

**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)

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

Lighting fixtures

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 mm<sup>2</sup> and a circuit breaker of (1 x 10 A + N) – Minimum wire size shall be 2.5 mm<sup>2</sup>.

The convenience socket outlet and exhaust fan shall have a cross section of 4mm<sup>2</sup> 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 prized 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 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 mm<sup>2</sup> 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 mm<sup>2</sup> and above are to be compacted. Multi-core cables 35 mm<sup>2</sup> 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 mm<sup>2</sup>), 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 mm<sup>2</sup> or stranded 4 mm<sup>2</sup> 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 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 trip 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 mm<sup>2</sup> 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 mm<sup>2</sup> 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 hiring 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 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 contractor 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 protect 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.
- A. 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 watthour 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 watthour 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**