum specified.
- C. On-Site System Tests: equipment will be tested to ensure that they are not damaged by transportation, correctly assembled and connected, properly powered, and operating as specified. The complete system tests will include the following minimum checks:
 - Visual inspection of every component (including painting assembly, labeling, etc.)
 - Dielectric strength and insulation resistances.
 - System performance (including all operation features).
 - Any other checks as necessary to ensure full compliance with the technical specifications.It will be demonstrated to the satisfaction of the engineer, that the installed equipment meet the requirements of the specification and is ready for taking-over.

- A. Experimental Period: after the on-site tests are satisfactorily completed in accordance with the technical specifications and approved procedures, and before final acceptance which is leading to provisional taking over; the contractor will assume a one-month experimental period during which the system performance will be fully demonstrated under actual operation conditions. This demonstration is to confirm, to the satisfaction of the engineer, that the system is free of remarks and is ready for provisional taking over.

3.3 DESIGN PARAMETERS:

- A. The telecommunication's service entrance and installation shall meet the requirements of the public service telephone network PSTN.
- B. Voice/data installations are to comply with the requirements of PSTN and the relevant CCITT recommendations and the electronic industries association/telecommunication industry association standard EIA/TIA-568 and commercial building telecommunication wiring standard.
- C. The communications wiring shall be installed to the requirements of the IEE and the manufacturer's recommendations.

3.4 ADJUSTING AND CLEANING:

- A. Clean telephone equipment and components of dirt and construction debris upon completion of installation including conduits inside each room, telephone pull boxes, cable tray in shaft, MDC, PBX and conduits leading to local city network.
- B. Touch-up scratched or marred enclosure surfaces to match original finishes.
- C. Protect installed equipment and components from damage during remainder of construction period.

END OF SECTION

SECTION 16740A

DATA SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

- A. Provide a complete, tested, cable distribution, & data equipment for data system (local area network. The data distribution system shall include fully terminated UTP backbone as well as UTP station cables. Switches and data cabinets to be supplied, installed and connected by IT specialist contractor including all needed switches, routers, patch panels, RJ45 outlets, cat6 cables, conduits, cable trays & cable organisers .
- B. One Main Data Cabinet (MDC) to be installed, where all data & telephone points are terminated.
- C. Provide system design services (development of specific details consistent with the contract documents) as required to complete shop drawings for data cables & data cabinets detail including detailed documentation for client's review and detailed documentation of as-built conditions.
- D. The Contractor shall coordinate with other system vendors where appropriate to facilitate equipment installation, scheduling, protection of equipment, and access to the project site in order to provide the owner a substantially complete project in a timely manner.
- E. The successful communications Contractor shall attend a mandatory pre-construction meeting with individuals deemed necessary by the owner prior to the start of work.
- F. The successful bidder will not be determined by price alone, but by a rating system to include a combination of price, qualifications, training procedures, and proposed documentation package.

1.02 CONTRACTOR'S RESPONSIBILITIES

- A. The Contractor shall furnish all data equipment and materials whether specifically mentioned herein or not, to ensure a complete operating system. The Contractor shall make sure that electric Sub-Contractor of first fix and raceway works has provided all conduits, junction boxes, and cable trays where specified for telecommunications cabling and shall bring forward all necessary deviations or new raceway requirements.
- B. The Contractor shall generate all shop drawings and information for the complete installation and wiring of the system. The Contractor shall provide (or sub-contract for) the on-site installation and wiring, and shall provide ongoing supervision and coordination during the implementation phase.
- C. The Contractor shall be responsible for the initial adjustment of the systems as herein prescribed and shall provide all test equipment for the system checkout and acceptance tests.
- D. The Contractor shall provide on-the-job training in the operation and maintenance of the system for personnel designated by the Employer.

1.03 QUALITY ASSURANCE

- A. All equipment provided by the Contractor shall be new and shall meet or exceed the latest published specifications of the manufacturer in all respects.
- B. Contractor to provide the latest model/revision of a specified piece of equipment, at the time of bid.

1.04 DELIVERY, STORAGE AND HANDLING

- A. Costs of all shipping to the site, and of all unusual storage requirements, shall be borne by the Contractor. It shall be the responsibility of the Contractor to make appropriate arrangements, and to coordinate with authorized personnel at the site, for the proper acceptance, handling, protection, and storage of equipment so delivered.
- B. Movement of material either at the time of delivery or subsequently shall be the sole responsibility of the Contractor. All costs associated with this movement shall also be the responsibility of the Contractor.

1.05 PROJECT CONDITIONS

- A. Contractor responsible for keeping schedule regardless of local disputes.
- B. Contractor responsible for protection of his work from acts of vandalism and environmental conditions.
- C. Contractor to clean up and repair all areas affected by his installation.

1.06 SEQUENCING AND SCHEDULING

- A. Provide your own schedule listing your activities including manpower allocation and material procurement that demonstrates how you plan to meet the construction schedule. This schedule should include manpower and duration required for each phase.

1.07 WARRANTY

- A. Warranty systems in writing against defects in material and workmanship for 1 year after system acceptance. During this time the system shall be kept in proper operating order at no additional labor or material cost to the Employer.
- B. Service must be rendered within 24 hours of notification.
- C. Visit site once a month during warranty period for checking and adjustment.
- D. Actions which may void guarantees or other contracts on equipment are to be submitted for approval prior to being undertaken. Contractor not responsible for guarantees for materials or work and/or existing contracts if above action is approved.
- E. Contractor assumes responsibility for quality and satisfactory operation of components and materials not manufactured by Contractor, submit guarantee endorsed by manufacturer of materials.
- F. Whenever a guarantee of durability, operating capacity or proper functioning are noted, manufacturer shall furnish detailed drawings, test certificates.

1.08 SHOP DRAWINGS

- A. Floor plans: Furnish floor plans for approval based on owner's final requirement showing exact outlet locations with an indication of outlet type and proposed label. Floor plans shall be coordinated with architectural and electrical power plans and shall be produced at the same scale as the electrical power plans. Schematic diagrams & elevations shall be submitted for each data cabinet detailing its full content.
- B. Terminal elevations: Furnish details showing terminal block and backboard elevations including all cable terminals, spaces for equipment, equipment racks, and station cable routing. Communications equipment closets shall be arranged to maximize the utility and growth potential available in spaces shown on the floor plans. Terminal elevations shall be based on detail elevations included in the contract documents and shall show additional detail as indicated herein.
- C. Outlet locations: Provide as shown.
- D. Terminal schedules: Furnish terminal schedules showing terminal block positions for all station cabling. Terminal outlet schedules shall show proposed labels for all four-pair UTP horizontal cables at station outlets along with patch panel locations.

1.09 SUBMITTALS

- A. Project initiation: Contractor shall furnish the following in a single consolidated submittal:
1. The name of the person who will act as the low voltage Contractor's official contact with the Contractor/owner/engineer.
 2. Electrical permits: The Contractor shall obtain all required permits and provide copies to the owner/engineer.
 3. Complete manufacturer's product literature for all cables, patch panels, cable supports, cable labels, outlet devices, racks, switches, routers and other products to be used in the installation. In addition, whenever substitutions for recommended products are made, samples (when requested by the owner/engineer) and the manufacturer's supporting documentation demonstrating compatibility with other related products shall be included.
 4. A time-scaled construction schedule, indicating general project deadlines and specific dates relating to the installation of the cable distribution system. At a minimum, this construction schedule shall include the following milestones:
 - Start of communications space construction
 - Start of fiber optic cable terminations
 - Start of Category 6 (telephone), Category 6 (data) UTP (including related termination hardware)
 - Data cabinets
 - Start of Category 6 (telephone), Category 6 (data) UTP cable testing
 - Final inspection
 5. Shop drawings
 6. Proposed Contractor Category 6 (telephone), Category 6 (data) UTP cable test result forms.
- B. Project completion: As a condition for project acceptance, the Contractor shall submit the following for review and approval.

1. Complete manufacturer's product literature and samples for all pre-approved substitutions for the recommended products made during the course of the project.
2. An exception list of deviations (in materials, construction, and workmanship) from that specified in this section and shown on the project drawings. The owner will review this list and declare each item as either an approved exception or as one the Contractor must correct.
3. Inspection and test reports: During the course of the project the Contractor shall maintain an adequate inspection system and shall perform such inspections to ensure that the materials supplied and the work performed conform to contract requirements. The Contractor shall provide written documentation indicating that materials acceptance testing was conducted as outlined in Part 3 below. The Contractor shall also provide documentation indicating that all cable termination & data cabinets testing procedure were completed and that all irregularities were corrected prior to job completion for owner/engineer analysis.

1.10 AS-BUILT DRAWINGS

1. Prior to contract close-out, submit one copy of the system As-Built drawings and documents to the Engineer for review. Submit two copies to the owner.

1.11 TEST RESULTS

Prior to systems acceptance and commissioning, submit system testing documentation showing methods and results for all tests performed.

Provide written certification by the Contractor that all active & passive equipment have been properly installed and tested as per the Specifications and Manufacturer's instructions. This written certification shall be signed by the executive officer of the contracting organization and submitted for approval.

1.12 SYSTEM INSTALLER

- A. The data system installer shall be a certified firm normally employed in the low voltage cabling industry with a reference list of five (5) projects and contact names to confirm successful Category 6 (telephone), Category 6 (data) UTP cables plant projects.
- B. The owner reserves the right to exercise its discretion to require the Contractor to remove from the project any such employee of the Contractor deemed by the owner to be incompetent, careless, insubordinate, or otherwise objectionable.
- C. The selected system installer should be factory certified for the products it installs and be able to provide a factory warranty of no less than 10 years covering both product and performance of materials installed. Quality and workmanship evaluation shall be solely by the owner/engineer and designated representatives.

1.13 REGULATORY REQUIREMENTS

- A. All work shall be performed in accordance with the latest revisions of the following standards and codes:

Uniform International Conference of Building Officials (ICBO).
Local Building Code of Lebanon
BS Code

B. Other References:

EIA/TIA-568 Commercial Building Wiring Standard

EIA/TIA-569 Commercial Building Standard for Telecommunication Pathways and Spaces

EIA/TIA TSB36 Additional Cable Specifications for Unshielded Twisted Pair Cables

EIA/TIA TSB40 Additional Transmission Specifications for Unshielded Twisted Pair Connecting Hardware

EIA/TIA 455-A Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components.

1.14 ABBREVIATIONS

DC Direct current.

MDC Main distribution cabinet

UTP Unshielded twisted pair (telecommunications station cable)

SW,Switch/Hub

PART 2 PRODUCTS

2.01 GENERAL WIRING

- A. The wiring plan shall be installed per requirements of these specifications utilizing materials meeting all applicable EIA/TIA standards. Cables shall be capable of high speed data transmission.

The following cables shall be used:

Fiber (multi mode) for vertical backbone data riser.
Cat 6 UTP for telephone and data wiring.

- B. Materials shall be as UL listed or shall be equivalent products of other manufacturers meeting the intent and quality level of the EIA/TIA TSB36 and TSB40 specifications. All approved equivalent products will be published by addendum prior to bid.
- C. All installed wire shall be tested "100 percent good" after installation by the installer.
- D. All products shall be new and brought to the job site in original manufacturer's packaging. Electrical components shall bear the Underwriters Laboratories label. All communications cable shall bear flammability testing ratings as follows:

CM Communications cable

CMP Plenum-rated communications cable

CMR Riser-rated communications cable

- E. Initial cable inspection: The Contractor shall inspect all cable prior to installation to verify that it is identified properly on the reel identification label, that it is of proper gauge, containing the correct number of pairs, etc. Note any buckling of the jacket that would

indicate possible problems. Damaged cable or any other components failing to meet specifications shall not be used in the installation.

2.02 STATION WIRING

- A. The horizontal wire provided for all outlets shall be one four-pair UTP, Category 6 (telephone), Category 6 (data) cable per jack:

1. Duplex data outlet shall have two data cables each with its own jack.

- B. The Category 6 (telephone), Category 6 (data) four-pair UTP cable must be UL Performance Level tested. Each 1,000-foot spool must be individually tested with test results affixed to the spool.

Recommended Products: 3M, Leviton, Tyco & Systimax or pre-approved equivalent.

2.03 STATION HARDWARE

- A. Flush-mounted jacks shall be high-quality Category 6 (telephone), Category 6 (data) RJ45 modular jacks with circuit board construction and IDC-style or 110-style wire, T568A terminations. Jacks shall meet EIA/TIA TSB40 recommendations for Category 6 connecting hardware.

- B. Faceplates shall match manufacturer for RJ45 outlets at all locations.

- C. Surface mount jacks shall be high-quality RJ45 modular jacks per A above.

2.04 DATA TERMINATION HARDWARE

- A. Data Category 6 (voice), Category 6 (data) termination hardware: The Category 6 (telephone), Category 6 (data) data station cable shall be terminated on Category 6 (telephone), Category 6 (data) RJ45 patch panels with circuit board construction. The RJ45 patch panels shall be either wall mounted or rack mounted. The Contractor is responsible for all wall brackets, patch panels, for all DCs equipment as shown on drawings and to the approval to university representative.

The panel cover shall permit masking of parts not in use. A cable safety feature shall be provided by a retaining system. Color-coded port identification shall be provided.

- B. Wall brackets must be provided for all patch panels for wall mount applications.

Approved products: 3M, Leviton, Tyco, & Systimax or pre-approved equivalent.

2.05 DATA DISTRIBUTION EQUIPMENT RACK

- A. Provide equipment racks in locations indicated on the drawings. Racks shall be equipped as detailed on the drawings and as hereafter specified and to university representative approval.

2.06 FIBER OPTIC CABLE SPECIFICATIONS

- A. Fiber optic cable shall be UL-listed type OFNP; six core, multimode fibers, each with a color-coded PVC buffer. Maximum attenuation shall be 3.75 dB/km at 850 nm and 1.0 dB/km at 1,300 nm. Minimum bandwidth shall be 160 MHz/km at 850 nm and 500 MHz/km at 1,300 nm and contain no metallic elements.

2.07 FIBER OPTIC CABLE TERMINATIONS

- A. Optical fiber connectors shall be ST or LC connectors.

Approved products: 3M, Leviton, Tyco, & Systemax or pre-approved equivalent.

- B. Optical fiber termination enclosure: The enclosure used in the computer room shall provide termination panels of sufficient size and capacity to terminate 100 percent of the fiber count of the inside or outside fiber optic cables. Patch panels must be wall or floor mounted & sized as shown on drawings minimum. Provide all termination accessories and enclosures and test for a complete fiber optic distribution system.

2.08 FIBER OPTIC PATCH PANEL (if needed)

- a. All fiber optical cables must be terminated on patch panels from which they are connected to the required devices.
- b. Fibre optic patch panels shall comply with transmission requirements of cat6 cabling system standards and must be mounted on 19" rack

2.09 FIBER OPTIC NETWORK (BACKBONE)

A. Backbone fibre optic cable shall follow TIA/EIA standards for fibre optic installation and certification.

B. The maximum distances for multi mode fibre for 100Mbit/s Fast Ethernet connection is 2000 meters, or with single mode fibre about 3000meters.

- A. Backbone fibre connections running on a 1000 Mbit/s Giga Ethernet can cover a maximum distance of 525 meters on a 50/125 micron multi mode cable (only 260 meters for 62.5/125 micron multi mode fibre optic cabling).
- B. The backbone cabling for Giga Ethernet should consist of 50/125 micron multi mode fibre optic cabling or of single mode fibre optic if longer distances must be covered.
- C. The fibre optic cabling shall be configured in a star topology originating from the MDC as shown on drawings.
- D. Avoid installing in areas where sources of high levels of EMI/RFI may exist. Specific distances are provided in ANSI/TIA/EIA.
- E. Bridge taps are not allowed for structured cabling.
- F. Grounding should meet requirements of EIA/TIA 607.
- G. Fibre optic cables for vertical system shall be indoor cables, multi-mode of the 62.5/125micron multi type. Its features are, but not limited to the following:
 - a. Central core design with 8 fibre
 - b. Rodent-protection and strength member combined.
 - c. Increased crush resistance
 - d. Halogen free, flame retardant sheath (FR/LSOH)
 - e. Temperature range from -10 to 50 deg Cent

2.10 DATA RACKS

- A. Switches enclosures shall lockable with cooling fan built-in to provide circulation.

- B. Data racks containing network components and patching panels shall be capable of having the front doors shut and locked without introducing any strain or pressure on any part of the equipment or cables installed within the racks.
- C. Data cabling racks, shall comprise:
- D. Standard 19" practice
- E. Removable front sides and rear panels.
- F. Safety glass front door with lock and removable keys.
- G. Full width fan trays
- H. Multi way power strip
- I. Cable management trays inside racks.
- J. Earth straps for all doors, sides, and panels.
- K. Earth bonding to building safety earth
- L. Earth cables must be provided to all metallic doors on data racks. Earth connections must be provided to all patch panels from the data racks earthing point.
- M. All equipment shall be installed in cabinets either on shelves or on rack mounting brackets.
- N. Each cabinet shall be provide with a documentation wallet.
- O. All equipment must be installed with the interface connectors to the front.

2.11 DATA PATCH PANELS

- A. Patch panels shall be designed to enable the connection of either voice or data services to the horizontal data cabling.
- B. Patch panels in wiring closets shall be interconnected using four pair cat6 data cables as a minimum, or optical fibres between adjacent closets.
- C. Patch panels shall be based on RJ-45 presentation, using IDC connections.
- D. Sufficient space must be allowed at the patch panel for labeling of all ports and patch cord wire guides.
- E. Patch panels shall be installed such that the connector pins are aligned uppermost and the retaining key on the bottom of the outlet.
- F. All patch panels shall include sufficient rear space for termination and marshalling of cables
- G. All patch leads, user leads, connection leads and main cable runs for each cabling system shall be of the same cable specification and from the same batch of cables.

Approved products: 3M, Leviton, Tyco, & Systimax or pre-approved equivalent.

2.12 LAN & SWITCH DESIGN

- A. Local area networks should be configured to ensure maximum resilience and continued operation failure of any single component. A redundant switch must be used when routing voice over IP or other IP enables audio/video devices in the network.
- B. The approved configuration is a pair of Ethernet switches, to which all servers and network services are attached and from which clients are attached directly or via switches.
- C. The routing information protocol (RIP) is designed for exchanging routing information.
- D. Switches must be configured and installed by a professional network specialist.
- E. Switches must support POE, QOS & VLANS.

- F. Typical features for switches: chassis system unit, redundant power supplies, high Ethernet port density, configurability, manageable and remote access, spanning tree protocol, VOIP support
- G. Switches to be available in two classes:
 - 1- High-End Switches, offering high performance, increased expansion, extremely high fault tolerance, and high availability capabilities and highly resilient. High end switches are used inside computer rooms. Switches to be 10 Gigabit Ethernet support, layer 4-7 switching, & security features.
 - 2- Mid-End Switches, typically on floor level, providing high number of possible VLANS, supporting POE, with 10/100/1000 Mbit/s port and flexible uplink ports, with layer 3 switching.

Approved products: SISCO or approved equal.

PART 3 EXECUTION

3.01 GENERAL

- A. The Contractor shall avoid penetration of fire-rated walls. Sleeving shall be installed for access where necessary.
- B. Any penetration through fire-rated walls (including those in sleeves) will be resealed with an Underwriters Laboratories-approved (UL) sealant. Typical of this type of product is Flame seal. Contractor shall also seal all floor, ceiling, and wall penetrations in fire or smoke barriers and wiring closets.
- C. Allowable cable bend radius and pull tension: In general, communications cable cannot tolerate sharp bends or excessive pull tension during installation. Refer to the cable manufacturer's allowable bend radius and pull tension data for the maximum allowable limits.
- D. Cable lubricants: Lubricants specifically designed for installing communications cable may used to reduce pulling tension as necessary when pulling cable into conduit. After installation, exposed cable and other surfaces must be cleaned free of lubricant residue.
- E. Pull strings: Provide pull strings in all new conduits, including all conduits with cable installed as part of this contract.
- F. The Contractor shall replace any damaged ceiling tiles that are broken during cable installation.
- G. The Contractor shall replace or rework cables showing evidence of improper handling including stretches, kinks, short radius bends, over-tightened bindings, loosely twisted and over-twisted pairs at terminals, and cable sheath removed too far (over 3.5cm).

3.02 LABELS

- A. The labeling plan shall be developed by the Contractor. The Contractor will label all outlets following the detailed shop drawing design, using permanent/legibly typed or machine-

engraved labels approved by the owner. The labeling information for data cabinets will include the switch number and patch panel number. Outlets shall be labeled to match the corresponding label in the patch panel all copper/fiber terminations for riser/backbone cables shall be labeled with the patch panel number.

- B. A floor plan clearly labeled with all outlet jack numbers shall be included in the as-built drawings.
- C. All labels shall correspond to as-builts and to final test reports.

DATA SYSTEM (16740A) (CONT'D)

3.03 TECHNICAL SPECIFICATIONS RJ45 CAT 6

ELECTRICAL DATA

Insulation Resistance	≥ 500 Mohm	(IEC 512-2-2a)
Dielectric Strength	Contact/ contact	1.0 KV
	Contact/ shielding	1.5 KV

TERMINATIONS

Typical termination resistance	≤ 20 Mohm	(EN 60603-7)
Current carrying capacity (DIN EN 60603-7)	≥ 1 A	(EN 60905)
Insertion cycles	≥ 750	(IEC 512-2-13b)

MECHANICAL DATA

Shield connection	patented 360° Shielding	
Conductor diameter	0.5-0.6 mm (AWG 22-24)	
Insulation diameter	1.05-1.06 mm	
Re-terminations of of LSA-PLUS contacts	≥ 200	
insertion/ pullout force	20 N	(EN 60603-7)

3.04 STATION WIRING INSTALLATION

- A. The low voltage Contractor shall supervise the installation of communications cable. All Category 6 and fiber optic cables shall be installed by individuals trained in voice and data cable system installations. All Category 6 (telephone), Category 6 (data) four-pair UTP cable must be handled with care during installation so as not to change performance specifications. The Contractor shall not over-tighten tie wraps or over-bend the Category 6 (telephone), Category 6 (voice and data) four-pair UTP cable.
- B. Exposed station cable will only be run with owner approval. Approval will be granted only when no other option exists. When station cable must be run surface to a single outlet, surface raceway shall be used to cover the cable.
- C. All cabling and associated hardware shall be placed so as to make efficient use of available space in coordination with other uses. All cabling and associated hardware shall be placed so as not to impair the owner's efficient use of their full capacity.
- D. Attaching cable to pipes or other mechanical items is not permitted. Communications cable shall be routed to avoid light fixtures (45cm minimum spacing), sources of heat (30cm minimum spacing), power feeder conduits (30cm minimum spacing).

DATA SYSTEM (16740A) (CONT'D)

3.05 STATION HARDWARE

- A. Surface mount jacks (where permitted) shall be securely attached to walls or permanent furnishing and will not be attached to the floor under any circumstances. Use of adhesive tape for this purpose will not be allowed.
- B. Flush-mounted jacks shall be mounted in a faceplate with back box.
- C. RJ45 jack pin assignments:
 - 1. Pin connections for both telephone, data station cable outlets, and patch panels shall match EIA/TIA-568 modular jack wiring recommendation T568A, which is both 10BaseT and ISDN compatible.
 - 2. Pin connections at data jack panels shall match pin connections at outlets—straight through wiring.

3.06 BACKBOARD CABLING/EQUIPMENT RACK CONFIGURATION

- A. All cabling shall be routed so as to avoid interference with any other service or system, operation, or maintenance purposes such as access boxes, switches or electrical outlets, electrical panels, and lighting fixtures. Avoid crossing areas horizontally just above or below any riser conduit. Lay and dress cables to allow other cables to enter the conduit/riser without difficulty at a later time by maintaining a working distance from these openings.
- B. Cable shall be routed as close as possible to the ceiling, floor, or other corners to ensure that adequate wall or backboard space is available to current and future equipment and for cable terminations. Cables shall not be tie-wrapped to existing electrical conduit or other equipment. The minimum bend radius shall be observed.
- C. Lay cables via the shortest route directly to the nearest edge of the backboard from the mounted equipment or block. Lace or tie-clamp all similarly routed cables together and attach by means of clamps screwed to the outside edge(s) of the backboard vertically and/or horizontally, then route via "square" corners over a path that will offer minimum obstruction to future installations of equipment, backboards, or other cables.
- D. Provide rack and jack panel hardware as required for all data station wiring.
- E. Do not over-tighten cable ties or binding on Category 6 station cable. Observe Category 6 cable bend radius.

DATA SYSTEM (16740A) (CONT'D)

3.07 TWISTED PAIR CABLE TESTING (CONT'D)

- A. Acceptance of the simple test procedures discussed below is predicated on the Contractor's use of the recommended products (including but not limited to twisted pair cable, cross-connect blocks, and outlet devices specified in the products paragraph) and adherence to the inspection requirements and practices set forth. Acceptance of the completed installation will be evaluated in the context of each of these factors.
- B. At a minimum, the Contractor shall test all station drop cable pairs from termination patch panels to outlet device, RJ45 jacks.
- C. Each wire/pair shall be tested at both ends for the following:
 - 1. termination order
 - 2. polarity (pair reversals)
 - 3. continuity
 - 4. shorts
 - 5. grounds
 - 6. attenuation
 - 7. near end cross talk
 - 8. cable length (record all lengths)
- D. When errors are found, the source of each error shall be determined and corrected and the cable retested. All defective components shall be replaced and retested. Defective components not corrected shall be reported to the owner/engineer with explanations of the corrective actions attempted.
- E. Test records shall be maintained using a form approved by the owner. The form shall record closet number, riser pair number or outlet ID, outcome of test, indication of errors found (i.e., a, b, c, d, e, f, or g), cable length, retest results after problem resolution, and signature of the technician completing the tests.
- F. Test results for each Category 6 four-pair UTP cable must be submitted with identification to match labels on all patch panel ports and RJ45 jacks and must match as-builts associated with that cable.

3.8 SOURCE QUALITY CONTROL

A. Manufacturer's Test

- 1. All cables, components, and equipment shall be factory tested for continuity and all functions before shipment. Submit documentation to Engineer where items have been tested by the manufacturer to applicable Industry Standards.

B. Inspection

- 1. Submit certified data to Engineer confirming that all products and materials furnished have been manufactured and connected under strict quality assurance.

C. Verification of Performance

- 1. Each reel of cable shall be supplied with a report certifying its performance.

3.9 EXAMINATION

A. Verification of Conditions

1. Contractor will advise the Engineer in writing if conditions are not suitable. It is expected, however, that the Contractor will work in incomplete areas in order to meet the schedule.

B. Protection

1. Protection of existing work that may be affected by damage from other trades is the sole responsibility of the Contractor.

3.10 INSTALLATION

- A. All cables, connectors, distribution frames, etc. that comprise this system shall be installed as per manufacturers recommendations, unless otherwise noted.

- B. The Contractor shall purchase installation guides from vendors, and become familiar with the installation requirements prior to commencement of the work. Any discrepancies between plans, specifications and the manufacturers recommendations shall be brought to the attention of the Engineer.

- C. The plans and specifications indicate the general arrangement and scope of work. To facilitate the installation and coordination with other trades, the Contractor may deviate from this general arrangement so long as the scope does not change. All such changes shall be submitted to the duly authorized Engineer. All such changes shall be made with no additional cost to the Employer.

- D. Refer to drawings for data cabinets details & coordinate with university representative.

- E. Cables shall be continuous, with no factory or field splices, or intermediate couplings.

- F. Contractor shall require where necessary cable support bridges over obstructions i.e. underfloor conduit, pipes, supports, etc.

- G. Contractor shall install cable supports and fasteners for horizontal cable.

- Used to keep cable off of black iron, ceiling stringers and ceiling tile.
- Hangers or straps permanently attached to the underside of concrete deck.
- Contractor to bundle cables in groups not to exceed 10 units.
- Straps installed every three feet along a respective cable run.
- Contractor to submit manufacturer's cut sheets and proposed installation method prior to starting work.

- H. Contractor shall provide sufficient slack at all termination locations to allow for proper termination. The Contractor shall not coil cable in ceiling, telephone closets and the main telephone room so as to avoid unnecessarily adding to cable lengths, unless specified.

- I. Contractor shall install fire stopping material, filling the interstices between the cable in conduit or floor ceiling assemblies, used to give comparable thermal conductance to the

barrier itself in addition to resisting the fire and restricting the passage of hot gases for the required fire rated time.

3.11 INSPECTION

Conformance to the installation practices covered above are to be verified when completed. In some cases, the customer may inspect before acceptance. The following points are to be examined:

- A. Completion of the design documentation.
- B. All terminated cables shall be tested as per the specification.
- C. Cable type shall be suitable for its pathway.
- D. The pathway manufacturer's guidelines shall be followed.
- E. The installers shall avoid excessive cable bending.
- G. Hanging supports shall be within 150cm.
- I. Telecommunications closet terminations shall be compatible with equipment?
- H. Patch panel instructions shall be followed? (*Inspect visually.*)
 - 1. Cable dressing first.
 - 2. Jackets (sheath) remain up to the connecting block.
 - 3. Pair terminations tight and undistorted.
 - 4. Twists maintained up to the connecting block.
- I. The correct outlet connectors shall be used.
- J. The jacket maintained right up to the connection.
- K. Fire proofing provided in common cable area.
- L. Protection from sharp or movable crushing, impact and construction activity.

3.12 LABELING

- 1. Permanently attach labels to both ends of all cables.
- 2. Label shall be typed and covered with clear plastic laminate.
- 3. Attach label 20cm from end of sheath.
- 4. Provide unit cost for cable labels and unit labor cost to affix label to cables.
- 5. Attach self-adhesive labels to top center of each faceplate.
- 6. Information on labels shall agree with plans. Any discrepancies shall be replaced at the Contractor's expense.

3.13 ADJUSTING

- A. Repair or replace defective work, as directed.
- B. Pay for restoring or replacing damaged work found by or due to testing, as directed and at the Contractor's own expense.

3.14 DEMONSTRATION

- A. The manufacturer shall demonstrate the operation and verify the accuracy of all equipment to the Engineer or its duly authorized representative.

3.15 PROTECTION

- A. After installation, protect from damage during subsequent construction and other normal activities.

END OF SECTION

SECTION 16770

FIRE ALARM SYSTEM

1. **GENERAL**

1.1.1. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Section 16010 of the Specification.

1.1.2. DESCRIPTION OF WORK: complete fire alarm system analog addressable intelligent interactive type including the following:

A. Main fire alarm annunciation and control panel, microprocessor based, analogue / addressable type, modular expandable, fully electronic, electrically supervised. The system will have batteries capable of monitoring the system for 24 hours and then sounding the alarm for 30 minutes

B. Automatic and manual detectors consisting of smoke, heat, manual, duct smoke detectors. Detectors will be located to code and as shown on drawings.

C. Alert devices consisting of sirens and horns and visual alarms. The system must be interfaced with the local fire fighters station at the main panel by telephone dialler.

D. Interface and control modules for releasing of fire rated doors located in between fire zones, and for complete interlocking with lifts, , HVAC, fire dampers, fire pumps, (refer to mechanical drawings for HVAC operation in case of fire).

Contractor shall be fully responsible to determine number of interface control modules as per NFPA requirements & and submit fire strategy to be followed in case of fire, for approval.

E. Complete wiring system, end of line devices and any related accessories.

1.2 REGULATIONS AND STANDARDS: fire alarm system is to be in accordance with the local fire protection Regulations, and in compliance with the following American National Standard where not in contradiction with the Regulations:

A.NFPA No. 72 National Fire Alarm Code - 1993

B.NFPA No. 90A Standard for the Installation of Air Conditioning and Ventilating Systems

C.NFPA No. 101 Life Safety Code

1.2.2. The system and components are to be listed and properly labeled by

Underwriters Laboratories Inc. or approved international equal recognized testing laboratory.

- 1.2.3. EQUIPMENT DATA: submit complete technical data for approval including codes and standards, manufacturer's catalogues and specification, construction and circuit description in detail for each type of component and technology used. Provide calculations to verify that batteries are rated to cater to the main fire alarm control panel, amplifiers, and repeater panel.
- 1.2.4. TESTS: equipment is to be tested for quality and operation at the factory, and labeled properly.
- 1.2.5. SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:
 - A. complete riser diagram
 - B. fire command center
 - C. PC based graphic system indicating zones and location of fire in case of fire incident. (located next to RP at reception desk)
 - D. detailed system schematic diagram
 - E. exact routing and layout of all wireways, conduit and cables, giving type and size with calculations to verify satisfactory wire sizes for all circuits
 - F. exact composition of main and terminal cabinets
 - G. terminal numbers and wiring diagrams
 - H. typical installation details of cabinets, detectors, stations, alarm devices etc.
- 1.2.6. APPROVED MANUFACTURERS: obtain fire alarm system from one of the following or other equal and approved.
 - A. Notifier (USA)
 - B. GE (USA)
 - C. Simplex (USA)
 - D. Edwards (Canada)
- 1.2.7. EQUIPMENT SUPPLIER is to be authorised distributor of manufacturer, and able to maintain a local staff of specialists for engineering assistance, maintenance and repair.

2. PRODUCTS AND SYSTEMS

2.1. DESIGN, OPERATION AND COMPONENTS

- A. DESIGN: fire alarm system is to be an independent, self contained, audibly and visually supervised, analogue addressable, pre-signal system. Manual alarm stations and automatic fire detector and sensor circuits are to be grouped in loops as shown on the Drawings, each loop having control and annunciator module on main fire alarm control and annunciator panel (MFAP).
- B. OPERATION: FIRST STAGE Priority One Alarms: upon actuation of any manual station, automatic detector or sprinkler flow switch, the system is to operate as follows:
1. The main control panel will display priority one alarm indicator, address, floor and location and type of detector and sound an audible signal which can be silenced. Any subsequent alarms will cause the audible to sound again. Visually indicate on the LCD control panel the addressable device or circuit of alarm initiation. The green normal LED is to extinguish and the red alarm LED is to light. The buzzer is to pulsate and the first line of the LCD is to indicate real time, number of messages waiting, type of alarm, zone of alarm and time the alarm occurred. The second line is to display the user specified message indicating the floor and exact location that initiated the alarm.
 2. the evacuation alarm will sound in the relevant zone where the signal originated, alerting users and staff in that particular floor, the floor above and the floor to evacuate. The evacuation alarm will be by actuating the sounders.
 3. the remaining floors will receive the alarm by actuating the sounders at alert. The tone shall repeat continuously (unless manually silenced) until the alarm initiating device is restored to normal and system reset. The silencing of an alarm condition is not to prevent the resounding of alarm devices if a subsequent condition occur.
 4. Automatically shut down all HVAC systems serving the zone refer to mechanical drawings.
 5. Automatically start all stairwell and elevator pressurisation fans as applicable refer to mechanical drawings.
 6. Recall all passenger elevators to Closest floor. A common pre-recorded message is to be sounded in all seized elevators.
 7. The operator is to acknowledge the alarm by pressing a dedicated button and the buzzer is to silence provided that there isn't an additional alarm pending. If there are additional alarms the operator is to acknowledge all pending alarms before the buzzer is to silence. To silence audible devices the operator is to press the alarm silence button. New alarms are to cause audibles to resound. To reset the system the device is to be cleared first then the reset

button is to be pressed.

- C. Priority Two Alarms: Signals originating from duct smoke detectors and will cause the following:
 - 1. the main control panel will display priority two alarm indicator, address, floor and location and type of detector and sound an audible signal which can be silenced. Any subsequent alarms will cause the audible to sound again,
 - 2. if the alarm was initiated from a duct smoke detector, then associated fan is to shut down, refer to mechanical drawings
 - 3. printer will print a hard copy of events (at security desk)
- D. SECOND STAGE: The authorised personnel is to evaluate the danger. In case general evacuation is necessary, the authorised personnel can sound the general alarm either at the main control panel or at any manual pull station. If no action is taken in five minutes the system is to switch to general evacuation automatically.
- E. SENSITIVITY the system is to be capable of setting the sensitivity of all analogue sensors by point and be capable of displaying the analogue value of the sensor. The system is to automatically identify any analogue sensor which becomes dirty.
- F. FAULTS AND WARNINGS: fire alarm system is to give visual and audible warning on main annunciator panel for the following faults:
 - 1. failure or disconnection of power supply
 - 2. failure of fuse or protective device
 - 3. removal of detector head on any initiating circuit
 - 4. break or short circuit in wiring of any initiating or alarm circuit (line isolation to be installed by contractor every 20 detection.
 - 5. each stairwell pressurisation fan that is running
 - 6. each smoke removal fan that is running
- G. Faults are not to prevent fire alarm being sounded and are to automatically indicate fault alarm by audible and visual warning. Audible warning is to remain on until silenced by respective cut-off switch whilst red illuminated LED remains on to indicate defective zone. When respective circuit is restored to normal, trouble bell is to sound again until cut- off switch is back to normal, thereby turning off the illuminated LED.

MAIN FIRE ALARM CABINET (MFAP)

- A. MFAP TYPE is to be of the intelligent response controller 19” rack mountable, modular in design for ease of installation, maintenance and configuration. The liquid Crystal Display (LCD) that offers at least two

lines of 40 character each is to be built in. The controller is to be able to differentiate between long term drift above the pre-alarm threshold and the fast rise. The unit is to contain a real time clock, a keyboard, buttons to scroll data, front panel switches for reset, alarm, trouble, test and program. The MFAP is to be have a dual audio channel capability to broadcast two messages simultaneously.

- B. **MFAP ARCHITECTURE:** A master polling computer module is to be serially connected to the display computer module. The master polling computer module is to be tasked with the database input / output functions, field annunciation panel co-ordination and operating system co-ordination. It is to contain at least 4 Meg of EEPROM memory for data base storage, and is to have at least four mounting connectors for series communication. The display central processing module is to be responsible for message generation and peripheral device support. It is to contain at least 4 Meg of EEPROM memory for message storage, and is to have at least four mounting connectors for series communication such as the printer, and the LCD. Series cards are to be fitted on both computer modules to gather the data and operate the peripherals. Two-way fire-fighter phone system communication is to be fitted.
- C. **MFAP OPERATION:** During normal state the green normal LED is to flash, the first line is to display the time, the number of active points and the number of disabled points. When the panel goes into alarm the green LED is to extinguish and the red alarm LED is to light. The buzzer is to pulsate and the first line of the LCD is to indicate real time, number of messages waiting, type of alarm, zone of alarm and time the alarm occurred. The second line is to display the user specified message indicating the floor and zone that initiated the alarm.
- D. **VISUAL INDICATORS:** twin light-emitting diodes (LED), tamper-proof type, with rated life of at least 40 years.
- E. **VOLTAGE AND POWER SUPPLY:** MFAP is to provide 24 V d.c. to all zone alarm initiating and alarm signalling devices and is to be designed to operate from 220 V a.c., 50 Hz 2-wire, earthed power supply. Power supply is to be an integral part of the main fire alarm panel, switch mode solid state design, with built in transient protection (up to 6 kV), including UL recognised EMI filter, spark gaps and varistors. Additional power supply units are to be provided for the amplifiers. The power supply is to provide diagnostic LEDs to notify operator upon AC power and/or the control unit CPU failure.
- F. **BATTERY BACK UP ON POWER FAILURE** is to exceed 24 hours normal load, followed by full alarm load capability of 30 minutes. Voltage is to be 24 V d.c. Battery is to be gel electrolyte no maintenance type, float charged, with automatic rapid charge at maximum allowable rate for type used. Battery voltmeter, charge/discharge ammeter, low battery alarm bell and pilot light are to be provided.

- G. CABINET: sheet steel, wall mounted type, finished in bright red baked enamel, with hinged door secured by lock. Smaller lockable door is to be provided in main door for access for routine checking and servicing. Opening of main door is to expose all components for inspection, adjustment or replacement, without further dismantling.
- H. RELAYS: plug-in type, fitted with dust-proof covers, operated at 24 V d.c., with auxiliary contacts rated 250 V, 5 A supplied as necessary to operate other systems interconnected to fire alarm system, as required in the Specification or as shown on the Drawings.
- I. LAMP TEST BUTTONS are to be provided to test LEDs or other pilot lights on annunciator panels.
- J. AUXILIARY OUTPUTS: MFAP is to be equipped for transmitting several auxiliary outputs to other systems as shown on the Drawings.

CABLING

- A. WIRES AND CABLES: Certified to have passed IEC 331 and 332 flame resistance and fire retardant tests, or UL requirements. Working voltage is to be maintained in a flame of 1000 deg. C for at least 20 minutes or 750 deg. C for three hours. Cables are to be silicone rubber insulated, with overall PVC sheath bonding to coated aluminium foil (FP 200 by Pirelli Cables) or MICC cables or other equal and approved. Conductors are to be copper of minimum size 1.5 mm² and/or as shown on the Drawings. The wiring is to be true class "A" (UL Listed).
- B. CONDUITS AND RACEWAYS: to comply with Section 16118 of the Specification.

MANUAL FIRE ALARM STATION

- A. TYPE: pre-signal, pull-down slide face panel type, with break-rod feature, reset to normal position only by use of special key. Initial operation of station is to cause only presignal device to sound. Inserting a key and turning is to initiate a general evacuation alarm.
- B. CONSTRUCTION: tamper-proof, surface or semi-recessed mounting, in suitably designed metal box. Exposed parts are to be bright red. Glass rod is to break under firm pressure or moderated impact, no hammer is to be necessary.
- C. OPERATION: station is to have operating characteristics compatible with system.
- D. INSCRIPTION is to read "PULL-DOWN FOR FIRE ALARM" in raised white characters. Dimensions of inscription are to conform with the Regulations. Other instructions on use of station are to be boldly inscribed.

INTELLIGENT OPTICAL SMOKE DETECTOR

- A. **DESIGN:** Detection principle is multiple light pulse coincidence circuit. Detector shall conform to EN54-7/9 or UL 268 multi-criteria type detector having capability of determining seriousness of an alarm condition, without the need to communicate with main control unit. Response of detector (which is microprocessor controlled) is determined by set of algorithms with at least eight remotely selectable and predefined algorithm. Optical chamber shall be designed for detection of every type of visible smoke and therefore have a scattering angle larger than 70 degree.
- B. **MOUNTING:** surface or semi-recessed ceiling mounted type, located as shown on the Drawings, with head removable from fixed twist-lock base. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel normal flat surface coverage is to be over 100m² at mounting height of 6m.
- C. **SENSITIVITY:** detector is to have field adjustable, response sensitivity monitored without removal of detector head, by use of metering test points accessible on exterior of detector head.
- D. **ALARM RESPONSE TIME** is to be adjustable, and not exceeding 7 seconds from time combustion product is introduced into detector. Detector is to be capable of detecting a nominal value of 0.006 grams of combustion products per cubic foot of air.
- E. **REGULATION, PROTECTION AND SUPPRESSION:** detector is to have automatic regulation to varying supply voltage (15 V - 28 V d.c.), reverse voltage protection, spike and surge suppression.
- F. **STATUS INDICATION:** detector is to have status indicating LED, flashing under normal operation for visual supervision. When detector is actuated, LED is to latch-on 'steady' and at full brilliance until reset from control panel.
- G. **PERFORMANCE:** detector is to have at least the following performance:
 - 1. nominal operating voltage: 24 V d.c.
 - 2. alarm current: 5 m A
 - 3. quiescent current: less than 200 micro A
 - 4. ambient temperature: -10 to +60 deg. C
 - 5. relative humidity: 10% to 95%
 - 6. smoke entry characteristics: 360 degrees in all directions
 - 7. effectiveness for air-flow: up to 12 m/s.

FIXED TEMPERATURE HEAT DETECTOR

- A. TYPE: Dual thermistor sensor is to monitor the ambient temperature from 0 to 60 deg C and give a fast response to fast rapid increase in temperature. Detector is to have plug-in, twist- lock type base, hermetically sealed against dust and moisture, mounted in recessed or surface mounted box compatible with type of installation.
- B. OPERATION: to operate at 24 V d.c. nominal voltage.
- C. REGULATION, PROTECTION AND SUPPRESSION: detector is to have automatic regulation to varying supply voltage (15 V - 28 V d.c.), reverse voltage protection, spike and surge suppression.
- D. STATUS INDICATION: detector is to have status indicating LED, flashing under normal operation for visual supervision. When detector is actuated, LED is to latch-on 'steady' and at full brilliance until reset from control panel.

DUCT SMOKE DETECTOR

- A. TYPE: is to be an intelligent, analogue air duct sensor housing the ionisation smoke detector specified above (refer to mechanical drawings).
- B. CONSTRUCTION is to be made of high impact plastic with a clear cover for easy viewing of the polling and alarm LED's. Two sampling tubes are to be provide and installed in the duct. Gaskets are to prevent air leakage. For each duct detector a separate alarm and test stations are to be provided.

RATE OF RISE HEAT DETECTOR.

- A. Type: Automatic heat detector with fast semiconductor sensor to guarantee reliable detection of fire with rapidly rising temperatures and integrated fixed temperature function for the detection of fires with slow rising temperature.

Intelligent fire detector with decentralized intelligence, automatic self-test, CPU failure mode, alarm and operating data memory, alarm indicator, and soft- addressing.

- B. Performance:

- 1. Nominal operating voltage : 24 VDC.
- 2. Alarm current: : 5mA.
- 3. Quiescent current : less than 200 micro A.
- 4. Ambient temperature : -10 to + 60 deg.C.
- 5. Response temperature : 54°C to 64°C for 5°C/min. rise.
32°C to 75°C for 30°C/min. rise.

COMBINED HEAT SMOKE DETECTOR.

- A. Type: Multi-sensor detector provided with built-in optical smoke detector and fast detector the optical measurement chamber is provided with enabling developed newly technology, sensor the detection of fire, and fire with high lead generator.

Multi-sensor intelligent heat smoke detector with time-related signal analysis, decentralized intelligence, automatic self-test, CPU failure mode, automatic data memory, alarm indicator and soft addressing.

- B. Performance:

1. Nominal operating voltage : 24 VDC.
2. Alarm current: : 5mA.
3. Quiescent current : less than 200 micro A.
4. Ambient temperature : -10 to + 60 deg.C.
5. Response temperature : 54°C to 65°C at 1°C/min. rise.

ADDRESSABLE CONTROL MODULE

The addressable control module shall be designed to convert specific signals on an addressable detection line from the manufacturer's control unit into control functions to actuate fire doors, smoke vents, ventilators etc.

The output contact of the addressable control module shall be rated for at least 0.5A and 220 VAC.

The addressable control module shall have an input for a connection of an external contact to provide a confirmation signal to be sent back to the control unit via the detection line after the control function has been carried out.

The addressable control module shall be connected to the control unit via fully supervised two-wire circuit. No separate power line shall be required.

The control function to be assigned to the addressable control module shall be programmable at the control unit.

The addressable control module shall have screw less terminals with built-in strain limits to prevent permanent deformation of the terminal and weakening of contact pressure.

The addressable control module shall have a protective plastic housing of at least IP-40 IEC protection category.

2.2. OTHER DETECTION SYSTEMS, ALARM AND SUNDRY DEVICES

ALARM AND SUNDRY DEVICES

A. **Low-Power Alarm Sounder and Horn**

- The low-power alarm sounder shall produce a continuous tone and shall be suitable for small to medium size rooms with low background noise level.
- The alarm horn shall be suitable for surface or recess mounting indoors. The electronic signals are diode polarized, heavy duty, tone selectable, weatherproof made of die cast zinc alloy with sage enamel finish.
- Horn with flashing light – this unit to be similar to the horn component described above, and combined in one unit with a strobe (flashing light). The unit to have a red fire lettering and flash approximately one or 2 times per second.

Technical Data

a)	Operating voltage	:	18 to 24 VDC
b)	Power consumption approx.	:	1.8 VA
c)	Sound intensity at 1m distance	:	85 dB/800 Hz.
d)	Ambient temperature (-4 °F to + 104 °F)	:	-20 °C to + 40 °C
e)	Protection category IEC 529	:	IP 30

3. FIELD AND INSTALLATION WORK

3.1. INSTALLATION

- 3.1.1. **WIRING:** FP 200 type cables are to be run on cable trays, in galvanised heavy gauge steel conduit or in duct banks. MICC cable is to be run on cable trays or fixed to wall (for single cable only) in concealed or exposed installations as shown on the Drawings. Wire sizing schedules and calculations are to be submitted to ensure acceptable voltage drop on all alarm circuits within the system and to indicate various zone wiring layouts in detail. All circuits are to be appropriately labelled and approved before handing over the project.
- 3.1.2. **MANUAL STATIONS** are to be mounted 1400 mm from finished floor level.
- 3.1.3. **CONNECTIONS AND TERMINATIONS** of circuits are to be made only at accessible boxes and fire alarm cabinets.
- 3.1.4. **DETECTOR HEADS** with twist-lock mounting are to be removable from floor level by use of pre-engineered grip on end of long rod, specially designed for the purpose.
- 3.1.5. **PANELS AND POWER:** Install the panels where indicated and connect to the AC critical care and life safety power supply, DC standby power, alarm circuits, supervisory circuits, signal circuits, local and remote annunciators, , smoke control dampers, fan shut downs, elevator controllers, smoke exhaust fans, and all other devices.

- 3.1.6. **AUTOMATIC DEVICES LOCATION:** Install product of combustion and automatic alarm initiating devices as indicated and connect to alarm circuit wiring. Co-ordinate device location with mechanical air diffusers (minimum 600 mm away) and other equipment.
- 3.1.7. **DOOR HOLDERS:** Connect from the fire alarm system to the designated doors so that operation of the fire alarm system shall release all doors equipped with electric hold-open or locking devices (refer to architectural drawings).
- 3.1.8. **CONNECTIONS TO OTHER SYSTEMS:** Connect from the fire alarm system to the lifts, HVAC system emergency generator(s) and fire pump(s) control panels to monitor operation as indicated on mechanical and electrical drawings and specifications.

3.2. TESTING AND ADJUSTING

- 3.2.1. **EQUIPMENT AND LABOUR:** provide equipment and labour for site testing of detector heads and sensors including set of shorting plugs with connectors for checking wiring to sensor and detector sockets, and test bench equipment for checking and calibration of all items of system.
- 3.2.2. **TEST FIRES:** ensure correct positioning of each automatic detector. Start test fires and measure MPCM (milligrams particulate per cubic meter) using particle detector.
- 3.2.3. **ADJUSTMENT AND TESTS:** when exact optimum positions are determined, adjust sensitivity of automatic detectors for optimum safety to false alarms ratio and carry out the following tests:
 - A. On heads and sensors of all types: check operation at required threshold using test equipment and methods specified by the manufacturer
 - B. On all circuits: verification of operation of fault indication for open circuit, short-circuit, earthing, excessive resistance or leakage and removal of heads
 - C. General check of functions for main annunciator panel and repeater.
- 3.2.4. **THE MANUFACTURER** is to make, inspect and test the fire alarm equipment, including those components necessary to the direct operation of the system such as manual stations, thermal detectors, smoke detectors, flow switches, bells and controls, to ensure the following (coordinated between system vendor and contractor).
 - A. That the type of equipment installed is that designated by the engineer's specifications.
 - B. That the wiring connections to all equipment components show that the installer observed code requirements.

- C. That the manufacturer's equipment has been installed in accordance with the manufacturer's recommendations and that all signalling devices of whatever manufacturer have been operated or tested to verify their operation.
 - D. That the supervisory wiring of those items of equipment connected to a supervised circuit is operating and that the governmental regulations, if any, concerning such supervisory wiring, have been met to the satisfaction of inspecting officials.
- 3.2.5. THE MANUFACTURER (or system vendor) is to supply to the Trade of this Division technical assistance with respect to any changes necessary to conform the work to paragraphs above. During the period of inspection by the manufacturer, this Division shall make available to the manufacturer, electricians as designated by the manufacturer. To assist this Division in preparing the bid, the manufacturer shall indicate the number of hours necessary to complete this inspection, prior to closing of tenders.
- 3.2.6. INSPECTION CERTIFICATE: On completion of the inspection and when all of the above conditions have been complied with, the manufacturer shall issue to the Consultant:
- A. A copy of the inspecting technician's report showing location of each device and certifying the test results of each.
 - B. A certificate of verification confirming that the inspection has been completed and showing the conditions upon which such inspection and certification has been rendered.
- 3.2.7. INSPECTION COSTS: all costs involved in this inspection both from the manufacturer and this Division shall be included with this Division's total price and it will be the responsibility of this Division to ensure that the manufacturer carries out all the work listed herein to the satisfaction of the Consultant.
- 3.2.8. INSTRUCTIONS AND TRAINING: The manufacturer is to provide the services of a competent alarm system technician to instruct the staff in the operation and maintenance of the system.
- 3.2.9. VERIFICATION BY AN ENGINEER: This Contractor is to arrange and pay for the services of an independent engineer to verify the complete fire alarm system and to submit 3 copies of his verification report signed and sealed to the Consultant. Prior to his verification, contractor shall provide the following:
- A. A copy of the manufacturer's verification report 7 days prior to engineer's verification.
 - B. Leaving the devices connected, loosen mounting screws on all fire alarm initiating devices in a condition for verification.
 - C. Co-ordinate with mechanical trade so that the testing and verification

of the fire protection affecting the fire alarm system can be done at the same time.

- D. A set of "As-Built" drawings on the installed fire alarm system.
- E. Give notice to the engineer at least two working days prior to his verification.
- F. During engineer's verification, electrical contractor shall have his electrician and a manufacturer's technician to accompany with and to follow engineer's instructions.
- G. Inform the Consultant of the timing of the verification so that he can also witness it.
- H. Submit the name of the engineer to the consultant for approval.
- I. The cost for the independent engineer's time is to be included in Contract.

END OF SECTION

SECTION 16771

AUDIOVISUAL INTERPHONE SYSTEM

1. GENERAL

The contractor shall allow for the supply, install, test and commission the Audio video interphone system, as herein specified and shown on the drawings. The system shall consist of 1 master video interphone station at the main entrance of the building, & color monitors located in the apartments and offices as shown on drawings..

2. SYSTEM FEATURES

The basic function of the system shall be to facilitate communication between a visitor at the main entrance and the tenant. The visitor initiates a call by punching a button. A buzzer alerts the tenant of a visitor, answers the call and an audio communication link shall be established between the entrance panel and the tenant monitor. The monitor handset shall have a push button to release the solenoid lock at the entrance door to allow the visitor in.

Each entrance panel and monitor station shall be installed as shown on the drawings. With all interconnection wiring, conduits and accessories. The conduit system shall be segregated from all other systems.

3. MONITOR STATIONS (SLAVE STATION).

The video monitor shall be surface mounted type with flat screen and high image quality. The monitor shall have 4" screen electronic call, LED for various signals, brightness, contrast and call volume controls. The unit shall be complete with door opening button.

4. MASTER INTERPHONE STATION(MAIN ENTRANCE UNIT).

Each main entrance unit/door station shall be flush mounted with an illuminated push button, color camera unit, microphone / speaker all as a built in unit. The faceplate shall be of thick anodized aluminum with block color finish with rounded aluminum push button. It shall consist of an audio-video module,

The audio-video module shall have manually oriented 1/3" CCD color TV camera, infrared illuminated LED, speaker unit with double amplifier and volume adjustment.

Electric latches and solenoid locks shall be included in this system the contractor shall coordinate and insure that the operation of the locks is possible via push buttons from the Audio-visual interphone system.

5. APPROVED MANUFACTURER.

- Bticino.
- Videx.
- Urmet.
- Golmar

Or approved equal.

END OF SECTION

SECTION 16781

CCTV SECURITY SYSTEM

PART 1 - GENERAL

1.1 **RELATED DOCUMENTS:**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Specification sections, apply to this Section.
- B. Requirements of the following Division-16 sections apply to this Section:
 - 1. "16110, 16135".

1.2 **SUMMARY**

- A. This section includes a closed circuit television (CCTV) system.
- B. System is to consist of the following basic components:
 - Color cameras for general surveillance with protective housing
 - Video distribution controller.
 - Power supply units.
 - Color monitor
 - DVR (1.5 TB HD, realtime, PC based).
- C. The work to be done as outlined hereunder includes the furnishing of all labor, supervision, and equipment for the performance of the installation work specified by this contract and any associated work required as necessary for the completion of the installation hereinafter specified and as may be required.
- D. The Security Contractor shall furnish all equipment and all incidental materials such as the necessary connecting hardware, etc. wiremold, cable and wire, mounting hardware, etc. which are necessary to complete the installation of this security system. All materials and workmanship provided by the Contractor shall be in accordance with the best practice of the state-of-the-art of the security systems installation trade.
- E. The installation shall be suitable in every respect for satisfactory operation that will require a minimum amount of maintenance.
- F. It shall be the Security Contractor's responsibility to see that the equipment is installed to manufacturer's specifications and that the correct power is supplied to each different type of equipment.
- G. It shall be the Security Contractor's responsibility to obtain necessary equipment manufacturer's installation specifications and drawings to complete all installation and contract work.

- H. All electronic equipment shall be grounded as required by manufacturer's specifications. All cabinets, junction boxes, control cabinets, etc. shall be grounded.
- I. The Contractor shall note the locations of CCTV cameras shown on drawings are the preferred areas of placement. However, the Contractor shall be responsible for the final location of each camera for optimal coverage and stability. The cameras shall be placed to provide optimum surveillance field of view.
- J. CCTV System Functional Description: System generates video images, processes them and distributes them to monitors, and record these images at the dedicated hard disc. All cameras shall be controlled from a control panel next to DVR. System is to ensure remote control for video camera equipment.
- K. Related Sections: The following sections contains requirements that relate to this section:
 - 1. "Wires and Cable".
 - 2. "Raceways".
 - 3. "Electrical Cabinets, Boxes and Fittings".

1.3 **SUBMITTALS**

- A. General: Submit the following according to the Conditions of the Contract and Specification sections.
- B. Product Data: for products specified in this section. Include data on features, components, ratings, and performance. Include dimensional plan and elevation views of components and enclosures and details of control panels. Show access and working space requirements.
- C. Maintenance Data: for systems and products to include in "Operating and Maintenance Manual" specified in Division 1. Include the following:
 - 1. Detailed operating instructions covering operation both under normal and abnormal conditions.
 - 2. Routine maintenance requirements for system components.
 - 3. Lists of spare parts and replacement components recommended to be stored at the site for ready access.
- D. Wiring Diagrams: detailing internal and interconnecting wiring for power, signal and control and that distinguishes between field-installed and factory-installed wiring.
- E. Product Certificates signed by the manufacturer certifying products comply with specified requirements.
- F. Qualification data for manufacturer and installer as specified in "Quality Assurance" Article. Data describes capabilities and experience.
- H. Field test reports for all tests required for system operation, certified by an official testing authority.

- I. Shop and Construction Drawings: Submit drawings for approval including, but not be limited to:
- detailed schematic diagrams
 - configuration and construction details of control cabinet, and operating consoles
 - console and cabinet layouts with equipment located in as-installed positions.
 - complete and detail cable routing.

Wiring diagrams are to bear manufacturer's signature indicating that they have reviewed the drawings and that they are correct with regard to sizes, wiring and configuration and will operate in accordance with function, scope and intent of the specifications.

1.4 **QUALITY ASSURANCE**

- A. Manufacturer's Qualifications: Firms experienced in manufacturing systems and equipment of the same types and capacities used for this project that they have a record of successful in-service performance.
- B. Service Center: Select a system manufacturer who maintains a service center capable of providing training, parts, and emergency maintenance and repairs at the project site with a 24-hour maximum response time.
- C. Installer Qualifications: Engage an experienced installer who is a factory-authorized service representative of the system manufacturer to supervise system installations.
- D. Codes and Standards: The installation shall meet, as applicable, to Underwriter's Laboratories (UL), NEMA, & NEC requirements.

PART 2 - PRODUCTS

2.1 **MANUFACTURERS:**

- A. Manufacturers: Subject to compliance, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

Vision
Pelco
American Dynamics
Honeywell
Sony

DVR: Vision, Honeywell

or other equal and approved.

2.2 **SYSTEM REQUIREMENTS**

The equipment proposed must have equivalent or better performance than the below.

2.2.1 ANALOG COLOR CAMERAS

Features

- 1/3" interline color CCD
- Vertical phase adjustment
- *Built in IR sensitive mechanical day/night filter
- IR, Night & Day, Auto Iris
- 2D/3DNR, noise reduction
- High resolution of 600TVL at day & 650TVL at night
- Compact, lightweight
- Automatic electronic iris
- Low power consumption
- 0.01 lux low light sensitivity
- IP66 Weather & vandal proof
- Automatic electronic shutter
- Top and bottom mounting holes
- Switchable back-light compensation
- Super Wide Dynamic
- *Extended IR LED's life cycle & sensitivity
- *Highlight eclipse
- * Stabilizer (Compensates Camera Movement)
- *Motion Detection

Technical Specification

Image Sensor	1/3" CCD, 2.8-12mm DC IRIS lens
Image Area	4.82 H x 3.64 mm V
Synchronizing System	Line locked
Auto Iris Control	VIDEO iris/DC iris
Back-Light Compensation	ON/OFF switch and level adjuster
Motion detection interface	Yes
Dome bubble rotation	Yes
Mounting arrangement	Industrial type
Easy to use OSD functions	

Electrical Requirements

Input Power	12VDC/24 Vac + 20%/10%
Surge Protection	Yes

2.2.2. ENVIRONMENTAL CAMERA HOUSING

Housing shall be made of extruded and cast aluminium with IP 66 degree of protection. It shall ensure full and easy access to the camera and lens for trouble-free installation and servicing.

The camera platform shall have four lenses, of height adjustment and shall be secured in any position along the full length of the housing.

The platform shall be constructed of non-conductive material in order to eliminate grounding problem.

The housing shall have a powder coat enamel finish and shall be marine climate resistance. A low current PTC shall automatically provide heat in the housing in order to maintain a clear viewing window.

2.2.3 COLOR MONITOR

Features

- 700 lines of horizontal resolution
- Rugged, attractively styled cabinet
- Convenient front controls
- VCR-matched time constants for excellent
- Playback characteristics
- Switchable DC restoration
- Switchable over scan/under scan
- Looping input with automatic
- 75 ohm
- LED power indicator
- Low power consumption

2.2.4. DIGITAL VIDEO RECORDING (DVR)

A. General

DVR to be real time, transaction based recording of up to 16 analog cameras, with a record rate of 300 fps minimum, with 1.5TB hard disc drive to record at real time speed at least 15 days. The DVR should be networkable and includes a CD writer for back up, and with the following minimum requirements;

Industry-leading ATM, tellers, and alarm interfaces

Programmable video recording & retention

Embedded operating system for enhanced security

RAID 1 option

Video search by date/time/transaction/number or event

Able to communicate with same application used for all other FDC buildings.

Compression: MPEG-4 (SM-4)

Resolution: CIF/2CIF/4CIF

Frame rate: 60/120/300fps (NTSC), 50/100/240fps(PAL)

Embedded linux based operating system

Storage: 1.5TB with independent surveillance, motion, and event/transaction settings.

B. Tape Transport

Recording Modes

Resolution

- Over 600-650 TV lines horizontal (color)

Luminance Signal

Frequency modulation recording

Input

0.5 to 2.0 V_{p-p}, BNC, 75 Ω, unbalanced.

Output

1.0 V_{p-p}, BNC, 75 Ω, unbalanced

S/N ratio

Greater than 45 dB.

D. On-Screen Data Display

Contact

Menus for setting day-present time, display format, timer programs (day of weeks, start/stop), user selection menus (alarm recording, tape condition, emergency recording, clock out, mode out, one-shot recording, buzzer, playback heads), default selections, power loss displays and alarm recording-elapsed time display.

Position On-Screen

Any position, sizes.

E. Alarm Response

Automatic alarm search.

F. Timer

- Eight start and stop times within a one week time period.
- Programmable recording speed.

G. Mechanical

Cabinet shall be rack mountable.

H. Environmental

Operating Temperature

+5° C to 40° C.

Humidity

85% RH (non-condensing).

I. Regulatory Approvals

- UL listed
- CSA certified.

Or approved equal

PART 3 - EXECUTION

3.1 **CCTV SYSTEM INSTALLATION:**

- A. Camera Mounting: Install cameras in the general vicinity indicated, adjusted to final locations defined by camera location tests. Provide adequate headroom below cameras and their mountings. Where necessary, change the type of mounting to provide adequate headroom below.

3.2 **IDENTIFICATION:**

- A. Identify: system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification".

3.3 FIELD QUALITY CONTROL:

- A. Manufacturer's Field Services: Provide services of factory-authorized service representatives to supervise the field assembly and connection of components and system pretesting, testing, and adjustment.
- B. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- C. Pretesting: Align and adjust the system and pretest all components, wiring , and functions to verify they conform to specified requirements. Replace malfunctioning or damaged items with new items. Retest until achieving satisfactory performance and conditions.
- D. Final Acceptance Testing Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 2 weeks. Provide a minimum of 10 days' notice of acceptance test performance schedule.
- F. CCTV Camera Location Test: Support each camera temporarily at the location indicated and connect to monitor. Adjust camera location and mounting and substitute fixed lenses as approved to provide required performance at monitor. Adjust locations within 15 feet (5m) of those indicated with no change in Contract cost.
- G. Record: results of tests.
- H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

3.4 CLEANING:

- A. Clean: all system components including camera housing windows, lenses, and monitor screens. Use methods and materials recommended by manufacturer.

3.5 ADJUSTMENT:

- A. Occupancy Adjustments: When requested within 1 year of date of Substantial Completion, provide on-site assistance in adjusting the system to suit actual occupied conditions. Provide up to 2 requested adjustment periods at the site for this purpose without additional cost.

3.6 DEMONSTRATION:

- A. Training: Arrange and pay for the services of a factory-authorized service representative to demonstrate adjustment, operation, and maintenance of the system and to train Owner's personnel. Include demonstration of methods to determine optimum settings for system controls.

END OF SECTION

SECTION 16610

UNINTERRUPTIBLE POWER SUPPLY SYSTEM

PART 1 - GENERAL

1.01 **PURPOSE**

The purpose of this specification is to define the design, manufacture and testing characteristics required in view of supplying and putting into operation an Uninterruptible Power Supply (referred to as a UPS in the rest of this document).

1.02 **SUMMARY**

Provide labor, materials, equipment and services, and perform operations required for installation of uninterruptible power supply systems and related work as indicated on the drawings and specified herein.

Only equipment that carries the certification and approval label of TUV or UL testing laboratories shall be approved.

The UPS system shall be capable to operate continuously providing uninterrupted and regulated power in the event of a power distribution to the connected load up to the specified battery autonomy.

The work shall include, but not be limited to, the following:

1. Solid-state rectifiers / chargers.
2. Static inverters.
3. Static transfer switches.
4. Maintenance bypass switches.
5. Batteries.
6. Accessories.
7. Furnishing load bands and test instruments during field-testing.

The UPS system shall be capable of withstanding any combination of the following environmental conditions in which it must operate, without mechanical or electrical damage or degradation of operating characteristics.

- a. Ambient temperature = 0 deg. C to 45 deg. C.
- b. Relative humidity = 0 % to 95% (non-condensing).

System efficiency = 92% at full load.

Type of UPS = ON LINE = using intelligent microprocessor and insulated gate bipolar transistor (IGBT) power semi-conductor technology.

The unit shall be compact and discreet. It shall integrate perfectly in the site.

1.03 **SUMMARY**

The UPS shall be of the latest technology (IGBT) in the field combining modular power circuit design with high frequency chopping (15 kHz). It shall feature:

- a. Continuity of supply for 15 minutes at 60% load.
- b. Instant response to load steps
- c. High reliability.
- d. A diagnostic panel.
- e. Communication facilities: Possibility for remote-control and monitoring, UPS administration on a LAN or WAN, connection on an Ethernet network for SNMP integration, multi-platform and multiple servers supervision and shutdown, load shedding by software control of different sockets.

1.04 PRINCIPLE OF WORK

A rectifier charger shall take the input mains to supply the inverter and shall keep the batter constantly charged.

The inverter shall supply a perfect, constant alternating current to the load with referenced neutral at all times.

In case of mains failure, the battery backup-shall takeover the supply to the inverter. This shall take place without any disturbances to the output.

The battery shall supply the inverter until its autonomy is exhausted.

In case of overload or a fault, the load shall be supplied directly from the normal power via a static switch.

1.05 FUNCTIONS

The UPS shall comprise:

- a. A safety device.
- b. A rectifier charger, producing DC from AC.
- c. An inverter, to restore perfectly AC power.
- d. A built-sealed lead acid battery for backup supply shall be provided on rack installation.
- e. A static switch.
- f. An integrated manual bypass for maintenance without load interruptions.

1.06 COMPLIANCE TO STANDARDS

- a. IEC 146.4
IEC 801-2/3/4 OR IEC 1000-4-2/3/4/.
EN 5091-1
IEC 1000-2-.

Furthermore the required units shall comply with the European Directives or equivalent regarding Electromagnetic Compatibility

- b. ISO 9001 official certificate for design and production to be submitted.

1.07 QUALITY ASSURANCE

Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.

1. Code Compliance: Comply with the applicable electrical code as applicable to installation and construction of electrical equipment.
2. IEC Standards: Comply with IEC standard 146 and 439.
3. VDE Standards: VDE 0875 cl. N – Radio Interference suppression.

Manufacturer's Qualifications: Firms regularly engaged in manufacture of uninterruptible power supply systems, of types and ratings specified whose products have been in satisfactory use in similar service for not less than 5 years. A list of installed systems of the same type and ratings as specified shall be submitted to the Engineer.

1.08 SUBMITTALS

Submit the following in accordance with Submittal Requirements specified in SUB-SECTION 16010.

1. Product Data: Submit manufacturer's data on uninterruptible power supply systems and components.
2. Shop Drawings: Submit dimensioned layout drawings and descriptive data of UPS systems and accessories including, but not limited to, weights, rectifiers / chargers, inverters, static transfer switches, maintenance switches, batteries and instruments, indicating accurately scaled UPS system equipment location and their spatial relationship to associated equipment; show connections to normal and standby power supplies, elementary diagrams of protection, control and instrumentation systems, wiring and single line diagrams, time current curves of protective devices. Submit calculations to indicate compliance with battery requirements of scheduled standby use with no more than specified drop in battery voltage.
3. Maintenance Data: Submit maintenance data, parts and recommended spare parts list for uninterruptible power supply and accessory' including "troubleshooting" maintenance guide. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of SUB-SECTION 16010.
4. Field Test Procedure: Submit a detailed site acceptance test procedure.
5. Submit a failure mode and effects analysis and a reliability prediction based on the final design.
6. Submit a detailed factory acceptance test procedure.
7. Submit certified factory and site test data and reports, for the UPS equipment and the batteries.
8. Submit battery manufacturer name, container type, the total number of containers required per UPS module, battery and rack dimensions and weights.

1.09 DELIVERY, STORAGE AND HANDLING

Handle uninterruptible power supply equipment carefully to prevent damage, breaking and scoring. Do not install damaged units or components, replace with new.

Store units in clean dry place. Protect from weather, dirt, fumes, water, construction debris and physical damage.

1.10 WARRANTY AND GUARANTY

The UPS system warranty shall be no less than one year after initial handing over, and must include repair, parts, labor. The manufacturer shall respond to requests for and provide warranty service within 8 hours maximum.

Battery: The battery provided herein shall be guaranteed by the UPS manufacturer on a pro rated basis for five years (unless otherwise specified herein), provided that the prevailing ambient temperature of the battery area does not exceed 80 °F. batteries shall deliver a minimum of 100% of rated capacity initially and a minimum of 80% of rated capacity at the end of the battery guarantee period in accordance with IEE standard 485.

Efficiency: The manufacturer shall guaranty, in writing, the stated system efficiency. If the stated efficiency is less than that stated, the manufacturer shall refund to the user an amount based on additional power costs incurred by loss of efficiency over a three-year operating period.

1.11 MANUFACTURERS

Manufacturers: Subject to compliance with requirements, provide uninterruptible power supply systems of one of the following:

1. UPS:
 - a. MGE
 - b. Socomec

2. Battery:
 - a. Oldham.
 - b. Exide.
 - c. Alcad.

Provide on calculation sheet the following data:

- Float and low dc voltages with supporting documents from the UPS manufacturer.
- Float and low dc voltage per element with supporting documents from the batteries manufacturer.
- Calculation of the required number of element and selection of the batteries model according to calculated power in Kw.

3. Batteries and Racks:
 - a. The battery shall be of the sealed maintenance free lead acid gas type, with a five years Certified guarantee from main supplier, suitable for office environment, have no gassing and need no watering or special ventilation.
 - b. Battery banks shall be arranged to minimize the requirements for floor space, consistent with providing for safe servicing of the cells and with a maximum of three tiers high. Provide suitable Code approved steel racks for support of batteries. Racks shall be protected with battery electrolyte resistant paint. Racks shall be designed, constructed and braced for the site seismic zone.
4. Contractor shall submit the following certified documents from UPS supplier:
 - a. Float and low DC voltage per battery element with supporting document form the batteries manufacturer.
 - b. Calculation of the required number of element and selection of the batteries model according to calculated power in KW.

1.12 SOURCE QUALITY CONTROL

Factory Tests: before shipment, the manufacturer shall fully test the system to assure compliance with the specification. These tests shall include operational discharge and recharge test on at least a one-minute batter plant to assure guaranteed rated performance.

1.13 EXAMINATION

Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

1.14 PREPARATION

Examine the Contract Drawings and specification in order to insure the completeness of the work required under this Section.

Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades so as not to delay job progress.

Provide templates as required to related trade for location of items.

PART 2 - PRODUCTS

2.01 PREPARATION

The double-conversion UPS (also called on-line) shall operate as defined below.

A. Normal Operation:

(Normal AC source available)

The rectifier / charger supplies the inverter with DC current while simultaneously float charging the battery. The load is continuously supplied with dependable electrical power by the inverter.

B. Operation by Battery Power:

(Normal AC source not available or outside tolerances)

Upon failure or excessive deterioration of the normal AC source, the inverter shall continue to supply the load from battery power without interruption or disturbance, within the limits imposed by the specified battery backup time.

C. Battery Recharge:

(Normal AC source restored).

When the normal AC source is restored, the rectifier / charger shall again power the inverter, without interruption or disturbance to the load, while automatically recharging the battery.

D. Static Bypass Operation (Static Switch):

Not required

E. Operation of the Manual Maintenance Bypass:

The UPS shall include a manually operated mechanical bypass system for maintenance purposes.

For personnel safety during servicing or testing, this system shall be designed to isolate the rectifier / charger, inverter and static switch while continuing to supply power to the load from the bypass AC source.

Transfer to the manual bypass mode and back shall be possible without interruption to the load.

The UPS shall also include a device making it possible to isolate the rectifier / charger from the normal AC source.

F. Battery Maintenance:

For safe maintenance on the battery, the system shall include a circuit breaker to isolate the battery from the rectifier / charger and the inverter.

When the battery is isolated from the system, the UPS shall continue to supply the load without interruption or disturbance, except in the event of a normal AC source outage.

PART 3 - EXECUTION

3.01 INSTALLATION

Install UPS system equipment and components as indicated, in accordance with equipment manufacturer's written instructions, and under the direct supervision of the manufacturer's field service engineer and with recognized industry practices to ensure that UPS system equipment complies with requirements. Comply with requirements of the applicable electrical code.

Engage battery manufacturer to provide constant on-site supervision of the battery and battery rack installation, testing and certification. Provide certification that the installation is in compliance with the battery manufacturer's instructions that the manufacturer is satisfied with installation, and that the manufacturer's warranty is in effect. The battery and battery rack installation shall be in accordance with IEC standards and certified with tests witnessed by the Employer's representative.

Grounding: provide equipment-grounding connections for UPS system. Tighten connections to fulfill manufacturer's torquing requirements.

3.02 DEMONSTRATION

Upon completion of installation of UPS system equipment, and after building circuitry has been energized with normal power source, test UPS system, with manufacturer's field service engineer present, to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise remove and replace with new units, and proceed with retesting.

Demonstrate operating procedures to Employer's personnel and provide written operating instructions with full explanation of technical information.

3.03 MAINTENANCE AND RELIABILITY

A self-test system shall be included to monitor the UPS operation continuously and shall identify any faulty sub-assemblies in the event of a failure.

The sub-assemblies shall be laid out for easy replacement.

A manually operated mechanical by-pass switch to isolate the UPS system and static by-pass switch for maintenance purposes while maintaining load power via the by-pass source without interruption shall be provided. It shall be of make-before-break type. The switch shall be entirely mechanically operated.

An integral battery circuit breaker shall also be provided within the UPS panel to isolate the battery from the rectifier / charger and the inverter for battery maintenance purposes.

3.04 STANDARDS AND TESTS

All equipment shall be designed and built in accordance with accepted engineering practice and applicable international standards, in particular the standards listed below.

- IEC 146-4: UPS – Performance.
- EN 50091-1: UPS – Safety.
- EN 50091-2: UPS – EMC.
- ENV 50091-3: UPS – Performance.
- IEC 60950 – EN 60950: safety of IT equipment, including electrical business equipment.
- IEC 61000-2-2: Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems.
- IEC 61000-3-4: Limits for harmonic current emissions (equipment input current > 16 A/ph).
- IEC 61000-4: EMC – electrical fast transient / bursts immunity.
- EN 55011: Limits and methods of measurement of radio interference characteristics of industrial, scientific and medical (ISM) radio-frequency equipment – level A conducted and radiated emissions.

The manufacturer shall provide, on request, a complete qualification file demonstrating compliance with the above standards.

The indicated levels of performance shall be confirmed by certification from independent laboratories TUV, or UL and properly labelled.

3.05 **REPLACEMENT PARTS**

the supplier undertakes to provide replacement parts for at least ten years following the date of delivery.

All spare parts related to this UPS shall be available at the local representative.

3.06 **WARRANTY**

The rectifier / charger and inverter subassemblies shall be guaranteed (parts and labor on site) for one year following the initial handing over.

Sealed lead-acid battery shall be covered by the same warranty as the UPS.

END OF SECTION

SECTION 16950

ELECTRICAL TESTS

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide labor, materials, temporary wiring, testing equipment, load bank, technical supervision and services, and perform operations required for testing of electrical equipment and installations and related work as specified herein and as shown on the drawings.
- B. Work Included: The work shall include, but not be limited to, the following:
 - 1. Preliminary inspections and tests.
 - 2. Electrical acceptance tests.
 - 3. Operational tests.
- C. Related Work Specified Elsewhere
 - 1. Basic Electrical Requirements - Section 16010.
 - 2. Other Division 16 sections.

1.02 DESCRIPTION

- A. Preliminary testing and visual inspections shall be conducted prior to acceptance and operational tests to avoid delays. **Contractor to submit for approval his testing procedure for each electrical system. Tests shall be conducted by contactor according to the approved testing procedure. All tests shall be conducted & recorded and submitted during handing over.**
- B. Electrical acceptance tests shall be conducted to assure that electrical materials, and their installations are in accordance with contract documents, regulatory agencies, applicable codes and standards listed herein, and that they may be energized.
- C. Operational tests shall be conducted to assure capability of equipment and systems to perform as specified and designed.

1.03 QUALITY ASSURANCE

- A. Testing and testing equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of IEC chapter 6.
Third party organization certificate is required for Lifts
- B. The Personnel engaged in the testing of electrical equipment and systems shall have a minimum of five (5) years of continuous experience in the testing of

the equipment and systems to be tested. Submit evidence of such qualifications to the Engineer.

- C. Contractor shall furnish testing equipment as required. Testing equipment, meters and instruments shall have been properly calibrated and certified within (6) months prior to testing and shall be in satisfactory condition to perform its functions.
- D. Contractor shall provide an appropriate and stable source of electrical power to the test locations.
- E. Perform tests in the presence of the Employer's Representative.
- F. Electrical equipment and installation shall meet acceptance and operational tests. Promptly repair or replace defective work and repeat the tests until the particular system and component parts thereof receive the approval of the Engineer. Any damages resulting from tests shall be repaired and/or damaged materials replaced, to the satisfaction of the Engineer.
- G. It is essential that certain trades and manufacturer's technical representatives be present during the testing. These representatives shall include:
 - 1. Electrical subcontractor who is thoroughly familiar with the project as to its intent, what equipment has been provided and how it is supposed to operate.
 - 2. Supplier of equipment particularly where packaged equipment has been provided.
 - 3. Manufacturer's representative who is thoroughly familiar with the operation of the equipment.
- H. The operation of the electrical installation by the Employers does not constitute an acceptance of the electrical installations. Final acceptance will depend on Contractor's demonstration of compliance with contract documents, completion of adjustments as specified and required, and submission of required documentation and certification of approval by governing authorities.
- I. Continuity tests shall be performed using direct current and audible bells or buzzers. Use of telephones is not acceptable.
- J. Safety devices such as rubber gloves and blankets, glow detectors, hot sticks, helmets, eye shields, protective screens and barriers, danger signs, etc. shall be used to adequately protected and warn personnel in the vicinity of the tests.

1.04 SCHEDULING

- A. Scheduling of tests shall be as approved by the Engineer.
- B. Schedule tests so that equipment can be energized immediately after completing the tests and approval of the reports.

- C. Notify the Engineer two (2) weeks prior to testing.

1.05 SUBMITTALS

- A. Submit the following in accordance with the requirements specified under "Submittals" in Section 16010.
 - 1. Submit two (2) copies of test reports including actual readings and corrected readings after each test period.
 - 2. Submit four (4) bound copies of final approved test reports at the completion of tests.
 - 3. Test reports shall be signed by the persons performing the tests and the witnesses to the tests and include but not be limited to the following data:
 - a. Date of test.
 - b. Description of equipment tested.
 - c. Description of test.
 - d. Test results.
 - e. Conclusions and recommendations.
 - f. Identification of test equipment.
 - 4. Include copies of the final approved test reports in the maintenance manuals.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Cooperate in the coordination and scheduling of the work of this Section with the work of related trades, so as not to delay job progress.
- C. Testing of outdoor equipment shall not be performed during inclement weather. Ground resistance tests on direct buried ground conductors or rods shall not be performed within 48 hours after rainfall.

- D. Megger and high potential testing shall not be performed during periods of high relative humidity. A guard shall be stationed at each location where exposed cables, buswork, connections or other components exist during megger and high potential testing.
- E. Equipment shall be thoroughly cleaned prior to testing. Vacuum the interiors of cubicles and remove foreign material. Insulators, bushing and bus supports shall be wiped clean with a lint free cloth.
- F. Preliminary tests and visual inspections of the electrical installation including verification checks of factory wiring shall be conducted prior to electrical acceptance and operational tests to avoid delays, and to assure that equipment and installations are free of faulty conditions prior to the application of test voltages.
- G. Where the equipment or system under test is interrelated with and depends upon other equipment, systems and/or controls for proper operation, functioning and performance, the latter shall be operated simultaneously with the equipment or system under test.
- H. Test fuses for continuity.
- I. Test current transformers for continuity and proper polarity.
- J. Test potential transformers for continuity and absence of short circuits.
- K. Set protective devices in accordance with the approved coordination study.
- L. If generators, motors or transformers require drying out to obtain the required insulation values, the drying method shall be in accordance with the manufacturer's recommendations.
- M. Verify that shipping devices and restraints have been removed.
- N. Check for proper interconnection and tightness at connections of shipping sections.

3.03 APPLICATION

- A. Equipment that can be paralleled under any conditions including interlock defeat shall be tested for proper phasing using hot-phase hot-stick or other approved methods. This includes, but is not limited to, primary selector switches, automatic transfer switches, tie breakers and busses, etc. at medium and low voltage levels.
- B. Full load currents of feeders serving single phase loads shall be measured to assure an equal load balance on each phase. Branch circuits shall be reconnected if necessary to achieve this balance.

- C. Megger values specified are minimum acceptable values at an ambient temperature of 60 degrees F and low relative humidity. Contractor shall convert readings to equivalent values at 60 degrees F if measurements are taken under other conditions.

- C. The phase rotation at busses, panels, switchboards, switchgear, etc., shall be checked and verified using a phase sequence meter for consistency and conformity to recognized standards, i.e. A-B-C left to right, top to bottom, front to back, when facing front of the equipment, and to provide an A-B-C (1-2-3) clockwise rotation. Where electrical installations and extensions of existing systems, or in new buildings at existing sites, phase rotation shall conform to the existing.

3.04 TESTS

A. Low Voltage Wire and Cable (600 Volts and Less)

- 1. Wire and cable shall be tested for continuity, freedom from short circuits and grounds and meggered to assure adequate insulation resistances for each conductor. Test to be recorded & submitted.
- 2. Test Voltages: Megger instrument shall be 1000 volts DC applied for one minute.
- 3. Acceptable Test Results: Insulation resistance between phase conductors and any phase conductor to ground shall be not less than 2 megohms for connected conductors and 100 megohms for disconnected conductors.

B. Motor Control Centers and Panelboards

- 1. Equipment shall be tested for continuity, freedom from short circuits, and grounds and meggered to assure adequate resistances.
- 2. Test Voltages: Megger instrument shall be 1,000 volts DC for equipment rated 380 volts and 500 volts DC for equipment rated 220 volts, applied for one minute.
- 3. Acceptable Test Results: Insulation resistance phase and any phase to ground shall be not less than 100 megohms for equipment rated 380 volts and 25 megohms for equipment rated 220 volts.

C. Switchboards

- 1. Test electrical and mechanical interlock systems for proper operation and sequencing .
- 2. Test ground connections as specified under "earthing System."
- 3. Perform ratio and polarity tests on instrument current and potential transformers.

4. Perform insulation resistance tests on each bus section, phase to phase and phase to ground as specified under "Motor Control Centers (MCC) & (MSPs) (EMSPs) and all Panelboards." Prior to performing insulation resistance tests on buswork, isolate the buswork by racking out or opening circuit breakers and disconnects, short circuit and ground current transformer secondaries, remove potential transformer primary fuses and assure grounding of the enclosure.
5. Perform control wiring performance test using the approved manufacturer's elementary diagrams.
6. For selective switchboard and switchgear arrangements, verify proper phasing between the line and load stabs of the tie breaker cubicle busses using hot-phase hot-stick techniques, A-A, B-B, C-C.
7. Test disconnect switches as specified under "Circuit and Motor Disconnects."
8. Perform an insulation resistance test at 1000 volts DC on each circuit breaker for one (1) minute from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase. Insulation resistance shall not be less than 100 megohms.
9. Set, calibrate and adjust protective device setting of each circuit breaker in accordance with the approved coordination study using secondary current injection.
10. Tests of relays associated with the distribution system shall include the following:
 - a. Check equipment ground and assure continuity of connections.
 - b. Remove blocking used for shipment.
 - c. Check overcurrent and undervoltage relays for proper current and voltage range. Adjust relays in accordance with the approved coordination study.
 - d. Check magnet coil for proper operating voltage.
 - e. Clean contacts and magnetic surfaces where necessary.
 - f. Check air gap between moving and stationary magnets with manufacturer's clearances.
 - g. Check auxiliary contacts for correct arrangement with coil de-energized, i.e., normally open or normally closed.
 - h. Check fuses for proper rating.

- i. Check connectors for tightness.
 - j. With loads disconnected, energize control circuits and test for correct functioning.
 - k. For timing relays, adjust the timing cycle for proper equipment operation.
11. Control and instrument switch test shall include the following:
- a. Inspect contacts and shunts, cleaning contacts if required.
 - b. Operate switch and note that design function are performed in proper sequence.
12. Ammeters shall be tested as follows:
- a. Check connections from current transformer for AC shunts for DC to ammeters.
 - b. Check ammeter scale with current transformer ratio for AC and shunt millivolt rating for DC.
 - c. Set pointer on zero scale with no load.
13. Power factor and VAR meter tests shall include checking polarities of instrument transformers and connecting so lagging current will be to right of center.
14. Voltmeter tests shall include the following:
- a. Check voltmeter scale with potential transformer ratio.
 - b. Set pointer on zero scale with no voltage.
 - c. Check voltmeter reading with test voltmeter when energized.
15. Wattmeter and wathour meter tests shall include the following:
- a. Check with current transformer and potential transformers ratio.
 - b. Set wattmeter pointer on zero scale with no load.
 - c. Check rotation on wathour meter.
16. Tests of instrument transformers shall include the following:
- a. Physically check polarity mark orientation on CTs and PTs with three line diagram on the plans and with manufacturer's drawings.
 - b. Check CT and PT polarity makings.

17. Electrical controls shall be tested by trial operation of control equipment after wiring is completed to see that each interlock and control function operates according to the manufacturer's operating instructions.
18. All nuts to be tightened according to devices manufacturer for torque levels. All nuts to be marked and rechecked on site. Torque level for each nut size & breaker to be recorded & submitted.

D. Motors

1. Motors shall be tested for freedom from short circuits and grounds meggered to assure adequate resistances.
2. Test Voltages: Megger instrument shall be 2,500 volts DC for testing 4,000 volt motors, 1,000 volts DC for testing 460 volt motors and 500 volts DC for testing 200 volt motors, applied for one minute.
3. Acceptable Test Results: Insulation resistance phase to ground shall be not less than 100 megohms for 4,000 volt motors, 20 megohms for 460 and 200 volt 3-phase motors and 5 megohms for 115 volt single phase motors.
4. Apply voltage momentarily and check each motors for correct direction of rotation. Correct if necessary.
5. Measure full load current reading of each motor and verify that the correct size heater elements have been provided for each starter overload relay. Where current flow exceeds the motor's nameplate value, install a "DO NOT OPERATE" tag, advise the Engineer and notify the Contractor to immediately correct the condition. If power factor correction capacitors are connected on the load side of the overload heaters, include the capacitive reactances in determining the proper overload heater size.
6. Submit a tabulation of each motor indicating the equipment identification, motor horsepower, voltage, measured full load current and heater rating and manufacturer's catalog number.

E. Grounding System

1. General
 - a. Tests on individual ground rods shall be performed with each rod isolated from each other and the grounding system.
 - b. Tests on the grounding system shall be made after installation and interconnection of the ground system elements including individual ground rods, ground grid cables, connections to structural steel, reinforcing bars, incoming water piping, ground busses on walls and within equipment, etc.
2. Tests of Individual Ground Rods

- a. Measure the resistance to earth of each individual ground rod using a Biddle Co. ground tester or two auxiliary ground rods as described in IEEE Standard 550 paragraph 3.4.2 using an alternating test current. Locate the auxiliary rods at sufficient distance from the rod under tests to insure that the regions in which their resistances are localized do not overlap. Calculated resistances to earth shall not exceed 25 ohms.
 - b. If the resistance is greater than 25 ohms, it shall be reduced by lengthening the rod or driving additional rods with a minimum separation of 3 meters and cadwelding the rods together until the resistance is less than 25 ohms.
3. Tests of the Grounding System: Test ground system for continuity by applying a low voltage DC source of current, capable of furnishing up to 100 amperes. The ground path using structural steel must conduct 100 amperes. Resistance as calculated from the current and voltage shall not exceed 5 ohms.
- F. Circuit and Motor Disconnects: Upon completion of the installation of electrical disconnects, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation and for verification of type and rating of fuses installed. Correct deficiencies, then retest to demonstrate compliance. Remove and replace defective units with new units and retest.
- G. Sockets
1. Upon completion of wire tests, check sockets for proper voltages and phasing, utilizing a receptacle tester for 120 volt 16 and 20 ampere devices and a voltmeter for other devices.
 2. Test three phase sockets for proper phase rotation using a phase sequence meter.
 3. Grounded sockets shall be tested for location and the effectiveness of the ground insert.
 4. Test ground fault circuit interrupter sockets with both local and remote fault simulations in accordance with the manufacturer's recommendations.
- H. Lighting Switches: Test lighting switches for correct operation with special emphasis on 3-and 4-way switches.
- I. Lighting Fixtures: Verify proper operation of lighting fixtures.
- J. Emergency Lighting Units - Battery Operated: After emergency lighting units have been installed and building circuits have been energized with the normal power source, apply and interrupt electrical energy to demonstrate proper operation. Remove and replace malfunctioning units with new units and proceed with retesting. Include the following tests:

1. Duration of supply.
 2. Low battery voltage shutdown.
 3. Normal transfer to battery source and retransfer to normal.
 4. Low supply voltage transfer.
- K. Control Circuits: Test control circuits for proper functioning and fail safe operation.
- L. Fire Alarm System
1. Provide the services of a factory-authorized service representative to supervise the field system pretesting, testing, adjustment and programming.
 2. Pretesting: Upon completing installation of the system, align and adjust the system and perform pretesting. Determine, through pretesting, the conformance of the system to the requirements of the drawings and specifications. Correct deficiencies by replacing malfunctioning or damaged items with new items and retest until satisfactory performance and conditions are achieved.
 3. Testing
 - a. Perform electrical and mechanical tests required by the equipment manufacturer's certification form. In addition, measure and adjust each of the ionization detectors to the maximum stable sensitivity setting. This shall be performed with the detector at its operational location and under normal operational environmental conditions in the area. Bench settings are not acceptable.
 - b. The completed smoke detection system shall be tested to insure that it is operating properly. This test shall consist of exposing the installed units to a standard fire test. Failure of the devices to detect smoke shall be considered a failure of the system and detectors in that system shall be re-adjusted or replaced. Acceptance of the system shall also require a demonstration of the stability of the system. This shall be adequately demonstrated if the system operates for a ninety (90) day test period without any unwarranted alarms. Should an unwarranted alarm(s) occur, the Contractor shall readjust or replace the detector(s) and begin another ninety (90) day test period. The Contractor shall recheck the detectors using the fire test after each readjustment or replacement of detectors. This test shall not start until the Employer has obtained beneficial use of the building under tests.
 - c. Wiring shall be checked and tested to insure there are no grounds, opens or short circuits.
 - d. A checkout report shall be prepared and submitted, one copy of which shall be registered with the equipment manufacturer. The report shall include, but not be limited to:
 - 1) A list of equipment installed and wired.
 - 2) Indication that equipment is properly installed and functions and conforms with these specifications.
 - 3) Test of individual zones as applicable.

- 4) Serial numbers, locations by zone and model number for each installed detector.
 - 5) Voltage (sensitivity) settings for each ionization and photoelectric detector as measured in place with the HVAC system operating.
 - 6) Response time on thermostats and flame detectors.
 - 7) Technician's name, certificate number and date.
- e. After completion of the tests and adjustments listed above, submit the following information to the Engineer:
- 1) "As-built" conduit layout diagrams including wire color code and/or number.
 - 2) "As-built" wiring diagrams.
 - 3) Detailed catalog data on installed system components.
 - 4) Copy of the test report.

END OF SECTION