

Section 16021

Telephone Service and Data

SECTION 16021**TELEPHONE SERVICES AND DATA****PART 1 - GENERAL****1.1 Releted Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of necessary equipment and materials and making arrangements for the connection of telephone and high-speed data transmission.

1.3 Reference Standards

Comply with all service installation standards of the serving utility.

PART 2 TELEPHONE SERVICE REQUIREMENTS**2.1 Source**

Telephone service will be provided from the Telephone Company system. Service to the project will be via Underground Conduit.

2.2 Coordination

The location of the service entrance must be coordinated with the telephone company. Provide materials and equipment required to enable the telephone company to connect service to the project.

Coordinate work of this section with Employer's telephone switch, telephone instrument, work station, and LAN equipment suppliers.

2.3 Location

Secure approval from the Engineer for the final locations of telephone and Data outlets.

2.4 Materials

1. In interior spaces use cable trays and PVC conduit for telephone and data services. If service is in or below floor slab or underground, use galvanized rigid steel conduit. Use 19.05mm (3/4-inch) minimum conduit with insulated bushings at each termination and install a pulling line in each raceway. Install raceways in accordance with Section 16110, Raceways.
2. Provide 19.05mm (3/4-inch) -thick exterior Grade A-A plywood telephone backboards (++) and Data Patch Panel as described on the drawings. Paint the backboard with one prime coat and one finish coat in pearl gray. Securely fasten the backboard to the wall.
3. Provide a No.70mm minimum ground, at the backboard location, connected to the building counterpoise.
4. Provide a 20-ampere, 230-volt, quadruplex convenience outlet at the backboard location and connect to a dedicated branch circuit.
5. Provide boxes in accordance with Section 16130, Boxes.
6. Twisted-Pair Cables, Connectors, and Terminal Equipment
 - A. Listed as complying with Categories 3 or 5.
 - B. Conductors: Solid copper.
 - C. UTP Cable: Four thermoplastic-insulated, individually twisted pairs of conductors; No. 24 AWG, color-coded; enclosed in PVC jacket.
 - D. STP Workstation Cable: Two thermoplastic-insulated, individually twisted pairs of conductors; No. 22 AWG, color-coded, overall aluminum and polyester shield and No. 22 AWG tinned-copper drain wire; enclosed in PVC jacket.
 - E. UTP and STP Plenum Cable: Listed for use in air-handling spaces. Features are as specified above, except materials are modified as required for listing.
 - F. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools.
 1. IDC Terminal Block Modules: Integral with connector bodies, including plugs and jacks where indicated.
 2. IDC Connecting Hardware: Consistent throughout Project.

2.4 Materials

- G. Cross-Connect Panel: Modular array of IDC terminal blocks arranged to terminate building cables and permit interconnection between cables.
 - 1. Number of Terminals per Field: One for each conductor in assigned cables.
 - 2. Mounting: Backboard or rack as indicated.
- H. Patch Panel: Modular panels housing multiple, numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 - 1. Number of Jacks per Field: **[One for each four-pair UTP cable or two-pair STP cable indicated] [One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to satisfy specified expansion criteria].**
 - 2. Mounting: **[Backboard] [Rack].**
- I. Jacks and Jack Assemblies for UTP Cable: Modular, color-coded, RJ-45 receptacle units with integral IDC-type terminals. Use keyed jacks for data service.
- J. UTP Patch Cords: Four-pair cables in (1200-mm) lengths, terminated with RJ-45 plug at each end. Use keyed plugs for data service.
- K. STP Patch Cords: Two-pair cables in (1200-mm) lengths, terminated with STP plug connectors at both ends. Match plug connectors with patch-panel connectors.
- L. Workstation Outlets: Dual jack-connector assemblies mounted in single or multigang faceplate.
 - 1. Faceplate: High-impact plastic; color as selected by Engineer.
 - 2. Mounting: Flush, unless otherwise indicated.
 - 3. Legend: Factory label top jack, "Voice" and bottom jack, "Data"; by silk-screening or engraving.

PART 3 - EXECUTION

Install the utility services as required by the contract documents. Demonstrate that the electrical system is operational.

3.1 Eamination

Examine pathway elements intended for cable. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation

1. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
2. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where cable wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and wiring except in unfinished spaces.
3. Install cable using techniques, practices, and methods that are consistent with Category [3] [5] rating of components and that ensure Category [3] [5] performance of completed and linked signal paths, end to end.
4. Install cable without damaging conductors, shield, or jacket.
5. Do not bend cable in handling or in installing to smaller radii than minimums recommended by manufacturer.
6. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
 - A. Pull cables simultaneously if more than one is being installed in the same raceway.
 - B. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
 - C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage media or raceway.
7. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
8. Secure and support cable at intervals not exceeding (760 mm) and not more than (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

3.2 Installation (cont'd)

9. Wiring within Wiring Closets and Enclosures: Provide adequate length of conductors. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

END OF SECTION

Section 1602

Telephone System

SECTION 16022**TELEPHONE SYSTEM****PART 1 - GENERAL****1.01 Work Included:****A. Related Work:**

Complete telephone distribution network and private telephone exchange system suitable for the project use, including, but not limited to the following:

Telephone distribution installations

Electronic private automatic branch exchange (PABX)

Main Distribution frame (MTTB) and main terminal cabinet (MTC)

PABX peripheral equipment

Operator's console(s)

Power supply equipment

Ancillary equipment.

1.02 Related Work:

A. Section 16010: Electrical General Provisions.

B. Section 16110: Raceway.

C. Section 16120: Wiring.

D. Section 16190: Supporting Devices.

1.03 Regulations and Standards: telephone installations are to comply with the requirements of local telecommunications authority and the relevant CCITT recommendations.

1.04 Submittals:

A. **Equipment Data:** Submit data for approval including complete technical data and manufacturer's catalogues for all equipment and materials.

1.04 Submittals: (cont'd)

- B. Tests: PABX and related equipment are to be tested at manufacturer's premises, and test certificates, certified by an official testing authority, are to be submitted to the Engineer before shipping and delivery to site.
- C. Shop and Construction Drawings: submit drawings for approval including, but not limited to, the following:

Detailed system schematic diagram

Exact routing and layout of all cabling and wireways

Exact composition of PABX cabinet(s), terminal boxes and other distribution boxes.

Type installation details of cabinet (s), boxes, and other equipment.

1.05 Approved Manufacturers:

Ericsson	Sweden
I.T.T.:	U.S.A.
N.E.C.:	Japan
Philips:	Holland
Siemens:	Germany

Or approved equal

PART 2 - PRODUCTS**2.01 Telephone Distribution Components:**

- A. Main Terminal Cabinet (MTC): is to be provided for terminating main lines. MTC is to be in compliance with the local requirements for telephone service entrance, and of capacity as shown on the Drawings.
- B. Telephone Distribution Cabinets and Boxes: Steel or metal alloy, general purpose enclosures, for surface or concealed mounting, of size and at location shown on the Drawings, dust-proof, IP 42 protection for indoor mounting and IP 55 for outdoor mounting, to IEC 144, with door and lock for sizes over 10 pair capacity, and with tamper - proof screwed covers for up to 10 - pair capacity.
- C. Terminal Blocks: screw or plug-in quick connect type in moulded high insulation resistance phenolic base, fixed by two captive screws, with doubled -ended nickel-plated brass connectors, and plug - in or set - screw terminals for connection of conductors with diameters between 0.5 and 1 mm.

- D. Conduits and Raceways are to be provided in accordance with Section 16110 of the specification.
- E. Telephone System Cable: two-pair and multi - pair cables for indoor cabling are to be polyethylene insulated, tinned solid copper conductors, twisted into pairs, color coded, with wrapping of aluminum polyester tape and gray PVC sheath. Minimum diameter of conductor is to be 0.6 mm Drain wire is to be provided in each cable, 0.4 mm diameter for 1 to 10 pair cables and 0.6 mm diameter for cables with more than 10 - pairs.
- F. Multi-Pair Cables for installation in duct banks, outdoor or directly buried are to be non - hygroscopic, Waterproof, polyethylene insulated, tinned solid copper conductors, minimum 0.6 mm diameter, twisted into Paris, color coded, with wrapping of aluminized polyester tape, PVC tape aluminum or copper sheath and PVC over-sheath.
- G. Cable Rating: cables are to be rated for maximum operating voltage of 150 V, with insulation resistance of 10,000 megaohm/km, and tested at 500 V d.c. applied core and core-earth.
- H. Telephone Outlets: are to have modular grid box and cover plates similar to other socket outlets and switches desecration Section 16140 of the Specification, with corgrip cover and fixed mounting set-screw terminal block in side box.

2.02: Electronic Private Automatic Branch:

A. Design:

- 1) Numbering: design is to permit station numbers to be assigned to lines at time of installation, in accordance with customer-desired numbering plan, and reassignment while in service to allow personnel moves without requiring number changes.
- 2) Outward Call Restrictions: it is to be possible to assign to each extension, restriction for outward calls as follows:
 - non - restricted: having unrestricted access to external lines for outward calls either by direct dialing or through operator.
 - semi-restricted: having unrestricted access to external lines for outward calls either by direct dialing or through operate
 - restricted: having no access to external lines neither through direct dialing nor through operator.
- 3) Segregation of External Line: it is to be possible to segregate external turn lines as follows:
 - lines for incoming calls directed to assigned stations
 - lines for outgoing calls accessible only by operators.
 - lines for outgoing calls accessible by operators and by all remaining non-restricted and semi-restricted extensions.

2.02: Electronic Private Automatic Branch: (cont'd)**B. Characteristics:**

1) Type:

PABX is to be fully electronic, digital stored program, microprocessor controlled with LSI switching circuits. Reed relays, mini-switches, cross-point switching and cross-point techniques are not acceptable. PABX is to be designed for use as a universal telephone exchange system for all applications. It is to be possible to connect any combination of DTMF and rotary dial telephones to the PABX, with the provision of manufacturer-made interface modules as necessary within the PABX and without the need to modify the assembly.

2) Capacity: is to be as follows:

- a- external lines as shown on the drawings.
- b- internal extensions: as shown on the drawings.
- c- operator's consoles: 1 with provision to one in future.

3) Grade of Service: is to be as follows:

- a- incoming traffic: $P = 0.01$
- b- outgoing traffic: $P = 0.01$
- c- internal traffic: $P = 0.001$
- d- traffic capacity per line: more than 0.19 erlang.

4) Characteristics: PABX is to be in accordance with Local Telecommunication Company recommendations and is to have at least the following characteristics:

- a- control : stored program
- b- control functions : performed by LSI micro-processors and mini-processors
- c- maximum loop resistance : 1300 ohms (including telephone set)
- d- insertion loss : less than 0.6 dB at 800 Hz, less than 1.5 DB between 300 and 3400 Hz
- e- CrossTalk Attenuation : more than 0.6 70 dB (in 200 to 3,200 Hz band)
- f- leakage impedance : more than 40 K ohms
- g- power supplies;
 - primary power 220 V (+/-15%)
 - battery 48 V d.c.
nominal (+/-12%)
- h- ambient room temperature : 40 deg. C
- i- relative humidity : 5% to 90 %
- j- compatible station : two - wire and/or three wire standard serial pulse or DTMF dialing.

2.02: Electronic Private Automatic Branch: (cont'd)**C. Systems Performance:****1) PABX Features:** are to include, but are not limited to, the following:

Station-to station calling: station user is to be able to directly dial other stations within PABX system without assistance of operator.

Direct Outward Dialing (DOD): non-restricted and semi-restricted station use is to be able to gain access to exchange network, without assistance of operator, by dialing an access code, receiving a second dial tone and then dialing desired network exchange number.

Executive override (break-in): station use is to be able to enter existing two-party busy station connection, this intrusion is to be preceded by a warning tone; if a person called releases his line he is automatically called back.

Camp on Busy: if internal extension called is busy, it is to be possible to dial a digit and to hang up, the two telephone stations are automatically called back as soon as they are simultaneously free.

Inquiry call: when telephone use is in conversation with the outside he is to be able to put his communication on hold, dial an internal number, consult privately, and then take back first communication.

Call Transfer: this is to enable any extension in the installation to directly divert and external communication to another extension without going throughout the operator.

Dial access to operator: station users within switching system are to be able to reach operator by dialing a single digit, and operator may complete these calls to trunk faculties or other stations.

Recall Dial Tone: this is to indicated to station user the successful use of the switch - hook flash when requesting a service feature during an established, call and without causing a re-origination to occur line lockout with warning: this gives 3-0 seconds warning tone and then holds the line out of service when a station line remains off - hook for longer than 10 seconds with out dialing, the hold out - of service is to be released when station goes on - hook.

Call forward: an internal extension is to be able to forward all incoming calls automatically to another selected telephone number.

Auto answer back: selected extension is to automatically answer on call after one ring.

Group Call: station use is to be able to establish an automatic conference between pre-designated group of stations.

Splitting: station use is to be able to consult privately with one party on a call without third party hearing.

2.02: Electronic Private Automatic Branch: (cont'd)**C. Systems Performance: (cont'd)**

Serial Call: operator is to be able to complete an incoming trunk call to two or more station lines in succession without requiring the outside party to recall operator.

Conference: stations are to be able to establish a conference of up to six parties (min) without operator assistance

Power failure transfer: this is to allow a limited number of pre-assigned stations to get access to or from the network in case of battery failure.

Call back queuing for trunks: this allows the user to wait for a trunk to be idle: when the trunk is idle, the exchange rings back, then waits for user to go off-hook and dial the number.

Direct distance dialing (DDD): this is to allow user to dial long-distance calls without intervention of operator.

Do not disturb (DND): operator is to be able to place individual extensions into a DND mode, such that to be appeared busy to all incoming calls.

Paging calls: selected extensions are to be able to send a paging call by dialing an access number followed by the called paging number.

2) Operator's Console Features: are to include at least the following:

- a- facility to check status of any individual trunk or extension line.
- b- ring-when-free facility for external calls transferred to a given busy extension.
- c- automatic return to operator if an extension does not answer an outside call within 15 seconds.
- d- time reminders: operator is to be automatically alerted after 30 seconds when an internal or outside call on the console is waiting.
- e- calling number display: visual display of PABX station seeking attendant assistance.
- f- Transfer of incoming call to wanted extension made by push-button key set.
- g- Priority: operator is to be able to interfere in an established communication of special announcements or transfer of incoming calls, warning tone is to be sent to both conversing parties.
- h- Splitting: operator is to be able to consult private with one party on a call without the other party hearing.

2.02: Electronic Private Automatic Branch: (cont'd)**C. Systems Performance: (cont'd)**

- i- Operator is to be able to connect any internal extension or outside trunk line with any other internal extension, operator is to be able to place an outgoing call for a station use without requiring the station user to hang up
- j- Call hold: calls that cannot immediately be extended, are to be placed in a hold buffer, when required extension becomes available, the call is to be retrieved from hold buffer and extended to extension.
- k- abbreviated dialing: operator is to be able to assign short dial codes for frequently called destinations.
- l- Automatic call supervision: if an unannounced extended call is not answered within a predetermined time, the call is to be automatically returned to the operator.
- m- Fault indication: any fault within the system is to be automatically detected and signaled by an alarm buzzer and an indicating lamp.
- n- Automatic and manual switch-over to night service: incoming CO trunk calls during night operation are to be routed to predetermined answering stations; routings are to be on a flexible basis by the attendant and are to remain in effect until changed.

D. System peripheral Equipment:

- 1) **PABX:** is to contain floppy disk for storage of all system and user data, to serve as back-up storage for protection of system configuration data and operating system software. Floppy disk processor is to be provided for this unit.
- 2) **Calls Detail Recording:** facilities are to be included in order that all trunk call information is to be automatically recorded for accounting purposes. Information is to be stored on floppy disk and printed on typewriter (or printer) upon request. Call reports are to be the full list of outward calls, with indication of number called, number on internal extension originating the call, date, time and duration of call or list of calls per certain extension.
- 3) **Paging System Interfacing:** Interfacing modules to the radio paging system are to be provided in coordination with the systems supplier/manufacturer.

2.02: Electronic Private Automatic Branch: (cont'd)**E. Construction:**

- 1) Cabinet: Exchange components are to be grouped in a modular, totally enclosed, sheet metal cabinet, with lockable front access doors, and whole assembly is to fit into one integrated form. Cabinet is to be dust and insect proof, an ventilation is to be provided as required for specified ambient conditions and air-conditioning facilities. Range of temperatures recommended for continuous operation of the system are to be submitted to the Engineer.
- 2) Plug - In Equipment: electronic circuits and components are to be plug-in card type, with solid state electronic components. Equipment is to be assembled neatly in tracks. Sensitive equipment is to have dust protection covers.

2.03 Other Equipment:**A. Operator's Console:**

- 1) Type: Desk-top, compact type, equipped to enable operator to provide all services required and have full control of system operation. As well as a busy lamp panel is to be included to show the condition of the extensions and public exchange lines.

B. Telephone Extension Sets:

- 1) Type: desk or wall type as shown on the Drawings. Dial is to be push button operated, dual tone multi-frequency type (DTMF) and pulse type, switch able.
- 2) Executive Set: is to be a multi-line type and is to have, but not limited to, and LCD display (2 lines x 40 characters min.), min. of 8 programmable keys, hands free operation, auto answer back, hold, release and hands free mute keys.
- 3) Construction: set is to be shock - resistant moulded plastic, of approved design and color, and appropriate for function intended. Set is to be dust and insect tight with bell and adjustable volume control. Serial number and other markings are to be large and legible. Base plate is to be engraved with year of manufacture, serial number, manufacturer and any other information required by the standards.
- 4) Connectors and Cord telephone sets are to have lock-in plug-ended connector cords not less than 2.5 m long, for connecting hand-set to telephone set base an for connection base to wall terminal box. Plugs are to snap-lock into mating connectors on hand-set base terminal box. Lock is to be released without special tools.
- 5) Receiver and Transmitter: capsule is to be protected by a click suppresser. Transmitter capsule is to be spit-proof type.
- 6) Impedance and Frequency response: set is to shown an optimum impedance adaptation to the extension lines in the band from 300 to 3,400 Hz. Frequency response curve for transmission is to be uniform and without sharp deviation within the band (30 to 3.400 Hz)
- 7) Insulation test: sets are t withstand an insulation test of 200 V , 50 Hz , for 30 seconds.

C. Main Distribution Frame (MTTB)

- 1) Size is to be suitable for ultimate capacity of PABX specified, cross-connection type with separate incoming and outgoing terminal blocks. All internal and external lines of PABX system are to be connected MTTB.
- 2) Protection against lightning and voltage surges on all trunk circuits is to be provided by protectors as recommended by the Manufacturer.
- 3) Terminals are to be identified by numbered tags corresponding to respective lines and extensions. Proposed numbering scheme is to be submitted for approval. Internal and external lines are to be connected by plugged twin terminals soldering will not be allowed.

D. Power Supply Equipment:

- 1) **Standby Power system:** rectifier-charger and batteries are to supply continuous d.c. power at specified voltage to the PABX. Capacity is to provide minimum eight hours continuous operation without loss of functions or reduction in system capacity after normal power supply failure. Batteries are to be floated on load side of rectifier and kept continuously fully charged
- 2) Rectifier: to be solid stage, with sufficient capacity to supply required power to PABX and maintain batteries in fully charged condition. Quality of output voltage is to be within required limits of PABX. Following restoration of normal power and full discharge of batteries, rectifier charger is to return batteries, rectifier charge is to return batteries to 90% full charge within 6 hours.
- 3) Batteries: lead-acid, sealed, maintenance free, stationary type. Necessary hardware and wiring are to be provided inside PVC conduit for interconnection. Suitable mounting rack is to be provided for battery installation.
- 4) Maintenance Kit is to be provided for servicing the battery.

PART 3 - EXECUTION**3.01 Installation**

- A. **Equipment Installation on Site:** is to be limited to fixation and inter-wiring of various items of the ready made equipment.
- B. **Cables:** are to be run concealed in underground ducts, on cable trunking, in walls or under floors in a manner to protect them from physical damage and excessive heat, and to permit ease of accessibility for servicing and modifications. Fixing accessories are to include two piece plastic clamps, galvanized screws, wall base-holders and fiber-plastic inserts of rawl-bolts, subject to the approval of the Engineer.
- C. **Operator's Console:** Install concealed wiring directly from main distribution frame via multi-pair cables to operator's console.
- D. **Conduits:** in accordance with section 16110 of the specification.

3.01 Installation

- E. **Tools:** use only proper tools for all installation work particularly in making connections.
- F. **Earthing:** provide interference-free earthing as necessary.
- G. **Super-intendance:** carry out installations under the direct supervision of a qualified technician, licensed by and trained at the factory.
- H. **Telephone sets:** install finally and only after obtaining approval from the Engineer.

3.02 Tests:

- A. **Test Plans:** PABX is to be tested in accordance with the contractor-developed and approved test plans. Test plans are to include insulation tests and system operation tests.
- B. **Phase I site testing:** Prior to system hand-over, it is to be demonstrated to the satisfaction of the Engineer that installed equipment meets the requirements of the Specification and is ready for hand-over. Test calls are to be made from stations selected at random, and a.c. power is to be disconnected to test reliability of emergency power system.
- C. **Phase II Site Testing:** System is to be tested under actual operating conditions for 30 days prior to acceptance. Tests are to demonstrate to the satisfaction of the Engineer that system is fully operational and compatible with the local telecommunication authority

END OF SECTION

Section 16050

Through-Penetration Firestop Systems

SECTION 16050**THROUGH-PENETRATION FIRESTOP SYSTEMS****PART 1 - GENERAL****1.1 Related Documents**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

- A. This Section includes through-penetration firestop systems for penetrations through the following fire-resistance-rated assemblies, including both empty openings and openings containing penetrating items:
 - 1. Floors.
 - 2. Roofs.
 - 3. Walls and partitions.
 - 4. Smoke barriers.
 - 5. Construction enclosing compartmentalized areas.
- B. Related Sections include the following:
 - 1. "Cast-in-Place Concrete" for construction of openings in concrete slabs and walls.
 - 2. "Building Insulation" for safing insulation and accessories.
 - 3. "Sprayed Fire-Resistive Materials."
 - 4. Division 15 Sections specifying duct and piping penetrations.
 - 5. Division 16 Sections specifying cable, cable trays and conduit penetrations.

1.3 Performance Requirements

- A. General: For the following constructions, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly penetrated.
 - 1. Fire-resistance-rated load-bearing walls, including partitions, with fire-protection-rated openings.
 - 2. Fire-resistance-rated non-load-bearing walls, including partitions, with fire-protection-rated openings.
 - 3. Fire-resistance-rated floor assemblies.

1.3 Performance Requirements (cont'd)

4. Fire-resistance-rated roof assemblies.
- B. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, as determined per ASTM E 814, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
 - C. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, as determined per ASTM E 814, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:
 1. Penetrations located outside wall cavities.
 2. Penetrations located outside fire-resistive shaft enclosures.
 3. Penetrations located in construction containing fire-protection-rated openings.
 4. Penetrating items larger than 100-mm- (4-inch) diameter nominal pipe or 100 sq. cm (16 sq. in.) in overall cross-sectional area.
 - D. For through-penetration firestop systems exposed to view, provide products with flame-spread ratings of less than 25 and smoke-developed ratings of less than 450, as determined per ASTM E 84.

1.4 Submittals

- A. Product Data: For each type of through-penetration firestop system product indicated.
- B. Shop Drawings: For each through-penetration firestop system, show each kind of construction condition penetrated, relationships to adjoining construction, and kind of penetrating item.
 1. Submit documentation that is applicable to each through-penetration firestop system configuration for construction and penetrating items.
- C. Qualification Data: Includes lists of completed projects with project names and addresses, names and addresses of Engineers and Employers, and other information specified.
- D. Product Certificates: Signed by manufacturers of through-penetration firestop system products certifying that products furnished comply with requirements.
- E. Product Test Reports: From a qualified testing agency indicating through-penetration firestop system complies with requirements, based on comprehensive testing of current products.

1.5 Quality Assurance

- A. **Installer Qualifications:** An experienced installer who has completed through-penetration firestop systems similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. **Installer Qualifications:** An experienced installer who is qualified by having the necessary experience, staff, and training to install manufacturer's products per specified requirements. A manufacturer's willingness to sell its through-penetration firestop system products to Contractor or to an installer engaged by Contractor does not in itself confer qualification on buyer.
- C. **Source Limitations:** Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.
- D. **Fire-Test-Response Characteristics:** Provide through-penetration firestop systems that comply with the following requirements and those specified in "Performance Requirements" Article:
 - 1. Firestopping tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is **UL, ITS**, or another agency performing testing and follow-up inspection services for firestop systems acceptable to authorities having jurisdiction.
 - 2. Through-penetration firestop systems are identical to those tested per ASTM E 814. Provide rated systems complying with the following requirements:
 - a. Through-penetration firestop system products bear classification marking of qualified testing and inspecting agency.
 - b. Through-penetration firestop systems correspond to those indicated by reference to through-penetration firestop system designations listed by the following:
 - 1) UL in "Fire Resistance Directory."
 - 2) ITS in "Directory of Listed Products."

1.6 Delivery, Storage and Handling

- A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to Project; curing time; and mixing instructions for multicomponent materials.

1.6 Delivery, Storage and Handling (cont'd)

- B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.7 Project Conditions

- A. Environmental Limitations: Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- B. Ventilate through-penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.8 Coordination

- A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.
- B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.
- C. Notify Engineer at least seven days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.
- D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until the Engineer, if required by authorities having jurisdiction, have examined each installation.

PART 2 - PRODUCTS**2.1 Products and Manufacturers**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. A/D Fire Protection Systems Inc.
 - 2. 3M Fire Protection Products.

2.2 Firestopping, General

- A. Compatibility: Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

- B. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by the qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:
 - 1. Permanent forming/damming/backing materials, including the following:
 - a. Slag-/rock-wool-fiber insulation.
 - b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
 - c. Fire-rated form board.
 - d. Fillers for sealants.
 - 2. Temporary forming materials.
 - 3. Substrate primers.
 - 4. Collars.
 - 5. Steel sleeves.

2.3 Fill Materials

- A. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 by reference to the types of materials described in this Article. Fill materials are those referred to in directories of the referenced testing and inspecting agencies as fill, void, or cavity materials.

- B. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

- C. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture.

2.3 Fill Materials (cont'd)

- D. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
- E. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.
- F. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.
- G. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.
- H. Mortars: Prepackaged, dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.
- I. Pillows/Bags: Reusable, heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents and fire-retardant additives.
- J. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
- K. Silicone Sealants: Moisture-curing, single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces and nonsag formulation for openings in vertical and other surfaces requiring a nonslumping, gunnable sealant, unless indicated firestop system limits use to nonsag grade for both opening conditions.
 - 2. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
 - 3. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

2.4 Mixing

- A. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION**3.1 Examination**

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with written recommendations of firestop system manufacturer and the following requirements:
 - 1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
 - 2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.
 - 3. Remove laitance and form-release agents from concrete.
- B. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.
- C. Masking Tape: Use masking tape to prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

3.3 Through-penetration Firestop System Installation

- A. General: Install through-penetration firestop systems to comply with "Performance Requirements" Article and firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

3.3 Through-penetration Firestop System Installation

- B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
 - 1. After installing fill materials, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.
- C. Install fill materials for firestop systems by proven techniques to produce the following results:
 - 1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
 - 2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
 - 3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 Identification

- A. Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:
 - 1. The words: "Warning--Through-Penetration Firestop System--Do Not Disturb. Notify Building Management of Any Damage."
 - 2. Contractor's name, address, and phone number.
 - 3. Through-penetration firestop system designation of applicable testing and inspecting agency.
 - 4. Date of installation.
 - 5. Through-penetration firestop system manufacturer's name.
 - 6. Installer's name.

3.5 Cleaning and Protection

- A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.

3.5 Cleaning and Protection (cont'd)

- B. Provide final protection and maintain conditions during and after installation that ensure through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce through-penetration firestop systems complying with specified requirements.

END OF SECTION

Section 16110

Raceways

SECTION 16110
RACEWAYS

PART 1 - GENERAL

1.1 Related Documents

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of electrical raceway systems.

1. Rigid metal conduit.
2. Rigid nonmetallic conduit.
3. Flexible metal conduit.
4. Liquid-tight flexible metal conduit.
5. Cable Tray.

1.3 Reference Standards

1. ANSI/ANSI C80.1 - Rigid Steel Conduit - Zinc-Coated.
2. ANSI/UL 1 - Flexible Metal Conduit.
3. ANSI/UL 360 - Liquid-tight Flexible Steel Conduit.
4. ANSI/UL 467 - Electrical Grounding and Bonding Equipment.
5. ANSI/UL 651 - Schedule 40 Rigid PVC Conduit.

1.4 Submittals

Submit manufacturer's literature and product data.

PART 2 - PRODUCTS**2.1 Conduit and Fittings**

1. Rigid Steel Conduit.
 - A. Conduit: Rigid hot-dipped galvanized steel (RGS) conduit with zinc-coated threads and an outer coating of zinc chromate.
 - B. Fittings: Threaded steel or malleable iron, either cadmium plated or hot-dipped galvanized.

2. Rigid Nonmetallic Conduit.
 - A. Conduit: Schedule 40 polyvinyl chloride (PVC).
 - B. Fittings: Solvent weld socket type.

3. Flexible Metal Conduit.
 - A. Conduit: Spiral-wound, square-locked, hot-dipped galvanized steel strip.
 - B. Fittings: One-screw and two-screw for 304.8mm (12 inches) and larger, double-clamp steel or malleable iron, either cadmium plated or hot-dipped galvanized.

4. Liquid-tight Flexible Steel Conduit.
 - A. Conduit: Spiral wound, square locked, hot dipped galvanized steel strip plus a bonded outer jacket of PVC.
 - B. Fittings: Compression type, malleable iron, with insulated throat, either cadmium plated or hot dipped galvanized.

PART 3 - EXECUTION**3.1 Conduit and Fittings**

1. Minimum Trade Size: 19.05mm (3/4 inch), except that 9.53mm (3/8-inch) flexible metal conduit may be used in lengths not exceeding 180cm for tap conductors supplying lighting fixtures.

3.1 Conduit and Fittings (cont'd)

2. Types According to Use: Use rigid steel conduit (RGS) throughout the project except as specified below.
 - A. Use PVC-coated RGS where exposed to rain, condensation, moisture, constant high humidity or corrosive atmospheres.
 - B. Use PVC in interior walls or ceiling spaces and where exposed when installed more than 2.5 meters above finished floor in open work areas, mechanical rooms or electrical rooms. Conduit which enters or leaves the top of panelboards or enclosures may be PVC, provided the top of the panelboards or enclosures are a minimum of 150cm above finished floor and such panelboards and enclosures are located in mechanical or electrical rooms.
 - C. RGS or rigid nonmetallic conduit 25.4mm (1 inch) and smaller may be embedded in slabs if the slab thickness is a minimum of 10cm thick.
 - D. Use RGS or rigid nonmetallic conduit encased in concrete with minimum 76.2mm (3-inch) thick walls, where installed below grade. Concrete encasement may be omitted when conduit is installed below floor slabs. All horizontal to vertical transitions shall be made using RGS elbows and RGS conduit stub-ups.
 - E. Connect all electrical equipment subject to vibration or movement with liquid-tight flexible metal conduit 60cm minimum length. Where the equipment is located in a duct or plenum used for environmental air, the length of conduit shall not exceed 12meters and the conduit shall be flexible metal conduit.
 - F. Transitions.
 - (1) Continue the heavier, more protective type conduit application not less than 101.6mm (4 inches) into the area where lighter, less protective type conduit is permitted.
 - (2) For below-grade to above-grade outdoor locations, extend concrete encasement around conduit 4 inches above finished grade and slope top away from conduit with a 15cm -per-foot slope.
 - (3) For below-grade to above-grade locations using PVC to metal conduit, make the transition from PVC to metal conduit before turning up with RGS elbow.

3.1 Conduit and Fittings (cont'd)

3. Preparation: Place sleeves in walls and floor slabs for the free passage of cables or conduits. Set sleeves in place a sufficient time ahead of concrete placement so as not to delay the work. Seal all openings and voids around sleeves through floors and walls. Be sure that plugs or caps are installed before concrete placement begins.
4. Installation Requirements
 1. Metallic conduits must be continuous between enclosures such as outlet, junction and pull boxes, panels, cabinets, motor control centers, etc. The conduit must enter and be secured to enclosures so that each system is electrically continuous throughout. Where knockouts are used, provide double locknuts, one on each side. For rigid metallic conduits, provide nonmetallic insulating bushings for conductor protection. Where conduits 38.1mm (1-1/2 inches) and larger terminate in equipment having a ground bus, such as in switchgear, motor control centers and panelboards, provide conduit with an insulated grounding bushing and extend a suitable grounding wire to the ground bus.
 2. Have rigid nonmetallic conduit adequately solvent welded at joints to form a tight, waterproof connection.
 3. Run concealed conduit as directly and with the largest radius bends as possible. Run exposed conduit parallel or at right angles to building or other construction lines in a neat and orderly manner. Conceal conduit in finished areas. Unless otherwise shown, remaining conduit may be exposed. Provide chrome-plated floor and ceiling plates around conduits exposed to view and passing through walls, floors, partitions, or ceilings in finished areas. Select properly sized plates to fit the conduit when securely locked in place.
5. Installation Methods.
 1. Install each entire conduit system complete before pulling in any conductors. Clean the interior of every run of conduit before pulling in conductors to guard against obstructions and conduit omissions.
 2. Cut all joints square, then thread and ream smooth. Coat cuts, threads or scratches on steel conduit with an approved zinc chromate or with a 90 percent zinc paint. When dry, draw up tight.

3.1 Conduit and Fittings (cont'd)

3. Make bends with standard ells or conduit bent in accordance with the NEC. Make field bends using equipment designed for the particular conduit material and size involved. Bends must be free from dents or flattening. Use no more than the equivalent of three(3) 90-degree bends in any run between terminals and cabinets, or between outlets and junction boxes or pull boxes.
4. Conduit bodies may be used in lieu of conduit ells where ease of installation and appearance warrants their use. Conduit bodies larger than 1 inch may be used only where approved.
5. Securely fasten and support conduit to structure or metal framing using hot-dipped galvanized, malleable iron pipe straps or other approved means. Wires of any type may not be used for securing conduits.
6. Provide a No. 30 nylon pulling line in conduits in which wiring is not installed under this work. Identify both ends of the line by means of labels or tags reading "Pulling Line-Telephone,"pulling line-Data@ ...etc.
7. Suitably cap conduit during construction to avoid water, dirt and trash entrance.
8. Use expansion-deflection fittings on conduit crossing structural expansion joints and on exposed conduit runs where necessary. Provide bonding jumpers across fittings in metal raceway systems.
9. With a coupling, terminate concealed conduit for future use at structural surfaces. Install a pipe plug flush with the surface.
10. Openings around electrical penetrations of fire-resistance rated walls, partitions, floors or ceilings shall be fire stopped to maintain the fire resistance rating using approved methods.

END OF SECTION

Section 16114

Cable Tray

SECTION 16114**CABLE TRAY****PART -1 GENERAL****1.01 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 Summary

Perforated hot-dipped galvanized after fabrication steel cable tray.

1.03 Related Work

- A. Section 16190: Supporting Devices
- B. Section 16125: Grounding and Bonding

1.04 Reference Standards

- A. BS 1767
BS 2989
- B. IEC 439
- C. NEC

1.05 SUBMITTALS

- A. Submit shop drawings and product data, including all dimensions and finishes for each type.
- B. Submit manufacturer's installation instructions.

PART 2 – PRODUCTS**2.01 Cable Tray**

- A. Cable tray shall be of the perforated type with return flanges for added rigidity and shall be manufactured from hot dip galvanized sheet steel. Minimum metal thickness shall be as follows:-
 - 1. 1.5 mm for cable tray up to 200 mm wide.
 - 2. 2.0 mm for cable tray above 200 mm wide.

2.01 Cable Tray (cont'd)

- B. Each length of cable tray shall be provided with heavy duty galvanized steel joint pieces and joint cover plates.
- C. Vertical runs of cable tray in electrical switch rooms and shafts shall be provided with clip-on type galvanized sheet covers.
- D. Provide cable tray complete with all necessary bends. Tees, crosses and risers, manufactured from hot dip galvanized sheet steel and manufactured by the same factory.
- E. All exposed cable trays shall be covered.

2.02 Tray Supports

- A. As recommended by the cable tray manufactured and indicated on the plans.

2.03 Approved Manufactures

Cables Trays and all necessary accessories

- BICC (U.K.)
- MONO Systems (U.S.A)
- DAVIS (U.K.) or equal and approved alternative

PART 3 – EXECUTION**3.01 Coordination**

- A. Co-ordinate layout of cable tray with other services to ensure that there is no conflict.
- B. Relocate cable tray as necessary to avoid building obstruction of other services.

3.02 Installation

- A. Install cable tray level and plumb according to manufacturer's written instructions, coordination drawings, original design and referenced standards.
- B. Remove burrs and sharp edges from cable trays.
- C. Fasten cable tray supports securely to building structure.
- D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independently of fittings. Don not carry weight of cable tray on equipment enclosure.

3.02 Installation (cont'd)

- E. Install expansion connectors where cable tray across a building expansion joint and in cable trays runs that exceed 30 meter space connectors and set gaps as required.
- F. Make changes in direction and elevation standard fittings.
- G. Make cable tray connections using standard fittings.
- H. Install cable
- I. Seal penetrations through fire and smoke barriers according to Division 7 Section "Firestopping".
- J. Install cable trays with sufficient space to permit access for installing cables.

3.03 Cable Trays

On completion of cable tray installation, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.

3.04 Protection

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and installer, that ensure cable tray is without damage or deterioration at the time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.

3.05 Groundingt

- A. Provide a separate ground wire on all runs of cable tray bonded to the appropriate switch gear, cabinets, electrical equipment in accordance with the grounding specification section.
- B. Provide 10 sq. mm copper bonding jumpers across all joints.
- C. Test complete system for ground continuity.

END OF SECTION

Section 16120

Wiring

SECTION 16120**WIRING****PART 1 - GENERAL****1.01 Work Included**

- A. Single core and multicore 600 volt wiring, 10mm² and smaller.
- B. Fixture Wiring
- C. Signaling Systems Wiring
- D. Power Distribution wiring

1.02 Related Work

- A. Equipment Identification Section
- B. Grounding and Bonding Section

1.03 Reference Standards

- A. IEC 227
- B. IEC 228
- C. IEC 502, 540
- D. IEC 287
- E. BS 6004, 6231, 6346, 7629.

1.04 Submittals

- A. Submit product data and manufacturers literature
- C. Submit proposals for colour coding of insulation
- D. Submit completed test sheets.
- E. Sample of cable pulling lubricant.

Part 2 - PRODUCTS**2.01 Materials**

- A. Building Wiring: Concentric lay, uncoated copper with a normal maximum operating temperature of 85 C, 600V, PVC insulation.
- B. Power and Control wiring: Concentric lay, uncoated copper with a normal maximum operating temperature of 70 C. Insulation to be 600 V PVC with black PVC jacket. Provide white conductor insulation with indelible black numerals at 25mm intervals on control cables. Maximum conductor size to be 10 mm².
- C. Flame Retardant Power and control Wiring: Multi Strand, concentric lay, coated copper with a normal maximum operating temperature of 90 C and 600V flame retardant cross linked polyethylene insulation and overall cable jackets of chlorosulfonated polyethylene, all in accordance with Standards and Codes. Cable jacket to be applied over tape wrapped cable cores.
- D. Flame Retardant Alarm and instrument Cable : Multi strand, concentric lay, coated copper with a normal maximum operating temperature of 90 C and 600V flame retardant cross linked polyethylene insulation, cable assembly shield of combination aluminum/mylar tape and 7 strand 0.6 mm² minimum coated copper drain wire applied to achieve 100% cover over insulated conductors and chlorosulfonated polyethylene cable jacket. Twisted pair cables with 60 mm to 90 mm lay staggered. Each pair to be numbered.
- E. Fixture Wire: Standard round coated copper with a operating temperature of 200 C with 600V silicone rubber insulated and braided glass jacket, all in accordance with Standards and Codes.
- F. Fire alarm Signal Cable: shall be fire resistant multi-core cable to conform with civil defence regulations and manufacturer recommendations.
- G. Lighting/Power Cable: Multicore copper conductors 600V grade PVC insulation lighting cable minimum size is 2.5 mm² and power cable minimum size is 4 mm². Provide one (1) larger size lighting/power cable (lighting cable size is 4mm² and power cable size is 6mm²) if entire circuit length from Electrical panel board to the last lighting fixture/outlet is more than 30 meters long.
- H. Loudspeaker Cable : Single pair with solid copper conductor (1.25mm diameter) in flat configuration with polyethene insulation and PVC jacket. Conductors to have a maximum DC loop resistance at 20 C of 28 ohms per kilometer and a nominal capacitance of 91 picofarads per meter.

2.01 Materials (cobt'd)

- I. Microphone Cable: Single pair screened with stranded copper conductors (13/0.2mm) with PVC insulation lapped copper screen and PVC jacket. Conductors to have a maximum DC loop resistance of 45.7 ohms per kilometer and a nominal capacitance of 430 picofarads per meter.
- J. Attendant Call Cable: Minimum 2.5 mm² cable as described in Part 2.01A above.
- K. Slave Clock Cable: Minimum 1.5 mm² cable as described in Part 2.01A above.
- L. Control cable: Multicore 2.5 mm² cable as described in part 2.01A above.

2.02 Manufactures Recommended:

- Pirelli General Cable Works Ltd (UK)
- General Cable (U.S.A)
- BICC Pyrotex Ltd (U.K)
- or equal and approved alternative

Part 3 - EXECUTION**3.01 Installation**

- A. Ensure conductor lengths for parallel feeders are equal.
- B. Lace or clip conductor groups at switchgear panels, pullboxes, wireways, etc.
- C. Provide grounding conductors and straps in accordance with the grounding specification Section.
- D. Wiring in conduit only to be installed after concrete, masonry and plastering work is complete and all conduit has been cleaned out and dried.
- E. Splice cables at accessible junction or outlet boxes only.
- F. Color code all wiring insulation as per equipment identifications specification Section.
- G. Terminate cables in accordance with the manufacturers recommendations.

3.01 Installation

H.	Colour codes	:	220V System
	Phases	:	phase "A" red, phase "B", yellow, phase "C" blue.
	Neutral	:	Black
	Ground	:	Green / Yellow in combination or green

3.02 Field Testing

Field testing: Insulation resistance of all conductors shall be tested. Each conductor shall have its insulation resistance tested after the insulation is completed and all splices, taps and connections are made except connection to or into its source and point (or points) of termination. Insulation resistance of conductors which are to operate at 600 volts or less shall be tested by using a Biddle Megger of not less than 1000 volts d-c, insulation resistance of conductors rated at 600 volts shall be free of shorts and grounds and have minimum resistance phase-to-phase and phase-to-ground of at least 10 megohms. Conductors that do not exceed insulation resistance values listed above shall be removed at Contractor's expense and replaced and test repeated. The Contractor shall furnish all instruments and personnel required for tests, shall tabulate readings observed, and shall forward copies of the test readings to the Engineer in accordance with Section 16010. These test reports shall identify each conductor tested, date and time of test and weather conditions. Each test shall be signed by the party making the test.

END OF SECTION

Section 16121

600 Volt Cable

SECTION 16121**600 VOLT CABLE****PART 1 GENERAL****1.01 Work Included**

Single and multi core insulated power conductors rated 600 volts, sized 10 mm² and greater.

1.02 Related Work

- A. Grounding and Bonding
- B. Wiring
- C. Equipment Identification

1.03 Reference Standards

- A. B.S. 6360, 6004, 6207, 6476, 6346, 5468
- B. IEC 502
- C. IEC 228
- D. IEC 287

1.04 Submittals

- A. Provide Product Data and manufacturers literature
- B. Provide Operation and Maintenance Data
- D. Submit completed factory any site test sheets
- E. Sample of cable pulling lubricant

PART 2 - PRODUCTS**2.01 General**

- A. Cables shall be one, three or four core consisting of 99% conductivity, bare annealed stranded copper conductors rated at a normal maximum operating temperature of 90 degrees
- B. Insulation for cables 10 mm² and greater shall be of extruded semi-conducting cross-linked polyethylene, meeting standards requirements. A semi-conducting tape may be used under the polyethylene.
- C. Provide a PVC overall jacket on all cables, with a durable marking on the surface of the jacket at intervals not exceeding 610mm. marking shall include manufacturers name, conductor size and voltage class of cable.
- D. Cable ampacity and electrical characteristics shall conform with specified codes and standards.
- E. Provide a ground wire with each circuit sized in accordance with the grounding specification Section. Ground wire shall be bare, concentric lay copper.
- F. Where armoring is required, it shall be steel strip armour on single core cables and galvanized steel or tape armour on multi-core cables.

2.02 Splices and Termination

- A. Cable splices and terminations shall be furnished in kit form and shall conform to the recommendations of the cable manufacturer. All material shall be furnished in factory sealed packages and shall not be opened until required for use.
- B. Splices shall be suitable for installation in manholes
- C. Terminal connectors shall be pressure; bolted clamp or compression type.

2.03 Cable Ties and Cable Markers

- A. Lacing material for site installed cable shall be non-releasing nylon ties.
- B. Tie-on cable markers shall be provided in accordance with equipment identification specification Section.

2.04 Wiring

Single core 600 volt cable of size 10 mm² and less is specified under different Section.

2.05 CU/XLPE/SWA/PVC:**A. CU/XLPE/SWA/PVC:**

1. To BS 5468, 1000V grade
2. Conductors : Plain annealed copper to BS 6360
3. Cables shall comprise of plain copper, stranded circular conductors insulated with an adequate thickness of extruded cross linked polythene (XLPE).
4. Conductors shall be laid up together and wormed circular with suitable pre-formed fillers and wormings, bound with polythene terephthalate (PTP) tape and covered with an extruded PVC sheath minimum 1.4 mm thick.
5. Multicore cables shall have steel wire or tape armouring, extruded sheath of black PVC.
6. Single core cables shall be unarmoured, unless otherwise specified, with an extruded black PVC outer sheath.
7. Outer sheath of single and multicore shall be at least 2.5mm thick.
8. Design electrical stress at any point in the insulation shall not exceed 3KV per mm.
9. Conductor screen: non-metallic comprising of either:
 - a. Semi-conducting tape; or
 - b. A layer of extruded semi-conducting material.
10. The electro-static screen over insulation shall comprise of a non-metallic layer of semi-conducting tape or extruded semi-conducting material applied over the insulation and in direct contact with it, followed by a layer of copper tape applied helically over the semi- conducting layer to ensure close contact throughout.

2.05 CU/XLPE/SWA/PVC: (cont'd)

11. Prevent void formation in insulation by careful control of its passage through the temperature graded water baths.

2.06 Approved Manufacturers

- A. Pirelli General Cable Works Ltd (U.K)
- B. General Cable (U.S.A)
- C. BICC Pyrotenax Ltd (U.K)
- D. or equal and approved alternative

PART 3 - EXECUTION**3.01 Internal Cable Installation**

- A. Support internal horizontal and vertical runs on cable tray using non-ferrous clamps at 1 meter intervals.
- B. Arrange multicore cables to run parallel on tray with a lateral spacing of the diameter of the largest cable.
- C. Arrange single core cables with phases in trefoil formation providing one cable diameter space between trefoil groups.
- D. Where cables are routed through walls or floors, the opening between the cables and the structure shall be sealed such that the fire resistance of the sealing barrier is at least as great as the surrounding structure.

3.02 External Cable Installation

- A. Immediately prior to the placement of each cable or cable group, the raceway route to be followed shall be inspected and ascertained to be complete in installation and free of all materials detrimental to the cable or its placement. All cables assigned to a particular duct or conduit shall be grouped and pulled in simultaneously, using cable grips or pulling eyes and acceptable lubricants.

All cables shall be carefully checked both as to size and length before being pulled into conduits or ducts. Cable pulled into the wrong conduit or duct or cut too short to rack, train, and splice as specified herein, shall be removed and replaced.

3.02 External Cable Installation (cont'd)

- B. Cable in manholes, Shafts,... etc.: Cable shall be supported at all times without short bends or excessive sags and shall not be permitted to lie on the manhole floor. Cable ends must not be submerged. Cable racks, saddle supports or trays shall be provided for permanent support. Temporary support required during placement shall be with rope slings, timbers, or alternate method acceptable to the Engineer.

Cable shall be located in manholes to provide minimum interference with other cables to be installed or installation of future cables in spare conduits.

- C. Cable Pulling: Pulling shall be done with nylon or rope recommended by cable manufacturer.
- D. Cable Grips: Factory installed pulling eyes shall be used for pulling cable where they are available. Woven wire cable grips shall be used to pull all single conductor cable, 70 mm² and larger. Pulling loops shall be used to pull single conductor cable smaller than 70 mm². When a cable grip or pulling eye is used for pulling, the area of the cable covered by the grip or seal plus 150 mm shall be cut off and discarded when the pull is completed.
- E. Inspection: The outside of each cable reel shall be carefully inspected and protruding nails, fastenings, or other objects which might damage the cable shall be removed. A thorough visual inspection for flaws, breaks, or abrasions in the cable sheath shall be made as the cable leaves the reel, and the pulling speed shall be slow enough to permit this inspection. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be replaced.
- F. Pulling Tension: The pulling tension of any cable shall not exceed the maximum tension recommended by the cable manufacturer. Pulling mechanisms of both the manual and power types used by the Contractor shall have the rated capacity in tons clearly marked on the mechanism. Whenever the capacity of the pulling mechanism exceeds the recommended pulling tension of the cable as given by the cable manufacturer, a dynamometers shall be used to show the tension on the cable and the indicator shall be constantly watched. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected.
- G. Sidewall Pressure: To avoid insulation damage from excessive sidewall pressure at bends in duct and conduit runs, the pulling tension in kilograms at a bend shall not exceed 450 times the radius of the bend in metres.
- H. Cable Bends: Extreme care shall be exercised during the placement of all cable to prevent tension and bending conditions in excess of the manufacturer's recommendations. The permanent radius of bend after cable installation shall be in accordance with the cable manufacturer's recommendations.

3.02 External Cable Installation (cont'd)

- I. **Supports:** All cable supports and securing devices shall have bearing surfaces located parallel to the surfaces of the cable sheath and shall be installed to provide adequate support without deformation of the cable jackets or insulation.

Final inspection shall be made after all cable is in place and, where supports, bushings, and end bells deform the cable jacket, additional supports shall be provided. Additional cable protection such as a wrapping of light rubber belting, friction tape, or similar materials shall be provided when required. Cable in vertical runs shall be supported by woven wire grips in accordance with the Code requirements.

- J. **Cable Identification:** The Contractor shall identify all cables in the locations specified in the equipment identification spec Section.

- K. **Moisture Seals:** Each cable shall be kept sealed except when termination and splicing work is being performed.

The ends of all cables shall be sealed with heat shrinkable caps. Cap sizes shall be as recommended by the cap manufacturer for the cable outside diameter and insulation. Caps shall contain sufficient adhesive that shrinkage of the cap during application results in formation of a positive watertight seal capable of withstanding complete immersion or total exposure without permitting the entrance of moisture.

Before and after pulling, the leading and seal of each length of cable shall be examined and repaired if necessary. All cut cable ends shall be promptly sealed after cutting except those to be spliced or terminated.

- L. **Crimping Tools:** Crimping tools used to secure conductors in compression type connectors or terminal lugs shall be those made for that purpose and for the conductor sizes involved. Crimping tools shall be a product approved by the connector manufacturer. The Contractor shall establish and maintain a tool certification program to ensure that crimping tools are kept in accurate operating condition.

- M. **Termination:** Cable shall be terminated in accordance with the following requirements.

- Train cable in place and cut squarely to required length. Avoid sharp bends.
- Install terminals or terminal connectors as required, ensuring a firm metal-to-metal contact.

3.02 External Cable Installation (cont'd)

- Insulate each connection of cable to an insulated conductor (whether cable, bus, or equipment bushing). The insulation shall cover all exposed surfaces of the conductors; the insulation voltage level of the completed termination shall be not less than the insulation voltage level of the connected conductors. Insulation of terminations shall be as specified in the following paragraphs.
- N. Insulation of Termination in 600 volt Cable: Terminations which require insulation in cable rated 600 volts or less shall be insulated in accordance with the following requirements:
- All exposed conductor and connector surfaces shall be covered with a minimum of three half-lapped layers of self-vulcanizing rubber insulating tape.
 - A minimum of three half-lapped layers of polyvinyl chloride electrical tape shall be applied over the rubber tape. The polyvinyl chloride tape shall extend a minimum of two cable diameters over the cable jacket and a similar distance over other conductor insulation or connector requiring insulation.

3.03 Field Testing

Insulation resistance of all conductors shall be tested. Each conductor shall have its insulation resistance tested after the installation is completed and all splices, taps and connections are made except connection to or into its source and point (or points) of termination. Insulation resistance of conductors which are to operate at 600 volts shall be tested by using a Biddle Megger of not less than 1000 volts d-c. Insulation resistance of conductors rated at 600 volts shall be free of shorts and grounds and have a minimum resistance phase-to-phase and phase-to-ground of at least 10 megohms. Conductors that do not exceed insulation resistance values listed above shall be removed at Contractor's expense and replaced and test repeated. The Contractor shall furnish all instruments and personnel required for tests, shall tabulate readings observed, and shall forward copies of the test readings to the Engineer in accordance with Section 1610. These test reports shall identify each conductor tested, date and time of test and weather conditions. Each test shall be signed by the party making the test.

END OF SECTION

Section 16122

Elevator Equipment Wiring

SECTION 16122**ELEVATOR EQUIPMENT WIRING****PART 1 - GENERAL****1.01. Work Included:**

- A. Elevators equipment wiring for
Passenger, patients and service elevators
- B. Elevator equipment wiring includes
 - 1. Elevator power service connections
 - 2. Telephone service connections
 - 3. Lighting and emergency lighting connections for car and elevator shaft.
 - 4. Connection for car-top receptacles
 - 5. Fire alarm system connection

1.02. Related Work:

- | | | |
|----|--------------------------|----------------|
| A. | Electrical elevators | Section: 14100 |
| B. | Wiring | Section: 16120 |
| C. | Fire Alarm System | Section: 16720 |
| D. | Wiring Devices | Section: 16140 |
| E. | Enclosed Safety switches | Section: 16490 |
| F. | Grounding and Bonding | Section: 16125 |

1.03. Work Covered Under Other Sections:

- A. The lighting, receptacles, telephone and fire alarm system installations shall be covered under the relevant sections of Division 16.

PART 2 - PRODUCTS**2.01: Components:**

- A. Provide the following switches in the respective elevator motor rooms:
- Elevator shaft lighting switch
 - Elevators motors rooms power switch
- B. For other wiring refer to the drawings and to elevators specification Section.
- C. Provide junction boxes complete with terminals in elevator motor rooms for:
- Service receptacle on top of cars
 - Lighting and emergency lighting in cars
 - Lighting in shaft
 - Telephone connections
 - Fire alarm connections

PART 3 - EXECUTION**3.01: Coordination:**

Coordinate location of lights, switches, receptacles, fire alarm sensors, machines, and junction boxes installed in elevator machine rooms and elevator pit with elevator system installer on site prior to installation.

3.02: Equipment wiring:

- A. Place elevator wall switches on lock side of door within elevator machine room.
- B. Provide lighting supply in elevator motor rooms for elevator car lighting and supply for elevator emergency lighting.
- C. Provide 220 volt single phase A/C supply in elevator motor rooms for elevator car top receptacles.

3.02: Equipment wiring:

- D. Provide provisions for telephone cabling connection in shafts for each elevator car.
- E. Provide signal cabling between elevator control panels and the fire alarm indicator/control panel.
- F. Terminate wiring in elevator motor room in junction boxes referred to above.

3.03: Tests:

All systems interfaced with elevator installation shall be tested in coordination with elevator system installation.

END OF SECTION

Section 16125

Grounding

SECTION 16125**GROUNDING****PART 1 - GENERAL****1.1 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of grounding and bonding equipment for electrical systems.

1.3 Reference Standards

1. ANSI/IEEE Std 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
2. ANSI/UL 467 - Grounding and Bonding Equipment.
3. BS 7430 and BS 7671

1.4 Submittals

1. Equipment Data: Prior to ordering materials, submit data for approval including, but not limited to, manufacturers catalogues for earth rods, connecting, clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits, and tools etc., and samples of conducts as requested.
2. Shop and Construction Drawings: submit drawings for approval including, but not limited to, the following:
 - (1) Exact location of earth pits, rods and details of installation and connections.
 - (2) Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering cross sectional area of all earthing, protective and bonding conductors.
 - (3) Layout and details of earthing provisions at substations, generator rooms, switch gear, distribution panel covering cross sectional area of all earthing, protective and bonding conductors.

PART 2 - PRODUCTS**2.1 Materials**

Earth Rod: Copper clad steel, 16mm diameter, 3m length, extendible as necessary to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.

2.2 Buried Earth Conductors:

Bare annealed copper strip conductors 25x3mm, or annealed stranded copper conductors 70mm² cross-section.

2.3 Tape Mats:

Where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4 m apart, welded together by exothermic welds to form a grid. Tape is to be 25x3mm strip conductor.

2.4 Earth Pit:

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

2.5 Earthing:

Conductors: insulated or bare copper conductor as described in the specification for the particular application.

2.6 Testing joints (Test Links):

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

2.7 Protective Conductors:

Single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming part of a multi-core cable, color coded.

2.8 Main Earthing Bar:

Hard drawn copper, 40x4 mm where formed into a closed loop, and 50x6mm where open ended. Earth bar is to be labeled AMain Earth Bar@ and is to be drilled, for connection of conductors, at a spacing not less than 75mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.

2.9 Protective Bonding Conductors:

Bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in sub-section 2.01 hereof.

2.10 Earthing Accessories:

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

PART 3 - EXECUTION**3.1 System Ground**

1. System Neutral: Where a system neutral is used, ground the system neutral as required by NEC Article 250. Ground the system neutral only at the point of service and isolate it from ground at all other points in the system.
2. Separately Derived Systems: Ground neutrals of separately derived systems such as generators, etc., in accordance with NEC 250-26.
3. Size: Size the system grounding electrode conductors to comply with NEC Table 250-94, unless shown larger.
4. Testing: Test the completed grounding system. If the resistance of the grounding system is less than 5 ohms, add ground rods to attain 5 ohms.

3.2 Equipment Ground

1. Manholes: Provide a No. 1/0 AWG bare stranded copper ground bus in all manholes. Mount bus 304.8mm (12 inches) above floor using one-hole pipe straps 914.4mm (3') on center. Connect bus to ground rod with a No. 1/0 AWG conductor. Bond all metallic components and electrical grounding conductors to the bus using lugs or clamps.

3.2 Equipment Ground (cont'd)

2. Switchgear Rooms: Provide a ground bus in switchgear room. Mount bus 304.8mm (12 inches) above finished floor and 1 inch from wall around perimeter of room. Connect bus by a grounding conductor with a cross-sectional area equivalent to the ground bus to an acceptable grounding electrode as described in NEC Article 250. Connect all noncurrent-carrying metallic parts of electrical equipment in the room to the bus.
3. Raceway Systems and Equipment Enclosures:
 - A. Ground cabinets, junction boxes, outlet boxes, motors, controllers, raceways, fittings, switchgear, other electrical equipment and metallic enclosures: Ground equipment and enclosures to the continuous-grounded, metallic raceway system in addition to any other specific grounding shown.
 - B. Provide bonding jumpers and ground wire throughout to ensure electrical continuity of the grounding system.
 - C. Provide grounding-type insulated bushings for metal conduits 38.1mm (1-1/2 inches) and larger terminating in equipment enclosures containing a ground bus and connect the bushing to the ground bus.
 - D. Provide a green insulated equipment grounding conductor for each feeder and branch circuit.
4. Size: When grounding and bonding conductors are not sized on drawings, size the grounding conductors in accordance with NEC Table 250-95. Size bonding jumper so that minimum cross-sectional area is greater than or equal to that of the equivalent grounding conductor as determined from NEC Table 250-95.

END OF SECTION

Section 16130

Boxes

SECTION 16130**BOXES****PART 1 – GENERAL****1.1 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of outlet boxes, floor boxes, junction boxes and pull boxes.

1.3 Reference Standards

1. ANSI/NEMA Publication No. OS 1 - Sheet-steel Outlet Boxes, Device Boxes, Covers and Box Supports.
2. ANSI/UL 514A - Metallic Outlet Boxes.
3. ANSI/UL 514B - Fittings for Conduit and Outlet Boxes.
4. B.S.

1.4 Submittals

Provide manufacturers product data and sample.

PART 2 - PRODUCTS**2.1 Outlet Boxes**

1. Flush Device Boxes: Provide galvanized steel boxes of sufficient size to accommodate wiring devices to be installed at outlet. Provide an extension ring for the device(s) to be installed. Square or rectangular boxes may be used. Unless otherwise noted, provide minimum 38.1mm (1-1/2 inch) deep by 101.6mm (4-inch) square minimum size box.
2. Exposed Device Boxes: Provide FS or FD cast boxes for surface mounting in areas having exposed rigid steel conduit systems.

2.1 Outlet Boxes (cont'd)

3. Boxes for Lighting Fixtures: Provide galvanized steel octagonal boxes with fixture stud supports and attachments as required to properly support ceiling and bracket-type lighting fixtures. Unless otherwise noted, provide 38.1mm (1-1/2 inch) deep by 101.6mm (4-inch) box.
4. Function Boxes and Pull Boxes: Galvanized steel or PVC type boxes with screw-on or hinged cover, code gauge and size to carry conduit bushes and wires.
5. Blank Cover Plate: Blank cover plate to be installed on outlet boxes which has no apparatus installed or where apparatus are installed but does not have suitable cover for box. Blank cover plates for wall outlets are to be attached by a bridge for horizontal and vertical adjustments.
6. Molded Plastic Outlet Boxes:
 - A. Type: boxes and covers used with PVC conduit systems are to be heavy gauge pressure molded plastic, minimum 2mm thick, self extinguishing, with softening point not less than 85 deg. C.Boxes are to have provision for securely terminating conduits and are to be manufacturer's standard for required application.
 - B. Fittings: boxes are to have brass inset threads to receive cover screws and for mounting devices or accessories, push-fit brass earth terminals and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets are to be provided for weatherproof installation.
 - C. Switch Boxes: Not permitted.
 - D. Listing: UL 514.

2.2 Floor Boxes

1. Box: Provide 63.5mm (2-1/2") cast-iron floor boxes with fully adjustable tops, appropriate cover plates and fittings (water tight). Boxes must be drilled and tapped for conduit openings.
2. Cover: Furnish Brass finished cover plates with rubber gaskets to become water tight. Provide wide flange cover plates for carpeted areas.
3. Listing; UL 514

2.3 Junction and Pull Boxes

1. Construction. Provide galvanized steel boxes conforming to NEC Article 370.
2. Interior Spaces. Provide NEMA 1 (IP20) type boxes at least 4 inches deep.
3. Exterior Spaces. Provide NEMA 4X (non-corrosive and water tight) type boxes at least 101.6mm (4 inches) deep.
4. Embedded. Provide NEMA 4 (non-corrosive and water tight) cast iron type with flush flanged cover when cast in concrete.

PART 3 - EXECUTION

3.1 Outlet Boxes

1. Flush Boxes: Unless otherwise indicated, mount all outlet boxes flush within 1/4 inch of the finished wall or ceiling line. Provide galvanized steel extension rings where required to extend the box forward in conformance to NEC requirements. Attach ring with at least two machine screws. Securely fasten outlet boxes. Provide plaster covers for all boxes in plastered walls and ceilings.
2. Fixture Boxes: Where boxes for suspended lighting fixtures are attached to and supported from suspended ceilings, adequately distribute the load over the ceiling support members.
3. Mounting Height: Mounting height of a wall-mounted outlet box means the height from finished floor to horizontal center line of the cover plate. Where outlets are indicated adjacent to each other, mount these outlets in a symmetrical pattern with all tops at the same elevation. Where outlets are indicated adjacent, but with different mounting heights, line up outlets to form a symmetrical vertical pattern on the wall. Verify the final location of each outlet with Engineer before rough-in. Remove and relocate any outlet box placed in an unsuitable location.
4. Back-to-Back Boxes: Do not connect outlet boxes back to back unless approval is obtained from the Engineer. Where such a connection is necessary to complete a particular installation, fill the voids around the wire between the boxes with sound insulating material.
5. Box Openings: Provide only the conduit openings necessary to accommodate the conduits at the individual location.
6. Insulation: Provide insulation behind outlet boxes mounted in exterior walls to prevent condensation inboxes.

3.2 Floor Boxes

Verify locations of all floor boxes with the Engineer before installation. Completely envelope floor boxes in concrete except at the top. Increase slab thickness at boxes if required to obtain a minimum of 25mm of concrete below bottom of box. Adjust covers flush with finished floor.

3.3 Junction and Pull Boxes

1. Installation: Install boxes as required to facilitate cable installation in raceway systems. Generally provide boxes in conduit runs of more than 20 meters or as required in Section 16110.
2. Covers: Provide boxes so that covers are readily accessible and easily removable after completion of the installation. Include suitable access doors for boxes above inaccessible ceilings. Select a practical size for each box and cover.

END OF SECTION

Section 16140

Wiring Devices

SECTION 16140**WIRING DEVICES****PART 1 – GENERAL****1.1 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of wiring devices and device plates.

1.3 Reference Standards

- A. BS 3676, 1363.
- B. IEC.
- C. ANSI/UL 20 - General-Use Snap Switches.
- D. ANSI/UL 498 - Attachment Plugs and Receptacles.
- E. NEMA WD 1 - General Requirements for Wiring Devices.

1.4 SUBMITTALS

Provide product data on wiring devices and plates.

PART 1 - PRODUCTS**2.1 Wall Switches**

- A. General
 - 1. Body and base shall be fully enclosed type, fire resistant, non-absorptive thermosetting phenolic compound or approved equal.
 - 2. Mounting yoke shall be corrosion resistant metal with plastic ears.

2.1 Wall Switches (cont'd)

3. Switches shall be flush mounted and wired with terminals of screw clamp type. Wiring terminal shall be suitable for holding two 4 mm² wires.
4. Color: Coordinate color of all other switches with the site engineer prior to ordering.
5. Rating: 15 Amps, 220 Volts, 50 Hz.

B. Lighting Switches:

1. Lighting switches shall be snap type, in accordance with code, heavy duty, general use type, single pole, double pole, single, two-way or intermediate as shown on the drawings.
2. Quick-Make, quick-break type with silver alloy contacts in arc resisting molded base, with toggle, rocker or push-button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side and/or back connection.
3. Water Proof Switch: Installed in wet area such as mechanical rooms, outdoors or as shown on drawings, with waterproof plate, water proof outlet box, IP 44 enclosure.
4. Double Pole Pilot Switch: rated as shown on the drawings, 230 V a.c., tumbler operated with red neon pilot light for off position. Switch is to be mounted to flush or surface box, as indicated on the drawings. Provided with cord outlet and cord extension to equipment controlled.
5. Approved Manufacturers
M.K
LEGRAND
Pass & Seymour
or equal and approved alternative

2.2 Receptacles

- A. Generally: All receptacles, unless otherwise indicated, shall have injection molded plastic base with self-adjusting, non-expanding contacts to prevent permanent distortion, flush mounted and arranged for side and/or back connection and with screw terminals accepting at least three parallel branch-circuit wires.
- B. Color: Coordinate color of all other outlets with the Engineer prior to ordering.

2.2 Receptacles (cont')

- C. Mounting yokes shall be corrosion resistant metal.
- D. Approved manufacturers: M.K, LEGRAND, Pass & Seymour.
- E. One or more of the following receptacles shall be provided as shown on the drawings:
 - 1. Single receptacle, polarized, grounding type, with three rectangular pin-holes two poles and earth, rated 16A, 230V.
 - 2. Duplex receptacle: are to be mounted in parallel under one common plate with break-off feature for two circuit connection.
 - 3. Weatherproof receptacle: 16A, 230V, 2 pole plus earth, enclosed in surface mounted cast-metal box and with spring-retained gasketed hinged flap cover. Receptacle splash sparkles type and proof to IP54. Outlet is to be used.
 - 4. Power Receptacles: Single Outlet, single phase, three wire, 16A, 230V, polarized with L-shaped earth contact, splash proof mold cast metal plated and matching plug. Outlet to be provided with an on-off switch.
 - 5. Industrial Socket Outlet: 3 phase, 16 A or 32A, 3P+N+E, 230-400V, single, with aluminum alloy enclosure, interlocked switch and matching plug.

2.3 Dimmer Switch

- A. Dimmer switches should be used to control individual incandescent or fluorescent lighting circuits.
- B. The dimmer switch shall be of electronic with thermistor control; factory calibrated, of suitable and rated for type and number of lamps indicated on the drawings for operation at 220 volts, 50 Hz.
- C. The dimmer switch shall be complete with an on/off toggle switch and a sliding dimmer capable of smooth continuous changes of lighting intensity from 1% for incandescent lamps and from 5% for fluorescent up to 100% light output.
- D. Dimmer switch shall be radio frequency interference shielded and capable of operating at 40 degrees C ambient temperature.
- E. Components are to be designed, rated and installed so that dimmer operates continuously at any setting. Components are to be installed in separate enclosure or as part of dimmer control panel as indicated on the drawings.

2.4 Dimming Panel:

1. Description for Panel:

Pre-assembled dimming panel containing (24) 16A dimmers, each protected by a 16A-1P circuit breaker, with a 16A continuous rating per dimmer circuit. Each dimmer is capable of controlling incandescent, magnetic and electronic low voltage, Hi-lume and ECO-10 fluorescent ballasts, neon/cold cathode, and non-dim loads. Load types and circuit zone assignments are selectable at the dimming panel without the need for additional equipment. Panel accepts a selectable at the dimming panel without the need for additional equipment. Panel accepts a 220-240V, 3 phase, 4 wire, 64A feeder (maximum wire size is 35mm sq), and has an integral isolation switch.

2. Control Unit:

Preset dimming control shall incorporate an airgap switch relay, which shall be accessible without removing the faceplate.

- Present dimming control shall meet ANSI/IEEE Std. C62.41 1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage.
- Preset dimming control shall provide power failure memory.
- Faceplate shall attach using no visible means of attachment.
- Controls shall incorporate built-in wide angle Infrared Receiver, providing control via a separate Wireless Remote Control Transmitter from up to 50 feet away.
- Programming of preset scenes shall be accomplished without the use of an ENTER or STORE button.

3. Accessories:

- Four-Scene Control(s) shall be capable of recalling any one of four scenes, master raise / lower and off. Control shall provide access for up to 16 scenes.
- Wireless Infrared Transmitter(s) shall be capable of recalling any one of four preset scenes and off. In addition, a master raise/lower shall be provided. The transmitter shall be manufactured by the dimming system manufacturer; the range of the transmitter to any single receiver shall be at least 50 feet.

3. Accessories (cont'd)
 - System should employ common architecture for products, accessories and user interface with security panel.

2.5 Device Plates

1. Finished Spaces: Use 302 stainless steel (18 percent chromium, 8 percent nickel), minimum 1mm thick.
2. Exposed Boxes in Dry Interior Spaces: Make plates of heavy cadmium-plated sheet steel. Edges of plates must be flush with edges of boxes.
3. Other Areas: Use weatherproof device plates. Provide polish chrome cast metal plates with resilient rubber or closed cell foam urethane gusted spring door covers for protection of device.

PART 3- EXECUTION

3.1 Device Coordination

Where items of equipment are provided under other sections of this specification or by the Engineer, provide a compatible receptacle for the cap or plug and cord of the equipment.

3.2 Wall Switches

1. Location: Set wall switches in a suitable outlet box centered at the height of 110cm from the floor, except as otherwise shown. Install switch on the strike side of the door as finally hung.
2. Position: Install wall switches in a uniform position so the same direction of operation will open and close the circuits throughout the job, generally up or to the left for the ON position.

3.3 Receptacles

Mount receptacles vertically with the ground on top in a suitable steel outlet box centered at the height of 30cm from the floor or as shown on the drawings. For horizontally mounted receptacles, ground should be on left.

3.4 Device Plates

1. Type: Provide device plates for each outlet of the type required for service and device involved.

3.4 Device Plates (cont'd)

2. Ganged Devices: Mount ganged devices under a single, one-piece, device plate.
3. Engraving: Engrave plates with 3mm-high black letters, for all wiring devices other than general purpose outlets & general lighting switches.

END OF SECTION

Section 16180

Metal Framing

SECTION 16180**METAL FRAMING****PART 1 - GENERAL****1.1 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of metal framing, including channels, fittings, clamps, hardware, electrical accessories and brackets.

1.3 Submittals

Submit manufacturer's literature and product data & sample.

PART 2 - PRODUCTS**2.1 Materials**

1. Make channels, fittings, clamps, electrical accessories and brackets of sheet steel or of malleable cast iron. Fabricate threaded fasteners of carbon steel.

2.2 Coatings

1. Galvanizing: Hot-dip galvanize all steel components.
2. PVC. At the factory, apply a minimum 10-mil-thick PVC coating, bonded to metal.
3. Electroplating. Electroplate threaded steel fasteners with cadmium.

2.3 Sizes

Provide channels fabricated from not less than 12-gauge sheet steel, 40mm wide and not less than 40mm deep.

PART 3 - EXECUTION**3.1 Application**

Use hot-dipped galvanized steel components in all areas. Use PVC-coated components when exposed to the weather or when located in a corrosive atmosphere.

3.2 Supports

Provide metal framing to support large or heavy wall-mounted equipment, wall-mounted raceways and ceiling-hung raceways.

3.3 Anchor Bolts

Use 12-mm diameter by 75mm long expansion bolts to attach framing to concrete. Space bolts a maximum of 65cm on center, with not less than two bolts per piece of framing.

3.4 Touch-up

Touch up all scratches or cuts on steel components with an approved zinc chromate or a 90 percent zinc paint. Use a PVC compound on PVC-coated components.

END OF SECTION

Section 16190

Supporting Devices

SECTION 16190
SUPPORTING DEVICES

PART 1 GENERAL**1.01 Work included:**

- A. Conduit supports
- B. Cable tray supports
- C. Trunking supports

1.02 Related Work:

- A. Raceway 16110
- B. Cable Tray 16114

1.03 Submittals:

Submit manufacturer's literature, dimensioned drawings and installation instructions.

PART 2 PRODUCTS**2.01 Conduit Supports:**

- A. Single Runs: Surface:- galvanized spacer saddles or ring bolt type hangers with special spring clips.

Flush : - galvanized pipe hooks or similar for walls and saddles for partition walls.
- B. Multiple Runs: Horizontal: conduit rack with 25 percent spare capacity.
- C. Vertical Runs: Channel support with conduit fittings and 25 percent spare capacity.

2.02 Cable Tray and Trunking Supports:

- A. Trapeze style hangers 41 x 41 mm galvanized steel channels, supported by 10 mm galvanized steel threaded rod from preset threaded concrete inserts or galvanized cantilever brackets on H section support frames, 38 mm x 38 mm, 12 gauge, or heavier capable of supporting weights of assembly plus 20 kg.

2.03 Anchor Methods:

- A. Hollow wall : Toggle bolts or spider type expansion anchors.
- B. Solid wall : Lead expansion anchors or preset inserts.
- C. Metal surface : Machine screw, bolts or welded studs.
- D. Wood surfaces : Wood screws.
- E. Concrete surfaces : Self-drilling anchors or power-driven studs.

PART 3 EXECUTION

- A. Layout to maintain headroom, neat mechanical appearance, consistent with the architectural treatment in the location.
- B. Install cable tray and trunking supports at 3 m on centers and at all bends and tee fittings.
- C. Ensure there is no conflict with other services.
- D. Conduit or cable straps shall not be welded to steel structures.
- E. Each conduit shall be supported within 300 mm of junction boxes and fittings. Conduit support shall be entirely independent of these boxes and fittings.
- F. Maximum spacing of conduit supports shall be 3m on center.

END OF SECTION

Section 16411

Power-Factor-Correction Capacitors

SECTION 16411**POWER-FACTOR-CORRECTION CAPACITORS****PART 1 GENERAL****1.1 Related Documents**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

- A. This Section includes power-factor-correction equipment.
- B. This Section includes automatic power-factor-correction units and capacitor equipment.

1.3 Submittals

- A. Product Data: For each type of product specified. Include data on features, components, ratings, and performance. Include dimensioned plan and elevation views of enclosures and details of control panels. Show access and workspace requirements.
- B. Shop Drawings: From manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Detail internal and interconnecting wiring and differentiate between manufacturer-installed and field-installed wiring.
- C. Product Certificates: Signed by manufacturers of products certifying that the products furnished comply with requirements.
- D. Factory Test Reports: Evidence of product's compliance with specified requirements.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements for tests specified in Part 3.
- F. Maintenance Data: For equipment to include in the maintenance manuals specified in Division 1 include the following:
 - 1. Lists of spare parts and replacement components recommended for storage at the Project site for ready access.

1.3. Submittals (cont'd)

2. Detailed operating instructions covering operation under both normal and abnormal conditions.
3. Include cell and fuse replacement instructions.

1.4 Quality Assurance

- A. Comply with NEMA CP 1 and IEEE 18.
- B. Comply with NFPA 70.
- C. Listing and Labeling: Provide power-factor-correction equipment specified in this Section that is listed and labeled.
 1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

1.5 Warranty

- A. General Warranty: Special warranties specified in this Article shall not deprive the Employer of other rights the Employer may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. Special Warranty for Capacitor Cells: A written warranty, signed by manufacturer and principal Installer, agreeing to replace capacitor cells that fail in materials or workmanship within the specified warranty period.
- C. Warranty Period: 3 years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 Manufacturers**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Westinghouse/JTE.
 - b. General Electric Co.
 - c. Square D Co.
or equal and approved alternative.

2.2 Capacitors, General

- A. Construction: Multiple capacitor cells or elements factory wired in 3-phase groups and mounted in metal enclosures.
- B. Capacitor Cells: Dry metallized-dielectric, self-healing type. Each cell is encapsulated in thermosetting resin inside a plastic container.
- C. Cell Rupture Protection: Pressure-sensitive interrupter for each cell.
- D. Capacitor Bank MCCB fuse links: Current-limiting, noninterchangeable type, factory installed in each phase and located within the equipment enclosure. Features include the following:
 - 1. Interrupting Capacity: 100,000 A, minimum.
 - 2. Ratings and Characteristics: As recommended by capacitor manufacturer.
 - 3. Neon lamp for each fuse. Connect to illuminate when fuse has opened, and locate so it is visible from outside the enclosure.
- E. Enclosure: NEMA 250, steel or aluminum, arranged to contain the fluid leakage from capacitor cells. Factory equip with mounting brackets suitable for type of mounting indicated. Enclosure types are as follows:
 - 1. Indoor Enclosures: NEMA 250, Type 12.

2.3 Fixed Capacitors

- A. Description: Integrally fused.
- B. Discharge Resistors: Factory installed and wired including resistors.
- C. Internal Wiring: Factory wired, ready for field connection to external circuits at a single set of pressure terminals.

2.4 Automatic Power-factor-correction Units

- A. Comply with NEMA ICS 2.
 - 1. Description: Factory installed in its own enclosure where indicated one electrical, one line diagram and connected to power circuits as indicated. Units include a separately mounted current transformer to sense current in the power circuit and to provide input to the unit controls.
- B. Configuration: System includes integrally mounted, factory-wired major components including the following:
 - 1. Multiple-MCCB Fuse links.
 - 2. Multiple contactors.
 - 3. Controls.

2.4 Automatic Power-factor-correction Units (cont'd)

4. Power-factor meter.
 5. Blown-fuse indicators.
 6. Main circuit breaker.
- C. Performance Requirements: Controls permit operator to select a target power factor adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on the circuit being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contactor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Switch only one capacitor bank at a time.
- D. Solid-state, microprocessor-based controls include an undervoltage relay that interrupts capacitor switching for power supply interruptions longer than 15 ms. "Advance" and "Retard" push buttons on the control panel permit manual sequencing of capacitor switching.
- E. Three-Pole, **600-V** Contactors: Rated for the repetitive high-inrush-switching duty presented by the capacitor loading.
- F. MCCB Fuse links for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.
- G. Air-Core-Type Inductors: Installed in capacitor circuits where required to limit switching surges to within contactor ratings. Inductors are mechanically braced to withstand the maximum fault current to which they may be exposed.
1. LED indicating lights designate energized capacitor banks.
 2. Plated copper, braced to withstand the maximum fault current to which it may be exposed.
- H. Enclosure Access: Hinged door with hand-operated catch. Door is interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.
- I. Standard cubicle doors to allow access to components. Door interlock prevents access while capacitors are energized.
- J. Current Transformer: Type and configuration to suit sensing and mounting conditions indicated.
- K. Power-Factor Meter: Switchboard type, mounted in the enclosure door, with 0.5 lagging to 0.5 leading scale and accuracy of plus or minus 1 percent.
- L. Main Circuit Breaker: Operable from outside the enclosure to disconnect the unit with an operating handle that can be padlocked.

2.4 Automatic Power-factor-correction Units (cont'd)

- M. Control Relays: Multi-stage Automatic type with two (2) spare stage for future banks additions. Include a loss of voltage re-setting device with integrally mounted on/off selector switch.
- N. Coordination: Coordination should be run with the main and sub-main switchboards manufacturer regarding interface components required.

2.5 Factory Finish

- A. Manufacturer's applied enamel over corrosion-resistant treatment or primer coat.

2.6 Source Quality Control

- A. Factory test power-factor-correction equipment before shipment. Comply with NEMA CP 1. Include the following:
 - 1. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.
 - 2. Functional test of all operations, controls, indicators, sensors, and protective devices.

PART 3 - EXECUTION**3.1 Installation**

- A. Install freestanding equipment on concrete housekeeping pad.
- B. Maintain minimum workspace according to manufacturer's written instructions.

3.2 Identification

- A. Identify components according to Division 16 Section "Electrical Identification."

3.3 Field Quality Control

- A. Inspections and Tests: Inspect and test component features, functions, operations, and protective devices according to manufacturer's written instructions and NETA ATS.
 - 1. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

3.3 Field Quality Control

- B. Adjust system for optimum automatic power-factor correction.

3.4 Cleaning

- A. On completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.5 Demonstration

- A. Training: Engage a factory-authorized service representative to demonstrate adjustment, operation, and maintenance of automatic power-factor-correction unit and to train Employer's maintenance personnel. Demonstrate method of determining optimum settings for system controls.
- B. Conduct a minimum of 2 hours' training.
- C. Schedule training and adjustment with Employer with at least 7 days' advance notice.

END OF SECTION

Section 16440

Switch Boards- 600Volt and Below

SECTION 16440**SWITCHBOARDS - 600 VOLT AND BELOW****PART 1 - GENERAL****1.1 Related Documents**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of low voltage switchboards.

1.3 Reference Standards

- A. NEMA AB1 - Molded Case Circuit Breakers.
- B. NEMA KS1 - Enclosed Switches.
- C. NEMA KS2 - Bolted Pressure Contact Switches.
- D. NEMA PB1.2 - Application Guide for Ground Fault Protective Devices for Equipment.
- E. NEMA PB2 - Dead-Front Distribution Switchboards.
- F. NEMA SG3 - Low Voltage Power Circuit Breakers.
- G. NEMA SG5 - Power Switchgear Assemblies.
- H. ANSI C37.13 - Low-Voltage AC Power Circuit Breakers.
- I. ANSI C37.13a - Low-Voltage AC Integrally Fused Power Circuit Breakers.
- J. ANSI C37.16 - Preferred Rating for Low-Voltage Power Circuit Breakers.
- K. ANSI C37.20 - Switchgear Assemblies Including Metal-Enclosed Bus.
- L. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures.
- M. UL 891 - Switchboards and Switchboard Unit Substations.
- N. UL 977 - Fused Power Circuit Devices.

1.4 Applicable Provision

Refer to Section 16010, Electrical General Provisions.

1.5 Submittals

1. Brochures: Submit brochures on the switchboard, main protective device, branch circuit protective devices and instrumentation.
2. Dimensional Drawings: Submit dimensional drawings of the switchboard, including top and bottom views showing entry and exit space for trenches conduits and busways, front and side elevations showing arrangement of all devices and also include dimensional data on all buses including material type and capacity of the buses.
3. Electrical Information: Submit one line diagrams for equipment being provided. Also submit information on all protective devices including type, ratings and settings of all trips provided.

PART 2 - PRODUCTS**2.1 Description**

4. General: Provide a completely factory assembled switchboard category 2B from incoming line lugs to load terminals of all branch protective devices. Include all necessary buses, supports, devices and provisions for future connections as shown on plans.
5. Size: The physical size and configuration of the switchboard and equipment may be varied to suit the manufacturer's standard design, provided the intended functions are accomplished. Any change in size or configuration must be so noted on the submittal.

2.2 Ratings

1. Voltage Characteristics: 400/230, Three phase, Four wire, 50 hertz.
2. Main Bus: as indicated on drawings.
3. Available Short Circuit Current. As indicated on the drawings.
4. Device Ratings. As indicated on the drawings.

2.3 Enclosure

1. Construction.
 - a. Fabricate the switchboard enclosure with the required number of vertical sections nominally 230cm high and with width and depth as shown on drawings. Bolt vertical sections together to provide a rigid, freestanding, metal-enclosed unit which must withstand all shipping, handling and installation procedures without damage or deformation.
 - b. Completely enclose the frame with removable, bolted, code-gauge sheet steel covered panels and hinged doors. Form all coverplates and doors to eliminate sharp edges.
2. Access.
 - a. Provide an assembly which permits access to buses and devices for installation and future maintenance from the front and rear.
 - b. Provide adequate wiring gutter space at top, bottom and sides for easy access to all wiring terminations.
3. Device Mounting.
 - a. Provide a unit with individually mounted main circuit breaker and group mounted branch circuit breakers.
 - b. Assembly must permit interchanging devices of the same type, rating and method of operation.
4. Lifting Provisions.
 - a. Provide permanent lifting means on top of shipping sections.
 - b. Include an integral roll-along lifting device for switchboards equipped with draw-out devices. Mount lifting device on top of switchboard.
5. Finish: Grind all steel surfaces smooth, with all burrs, sharp edges, welding splatters, loose rust, scale and the like totally removed after fabrication. Following this, chemically clean and treat steel work to allow a good bond between the steel surfaces and apply a rust-preventive primer paint. After priming, thoroughly paint the inside and outside with a suitable finish paint. Supply 1 pint of finish paint for each switchboard for touch-up after installation.

2.4 Buss

1. Main, Section and Branch Bus.
 - a. Material: Fabricate all buses of 98% IACS conductivity, tin- or silver-plated copper with rounded edges. Make all connections using a minimum of two bolts.
 - b. Design:
 1. Rate main bus for currents as indicated on drawings:
 2. Determine current rating for section bus and branch bus on the basis of service to all devices including spares and spaces for future addition. Size section bus a minimum of 60% of the main bus rating.
 3. Size all buses to limit their temperature rise within the switchboard to 65EC based on a 40EC outside ambient temperature.
 4. Size all buses so that current density will not exceed 1000 amperes per square inch.
 5. Have each individual phase bus bar insulated to withstand 2000 volts a-c for 1 minute.
 - c. Neutral Bus: In each switchboard section include an uninsulated neutral bus on insulated bus supports secured to the section frame and bolt to neutral bus bars in adjacent sections, thus providing a continuous neutral bus.
 - d. Ground Bus: In each switchboard section, include an uninsulated copper ground bus bar for the equipment. Secure the bar to the unit frame and bolt to the ground bus bars in adjacent sections, thus providing a continuous equipment ground bus. Arrange the equipment ground bus to ground the switchboard parts which do not carry current. Include terminations at the bus bar for feeder and branch circuit grounding conductors. The terminations must be exothermically welded on or be of an approved pressure connector type. Make area of ground bus not less than 25mm.
 - e. Length: Extend all buses the entire length of the switchboard. Buses must have the required capacity for their total length. Make provisions for extensions from either end of buses.
 - f. Insulators: Support main, section and branch bus systems with insulators to provide short circuit bracings. Use non-carbonizing, non-tracking insulators.

2.5 Device and Bus Isolation

Isolate vertical buses from each other using insulating barriers. Provide insulating barriers between vertical and main bus and between main bus and load terminal. Include barriers at rear and sides of individually mounted devices. Provide horizontal barriers for complete compartmentalization of individually mounted devices.

2.6 Main Protective Device

1. Type: As the main protective device for the switchboard, provide a 100% rated, 3-pole, low voltage, non-fused power circuit breaker.
2. Operating Mechanism: Stored energy, quick-make, quick-break type.
3. Characteristics.
 - A. Mounting: Draw-out.
 - B. Operation: Electrical.
 - C. Trip: Long time, and short time and instantaneous, with settings as indicated on the drawings.
4. Accessories.
 - A. Integral ground fault protection.
 - B. Ground fault indicating target.
 - C. Mechanical pushbutton trip and indicator.
 - D. Provisions for padlocking in the open position.
5. Acceptable Manufacturers: General Electric, ABB, Westinghouse Square D.

2.7 Branch Circuit Protective Devices

1. Type: As branch circuit protective devices, provide 100% rated, 3-pole, molded case circuit breakers.
2. Operating Mechanism: Quick-make, quick-break, over-center switching mechanism.

2.7 Branch Circuit Protective Devices (cont'd)

3. Characteristics.
 - A. Mounting: Stationary with bolted connections.
 - B. Operation: Manual.
 - C. Frame Size: As indicated on drawings.
 - D. Trip: Long time, short time and instantaneous with settings as indicated on the drawings.
4. Accessories.
 - A. Mechanical pushbutton trip and indicator.
 - B. Provisions for padlocking in the open position.
5. Acceptable Manufacturers. General Electric, ABB, Westinghouse, Square D.

2.8 Metering

1. Meters: Equip the switchboard with ammeters and voltmeters. Provide meters for semi-flush mounting, and minimum size 10 cm square. Use ammeters with 2% accuracy and 250-degree indicating scale. Provide meters such as General Electric Type AB-40, Westinghouse KA-241 or approved equal.
2. Switches and Transformers: Provide rotary meter switches, current transformers and potential transformers as required. Use General Electric Type M, Westinghouse Type W-2 or approved equal.
 - A. Provide ammeter rotary switch with positions 1, 2, 3 and OFF.
 - B. Provide voltmeter selector switch with positions 1-2, 2-3, 3-1, 1-N, 2-N, 3-N and OFF.

2.9 Control Wiring

For switchboard control wiring provide 600-volt, Type TBS or SIS wire. Install all control wiring complete at the factory, neatly bundled to protect it from mechanical damage.

2.10 Identification

1. Nameplates: To identify switches, breakers, and other major devices, provide engraved phenolic nameplates with black characters on a white background. Engrave the nameplates with characters a minimum of 5mm high. Mount nameplates on the front of door or panels adjacent to the device, and secure with screws.
2. Legend: Indicate on the nameplate legend the name of the circuit, panelboard, motor control center or equipment served by the device.
3. Mimic Device: Provide a plastic strip mimic bus on the front of the switchboard. Use symbols similar to a one-line diagram. Secure mimic bus with screws.

2.11 Ground Fault Protection

1. Description: Provide ground fault protection on main circuit breaker devices. The unit shall include coordinated current sensors, solid state relay and monitor of the same manufacturer.
2. Current Sensors: Provide a zero sequence type current transformer around all phase and neutral conductors.
3. Solid State Relays: Provide solid state relays which are adjustable from 100 to 1200 amperes, and from instantaneous to one second time delay by means of lockable, direct indicating knobs on the front of the unit.
4. Monitor Panel: Provide a monitor panel mounted on front of the switchboard which shall include the following:
 1. Red light to indicate a ground fault function has occurred.
 2. "Reset" pushbutton.
 3. "Test" pushbutton.
 4. "Control Power On" pilot light.
5. Testing: The switchboard manufacturer shall test the ground fault system at the factory and shall verify tripping of the ground fault relays. This test shall not involve operating the push-to-test button, but shall involve passing a primary current through the current sensor and measuring the time required for the relay to trip the associated device. Any relay which will not track the published characteristic curves shall be replaced with one that is accurate.

2.12 Listing

The switchboard shall be U.L. listed as suitable for use as service entrance equipment.

2.13 Undervoltage and Reverse Phase Protection

Provide a Westinghouse CVQ or General Electric ICR relay which provides both undervoltage and reverse phase (100% negative sequence) protection where indicated on the drawings.

2.14 Manufacturers

Acceptable manufacturers are General Electric, ABB, Square D and Westinghouse.

PART3 - EXECUTION**3.1 Protection of Switch board**

See Section 16010, paragraph 3.1 - Electrical General Provisions.

3.2 Foundation Pad

Provide a foundation pad for the switchboard as specified in Section 16010, A Electrical General Provisions. Secure the switchboard to the pad as recommended by the manufacturer. Include openings for bottom feeds to the switchboard which are compatible with the equipment provided.

3.3 Equipment Installation

6. Field Connections: Make field connections of buses between switchboard sections with splice bus and hardware provided by the switchboard manufacturer.
7. Equipment Settings: Properly set adjustable current and voltage settings as noted on shop drawing submittals. Effectively accomplish grounding and bonding.
8. Restoration: Restore all damaged surfaces to factory finish.
9. Inspection: Thoroughly inspect the switchboard for items such as loose connections and presence of foreign materials and remedy prior to energizing the switchboard. All bolted connections shall be torqued to the manufacturer's recommendations.
10. Double Lugging: Double lugging on one protected device to feed two separate loads will not be permitted.

3.4 Testing

1. After installation and before acceptance by the Engineer, the Contractor shall test all ground fault relays in accordance with NEC paragraph 230-95. This test shall involve passing a primary current through the current sensor with a suitable, low voltage test set and timer, which shall allow verification that the ground fault relays track their published curves and that they actually trip the devices on which they are applied. This test shall also include the polarity of the current sensors and give an indication of satisfactory operation of voltmeters, ammeters and their selector switches.
2. The Contractor shall notify the Engineer of this test date 7 days in advance so the tests can be properly witnessed.

END OF SECTION

Section 16455

Motor Starters- 600 Volt & Below

SECTION 16455**MOTOR STARTERS - 600 VOLT & BELOW****PART 1 - GENERAL****1.1 Related Documents**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of individual motor starters rated 600 volts and below.

1.3 Reference Standards

1. ANSI C19 - Industrial Control Apparatus.
2. NEMA ICS - Industrial Controls and Systems.
3. UL 508 - Industrial Control Equipment.

1.4 Applicable Provisions

Refer to Section 16010, Electrical General Provisions.

1.5 Submittals

Submit Shop drawings and product data for each component.

PART 2 - PRODUCTS**2.1 Magnetic Motor Starter**

1. Type: Provide magnetic, full-voltage, non-reversing motor starters, unless otherwise indicated.
2. Overload Relays: Provide an ambient-compensated thermal overload relay in each phase leg.

2.1 Magnetic Motor Starter (cont'd)

3. Contactor: Size contactors according to NEMA standards or as shown. Provide main pole in each phase leg, the number and type of auxiliary contacts to perform the required functions, and two spare auxiliary contacts, one normally open and one normally closed. Use double break contacts of silver-cadmium oxide or similar material to minimize sticking or welding. Provide contactor coils suitable for continuous operation at 230 volts, 50 hertz.
4. Control Power Transformer.
 1. Voltage: Provide in each enclosure a single-phase control power transformer with a 400-volt primary and a 230-volt secondary.
 2. Fuses: Fuse both primary lines of the transformer and connect to Line 1 and Line 2. Fuse the secondary line leaving transformer terminal X1. Ground the line leaving terminal X2. Use rejection-type fuse clips and RK-1 type current limiting fuses on the primaries. Coordinate primary fuses with secondary fuse to clear a faulted transformer but not blow on magnetizing inrush current.
 3. Size: Provide manufacturer's standard size transformer, unless noted otherwise on the drawings.
5. Enclosure: Provide a IP-42 enclosure, unless otherwise indicated on drawings.
4. Control Devices: Provide control devices on the front of the enclosure, as follows:
 1. Selector Switches: Heavy-duty, oil-tight, maintained contact, 3- position, with marked nameplate HAND-OFF-AUTOMATIC, unless other-wise indicated.
 2. Pushbuttons: Heavy-duty, oil-tight, momentary contact with marked nameplate START-STOP, unless otherwise indicated.
 3. Indicating Lights: Pilot light assemblies shall be heavy-duty, oil-tight transformer type with rated life of 20,000 hours. Neon lamps are not acceptable. Provide red (running) and green (stopped) lenses. On two-speed starters, provide amber (low speed), red (high speed) and green (stopped) lenses.

2.2 Combination Switch-starter

1. Type: Provide combination disconnect switch and magnetic motor starter, as indicated on the drawings.
2. Switch: Heavy-duty, quick-make and quick-break. Provide fused or un-fused type as indicated on the drawings. Make provisions for padlocking in the open position.
3. Fuse Clips: Provide rejection-type fuse clips.
4. Starter: Provide magnetic motor starter as specified in paragraph 2.1.
5. Enclosure: Provide an IP42 enclosure, unless otherwise indicated on drawings.
6. Fuses: Provide fuses conforming to Fuses - 600 Volt and below.

2.3 Manual Motor Starters

Provide line voltage manual motor starters for single-phase motors, as indicated on the drawings. Include bimetallic thermal overload protection in each ungrounded phase leg. Provide the toggle-operated starter in a NEMA 1 enclosure, unless otherwise indicated.

2.4 Acceptable Manufacturers

Acceptable manufacturers are ABB, General Electric, ITE, Square D, Westinghouse.

PART 3 - EXECUTION

3.1 Installation

1. Install units where indicated on the drawings. In general, mount combination units so that operating handle is approximately 150cm above finished floor. On non-combination units, mount so that control device is approximately 120cm above finished floor. Where grouped, align tops of units.

3.2 Overload Settings

Set overload relays at maximum values permitted by NEC 430-32, based on actual installed motor nameplate full load amperes.

END OF SECTION

Section 16470

Panelboards- Distribution & Branch Circuit

SECTION 16470**PANELBOARDS - DISTRIBUTION & BRANCH CIRCUIT****PART 1 - GENERAL****1.1 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of distribution and branch circuit panelboards.

1.3 Reference Standards

1. ANSI/UL 50 - Cabinets and Boxes.
2. ANSI/UL 67 - Electric Panelboards.
3. NEMA AB 3 - Molded Case Circuit Breakers and Their Application.
4. NEMA PB 1 - General Instructions for Proper Handling, Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

1.4 Submittals

1. Provide product data on panelboards and circuit breakers.
2. Provide shop drawings with a schedule for each panelboard which indicates the circuit breaker arrangement and other pertinent features. Panelboard schedules must be identical to the schedules in the project documents, unless there is a technical reason which requires a deviation. Submitted panelboard schedules must also contain confirmation of panelboard characteristics.

PART 2 - PRODUCTS**2.1 Enclosure**

1. Cabinet: Construct cabinets in accordance with UL 50. Use not less than 16-gauge galvanized sheet steel. Provide a minimum 4-inch gutter wiring space on each side. Reinforce cabinets and securely support bus bars and overcurrent devices to prevent vibration and breakage in handling. Provide cabinets without conduit knockouts. All conduit knockouts shall be made in the field. Surface-mounted panelboards in finished spaces shall have cabinet finishes to match doors and trim as specified below. In unfinished areas such as mechanical and electrical rooms, galvanized sheet steel cabinets are sufficient, provided galvanizing occurs after components are cut or sheared.
2. Doors and Trim: Fabricate doors and trim of cold-rolled sheet steel. Equip doors with flush-type combination catch and key lock. Key all locks alike. Fasten trim for panelboards to cabinets by an approved means which permits both horizontal and vertical adjustment. Trim for surface-mounted panelboards must fit the cabinet with no overhang. Apply a finish to trim and doors consisting of two coats of enamel over a rust-inhibiting prime coat.

2.2 Bus

1. Fabricate phase, neutral and ground buses of 98% IACS conductivity copper with rounded edges. Size bars as indicated and brace them to withstand symmetrical short circuit current as indicated on drawings. Install buses in allotted spaces so that devices can be added without additional machining, drilling or tapping. Use buses with silver-plated contact surfaces. Include copper neutral bus rated not less than the phase bus ampacity. Include copper ground bus rated not less than 50 percent of main bus ampacity.

2.3 Magnetic Motor Starter

Provide circuit breakers for the specified service with the number of poles and ampere ratings indicated.

1. Provide breakers which are quick-make and quick-break on both manual and automatic operation. Use a trip-free breaker which is trip indicating. Incorporate inverse time characteristic by bimetallic overload elements and instantaneous characteristic by magnetic trip.
2. For multi-Pole and 3-pole breakers, use the common-trip type so that an overload or fault on one pole will trip all poles simultaneously. Handle ties are not acceptable.
3. Unless otherwise indicated, provide circuit breakers with the minimum following interrupting ratings:
 1. 10,000 rms symmetrical amperes at rated voltage.

2.3 Magnetic Motor Starter (cont'd)

4. Connect breakers to the main bus by means of a solidly bolted connection. Use breakers which are interchangeable, capable of being operated in any position within the panel. Independently mount breakers so that a single unit can be removed from the front of the panel without disturbing or removing main bus, other units or other branch circuit connections.
5. Cable lugs shall be copper or bronze.

2.4 Circuit Identification

For each panelboard, provide a steel directory frame mounted inside the door with a heat-resistant transparent face and a directory card for identifying the loads served. Type directory as specified in Section 16010.

2.5 Listong

1. UL 67 - Electric Panelboards.

2.6 Acceptable Manufacturers

Acceptable manufacturers are GE Company, Square D Company, Westinghouse, ABB.

PART 3 - EXECUTION**3.1 Installation**

Install panelboards in the locations as shown on plans.

3.2 Mounting Height

- A. Install the panelboards such that the center of the switch or circuit breaker in the highest position will not be more than 210cm above the floor or working platform.

3.3 Protection

1. Permanent Doors and Trim. Permanent doors and trim shall be installed immediately before panelboards are energized. Permanent doors and trim shall be maintained in factory condition after installation. Doors shall remain closed at all times except when the panelboard is de-energized and work is taking place within the panelboard.

3.3 Protection (cont'd)

2. Cabinets: Cabinet interiors shall be maintained "white glove" clean at all times. Cabinet exteriors shall be maintained free of mud, spray-on insulation, paint spray, and all substances not placed on the exterior surface by the panelboard manufacturer.

END OF SECTION

Section 16490

Enclosed Safety Switches

SECTION 16490**ENCLOSED SAFETY SWITCHES****PART 1 - GENERAL****1.1 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing and installation of enclosed safety switches.

1.3 Reference Standards

1. ANSI/UL 98 - Enclosed and Dead-Front Switches.
2. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches.

1.4 Applicable Provisions

Refer to Section 16010, Electrical General Provisions.

1.5 Submittals

Provide shop drawings and manufacturers product data on each type and rating of switch.

PART 2 - PRODUCTS**2.1 Characteristics**

1. Voltage: Provide switches with a voltage rating of 600 volts a-c, as required for the installed system voltage.
2. Type: Provide switches conforming to NEMA KS 1 standard for Type HD (heavy duty).
3. Contacts: Provide switches with quick-make, quick-break contacts.
4. Poles. As indicated on plans.

2.2 Construction

1. Enclosure: Provide IP-42 switch enclosures for indoor dry locations and IP-55 for outdoor locations unless otherwise shown.
2. Operating Handle: Provide a handle suitable for padlocking in the OFF position with as many as three padlocks of 8mm diameter shank. Use a defeatable, front accessible, coin-proof door interlock to prevent opening the door when the switch is in the ON position and to prevent turning the switch ON when the door is open.
3. Terminal Shield: Provide incoming line terminals with an insulated shield so that no live parts are exposed when the door is open.
4. Neutral: Provide each switch with an isolated, fully rated neutral block. Make provisions for bonding the block to the enclosure.
5. Ground: Provide each switch with a ground lug.
6. Fuse Holders: Where fusible switches are shown, provide switches with rejection-type fuse holders which are suitable for use with fuses specified under specifications Section, Fuses - 600 Volt and Below.
7. Nameplates: Provide metal nameplates, front cover mounted, that indicates the switch type, catalog number and horsepower rating (with both standard and time delay fuses).

2.3 Listing

UL 98 - Safety Standard for Enclosed Switches.

2.4 Acceptable Manufacturers

Acceptable manufacturers are:-

- GE Company.
 - Square D Company.
 - Westinghouse.
 - ABB.
- or equal and approved alternative

PART 3 - EXECUTION

Install switches where indicated on drawings. In general, mount so that operating handle is approximately 150cm above finished floor. Where grouped, align tops of switches.

END OF SECTION

Section 16510

Lighting Installation

SECTION 16510**LIGHTING INSTALLATIONS****I- GENERAL LIGHTING FIXTURES****PART 1 – GENERAL****1.01 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 Summary

This section specifies the furnishing and installation of all indoor and outdoor lighting fixtures and all related fixtures, control gear and accessories.

1.02 Fixture Design Standards

The specification and the Drawings is 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 the following standards:

- A. IEC
- B. Illuminating Engineering society(IES) of North America.

1.03 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 ceiling type, structural members, ducts, pipes and other installations. Such fixtures are to be located in coordination with final equipment layout so that illumination is as intended by the design

1.04 Submittals

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

Product data on each fixture, lamps and ballasts including manufacturer's name, catalogue number, rating and dimensions.
Photometric data for lighting calculations.

1.04 Submittals (cont'd)

- B. Shop Drawings: Submit drawings for approval including the following
- Exact position of each fixture on reflected ceiling plans, with indication of ceiling type.
 - Installation details including suspension and mounting provisions.
 - Wiring details, circuit and panel board references and lighting control arrangements.
- C. Samples: submit a complete sample of each fixture type, including color and texture samples of each fixture.

PART 2 - PRODUCTS**2.01 Lighting Fixtures**

- A. Lighting Fixture Construction - General
- 1) Generally construction and wiring of fixtures are to comply with the specifications, Regulations and Standards. Fixtures are to be fabricated, assembled and wired entirely at factory. Manufacturer's name, factory inspection sample and official quality label are to be fixed to each fixture supplied.
 - 3) Sheet Steel Housings to be not less than 0.6 mm thick, and thicker when required by the Specification or the Standards.
 - 4) Sheet Steel Reflectors to be not less than 0.5 mm thick.
 - 5) Aluminium Reflectors to be not less than 0.7 mm thick, unless otherwise approved.
 - 6) Fabrication metalwork is to be mitred, welded and ground smooth without tool marks or burrs. Flat metal parts are to be stiffened by forming grooves and edges during fabrication. Metal parts are to have finish free from irregularities.
 - 7) Rust-Proof Ferrous Base ferrous metal parts are to be bonderized (treated with corrosion resistant phosphate solution) and given an approved rust-inhibiting prime coat before application of final finish.
 - 8) Finish For Non-Reflecting Metal Surfaces approved baked enamel paint. Paint colour on fixture frames and trims is to be as specified or as selected by the Engineer.

2.01 Lighting Fixtures (cont'd)

- 9) Finish For Light Reflecting Surfaces white baked enamel paint having reflection factor not less than 85%. Mirror reflectors, where specified, are to be highly polished, anodized aluminium with reflection factors not less than 97%.
- 10) Mechanical Resistance of Finish after finish has been applied on steel surfaces and cured, it is to withstand a 6 mm radius bend without showing signs of cracking, peeling or loosening from base metal.
- 11) Heat Resistance finishes, wires and components inside fixtures are to be certified materials to resist the temperatures, or other conditions encountered in the fixtures.
- 12) Wiring Inside Fixtures to be not less than 1.5 mm², and insulated to have acceptable characteristics to resist maximum temperatures inside fixtures. Wiring is to be terminated on screw type, fixed, insulating terminal blocks.
- 13) Hinges fixture with visible frames and hinged diffusers are to have concealed hinges and catches, and stainless steel retaining clips.
- 14) Suspension Aligners to be provided for pendant fixtures for axial, vertical and horizontal alignment. Vertical adjustment is to be minimum 25 mm.
- 15) Recessed Fixtures to be constructed to fit into suspended ceilings without distorting fixture or ceiling. Plaster rings are to be provided for plaster or concrete ceilings.
- 16) Outdoor Fixtures to be non-ferrous metal or specially treated material for outdoor use.
- 17) Removal of parts for maintenance is to be possible without removing fixture housing.

B. Fluorescent Fixtures

- 1) Lamp Holders: Heavyduty, moulded white plastic with non-corroding spring contacts.
- 2) Lamp Holders for Industrial Fittings spring loaded turret type, heavy duty, dust protected.
- 3) Ballasts Generally: Single, Two, Three or Four lamp ballasts may be used in any one fixture. Two - lamp ballasts are to be lead-lag, series type. Equipment is to be enclosed in sheet steel casing with corrosion resistant finish.

2.01 Lighting Fixtures (cont'd)

- 4) Ballast Thermosetting: Compound is not to soften, liquify or support combustion under any operating condition or upon ballast failure, and is to fill ballast enclosure and dampen vibrations. Temperature rise, under normal operating conditions is not to exceed 55 deg. C above maximum ambient temperature of 40 deg. C.
- 5) Ballast Protection: Each ballast is to have one-time external fuse and fuse holder rated in accordance with manufacturer's instructions.
- 6) Ballast type suitable to work with electronic starter, or dimming type, as stated in fixture description and as shown on the Drawings. Power factor corrected to above 0.9, having manufacturer's lowest case temperature. Sound rating is to be class "A".
- 7) Ballast Rating ballast is to be manufactured and certified for the specific lamp it controls and for operation from nominal power supply, with voltage and frequency equal to nominal voltage and frequency of distribution network.
- 8) Capacitors: Snap-Type connectors and fastening. Bolt type M8 for fixing to fixture.
- 9) Starters: To be selected in conjunction with respective ballast and lamp.
- 10) Electronic Ballasts for use on 26 mm and 38 mm diameter krypton or argon inertgas filled triphosphor. Tubes are to be used in conjunction with electronic dimming controls. Dimming is to be possible down to 5% of normal output. Ballasts are to be as manufactured by Helvar or Osram or other equal and approved, with minimum life expectancy in of 10000 hours.

C. Incandescent Lamp Fixtures

Incandescent Lamp Sockets: to comply with IEC 61 and IEC 238, high grade porcelain, Type E27 (ES) screw sockets for lamps not exceeding 200 W and type E40 (GES) screw sockets for lamps 300 W and over.

D. High Intensity Discharge Lamp Fixtures

- 1) Type fixtures are to be complete units including integral ballasts (and ignitors for HPS lamps) and lamps of required number and type, and are to have lighting distribution characteristics equivalent to model and manufacturer indicated in the fixture schedule on plans.

2.01 Lighting Fixtures (cont'd)

- 2) Accessories fixtures are to have mounting accessories as indicated on plans, such as suspension rods or chains, rails or brackets, and protective glass covers with gaskets for protection against dust and humidity or corrosive atmosphere predominant in specified location.
- 3) Ballasts And Ignition Devices are to be power factor compensated to at least 0.9 lagging, and type specially selected for lamp type and size used. Lamp is to be able to start with at least +/-10% variation from nominal line voltage and continue in normal operation with dips attaining 20% for four seconds. Compensation is to ensure there is no great increase in operating current during starting and that gear losses do not exceed 10% of normal wattage. RF suppression circuit is to be provided.

2.02 Lamp

- A. Rated Voltage of incandescent and PL lamps is to be equal to nominal voltage of distribution network. Lamps with different rated voltages are not acceptable.
- B. Incandescent Lamps for General Lighting Service (GLS) to have screw base type ES for lamps 200 W and below and type GES for lamps 300 W and above. Frosted lamps (IF) are to be used unless otherwise specified. Minimum rated life is to be 800 hours and luminous output above the following

950 lumens for 75 W lamps, 1350 lumens for 100 W lamps, 2200 lumens for 150 W lamps, 3100 lumens for 300 W lamps.
- C. Reflector Lamps (R) for indoor and outdoor use, with silver reflector and prismatic lens. Light beam is to be narrow (spot), wide (flood) or extra - wide (wide floor) as indicated in the fixture description.
- D. Tungsten-Halogen Lamps tubular, quartz, resistant to high temperatures. Guaranteed rated life is to be above 2000 hours and luminous output above the following.

9500 lumens for 500 W lamps.
22000 lumens for 1000 W lamps
4400 lumens for 2000 W lamps.

2.02 Lamp (cont'd)

- E. Straight Tubular Fluorescent Lamps to IEC 81 (SSA 138 and SSA 139) and, unless otherwise specified, are to be triphosphor and electronic starter operated type, bi-pin, rated as indicated in the fixture description and with improved fluorescent internal coating. Colour of light is to be "super quality white" equal to Philips No. 84 unless otherwise specified. Lamps are to be low energy type with tube diameter 26 mm. Guaranteed rated life is to be above 8000 hours and luminous output above the following

1300 lumens for 18 W lamps (600 mm long)

3200 lumens for 36 W lamps (1200 mm long)

5200 lumens for 58 W lamps (150 mm long)

- F. High Pressure Mercury Vapour Lamps to IEC 188, and to include quartz discharge tube in an internally coated void outer tube. Coating is to be yttrium vanadate phosphor with colour temperature of 3300 deg. K. Guaranteed rated life is to be above 8000 hours and luminous output above the following

3800 lumens for 80 W lamps.

6500 lumens for 125 W lamps.

14000 lumens for 250 W lamps.

- G. High pressure sodium lamps type SONT (tubular), with guaranteed average rated life (down to 80% output) above 10000 hours, and having initial luminous output above the following

15000 lumens for 150 W lamps

25000 lumens for 250 W lamps

50000 lumens for 400 W lamps

135000 lumens for 1000 W lamps

- H. Metal halide lamps comprising quartz discharge tube enclosed in clear tubular hard - glass outer bulb, operating on same principle as all gas discharge tubes with iodide additives indium, thalium and sodium in the mercury discharge, to increase intensity in three spectral bands; blue, green and yellow - red with high colour rendering, Lamps are to be IEC 188 with E40 base. Guaranteed average life is not to be less than 10000 hours and luminous outputs, after 100 hours burning, are to be above the following

32500 lumens for 400 W lamps

90000 lumens for 1000 W lamps

190000 lumens for 2000 W lamps.

Permissible base temperature is to be not greater than 250 deg. C, and maximum bulb temperature not greater than 550 deg. C. Lamp burning position of 2000 W, 220 V lamp is to be possible up to 75 degrees.

PART 3 - EXECUTION**3.01 Installation**

- A. Generally install fixtures level, aligned and parallel or square to building lines and at uniform height as shown on the Drawings or as approved by the Engineer. Make final height adjustment after installation..
- B. Fixture Support: Provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. and method of fastening for approval. Rigidly secure fixtures mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.
- C. 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.
- D. Suspended Ceilings: If ceiling construction is unable to support weight of fixtures without strain or deformation suspend fixtures directly from building structure.
- E. Solid Ceilings: Coordinate dimensions of recesses in ceilings with exact fixture dimensions and structural elements.
- F. Continuous Rows: Arrange fixtures so that individual fixtures can be removed without dismantling remaining fixtures.
- G. Cover Plates: Install cover plates over fixture outlet box or opening in ceiling or structure when left unused.
- H. Flush Recessed Fixtures: Install to completely eliminate light leakage within fixture and between fixture and adjacent finished surface.
- I. Ventilation: Keep ventilation channels free after fixture is installed, if required by the design of the fixture.
- J. Earth Metal frames of fixtures as described in section 16161 of the specification.
- K. Tightness: Ensure that enclosed fixtures are reasonably insect/dust tight when installed, and completely weather proof for installations subject to weather conditions.
- L. 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.

3.02 Inspection and Tests on Site

- A. Visual Inspection: Check neatness of installation, uniformity of equipment and nameplates, etc.
- B. Illumination: Measurements to be taken at selected locations, to determine level and uniformity.
- C. Operation: Check lighting installations for operation including control and regulation equipment.
- D. Electrical Data: Measure power factor, current and voltage at start for installations with discharge lamps.

SECTION 16510**LIGHTING INSTALLATIONS****II - OUTDOOR AREA LIGHTING****PART 1 - GENERAL****1.01 Work Included**

Outdoor area lighting including, luminaries, columns, related power distribution and control, protective earthing and related builder's work including columns foundations, cable pits, cable trenches and ductwork.

1.02 Standards

Luminaries generally are to comply with IEC 598 and the applicable C.I.S.P.R. recommendations. Manufacturer is to verify compliance with these standards and the applicable local regulations and design standards.

1.03 Technical Requirements

Minor deviation from the Drawings may be considered for improvement in construction details, but no changes are to be made without the written approval of the Engineer.

1.04 Ambient Conditions

Unless otherwise specified, equipment is to be designed and derated for continuous and trouble-free service at 50 deg. C ambient temperature and 100% relative humidity, with temperature reaching 70 deg. C in direct sunlight and with high content of ultra-violet rays. Equipment is to withstand full load operation whilst exposed to sun.

1.05 Submittals

- A. Equipment Data: Submit complete data for approval including, but not limited to, the following
 - 1) Detailed literature, in English, for each type of luminaries or fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles, and any modification to a standard product if applicable.

1.05 Submittals (cont'd)

- 2) Detailed Specification and Drawings for each column type including shape, base/mounting flanges, bolts, nuts etc. cross-sections, design criteria and calculations, brackets, finishes, provisions for cabling, cut-out or circuit-breaker etc.
 - 3) Photometric data for lighting calculations including polar curves, coefficients of utilization, efficiency and depreciation factors.
- B. Shop and Construction Drawings: submit drawings for approval including, but not limited to, the following:
- Layout of equipment in exact positions with mounting and construction details, concrete foundation dimensions and reinforcement, routing and sections of duct banks and trenches, backfill and packing materials, earthing rods etc.
- Cabling and wiring diagrams, single line drawings, loads, phase distribution, protection and control, earthing and the like
- Calculations of illumination levels and glare, based on CIE methods.
- C. Samples submit fully equipped sample of luminaries or other materials or components if required by the Engineer.

PART 2 - EXECUTION**1.05 Submittals**

- A. Equipment
- Install equipment to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made to accomplish this but no changes are to be made without the approval of the Engineer.
- B. Columns Bases: Install columns on concrete bases or as detailed on the drawings. Before commencement of construction, ensure that bases are suitable for column installation. Holding down and plumb adjusting nuts, washers, lockouts or nyloc nuts are to be stainless steel or cadmium plated.
- C. Columns: Erect columns so that luminaries are located on a line parallel to theoretical profile of road. Alignment of columns, both horizontally and vertically, is to be secured to the satisfaction of the Engineer. Brackets are to be set at 90 degrees to longitudinal axis of road.

1.05 Submittals (cont'd)

- D. Mounting Adjustments: After demonstration to the Engineer that specified lighting requirements have been met, carry out final setting and locking in position of the floodlights.
- E. Cabling, conduits, and Ductwork: Carry out in accordance with relevant sections of the Specification. Cable ducts are to be directly buried except at crossings with other service work or roads.
- F. Earthing: Carry out in accordance with Section 16161 of the Specification.

2.02 Inspection and Tests on Site

- A. Visual Inspection is to include inspection of condition of each piece of equipment, quality of workmanship, alignment, perpendicularly, labelling and like, all in conformance with the Specification.
- B. Insulation Resistance and Continuity Tests are to be carried out on each circuit and piece of equipment before energization, with circuit breakers in the open position and lamps not installed.
- C. Operational Tests are to be carried out on all circuit breakers and control gear, with lamps installed, including recording voltage at terminals of ballasts on final columns of each circuit and at distribution panel or the like.
- D. Performance tests are to be carried out after 100 hours normal operation and are to include measurement of lighting levels and uniformities on required illuminated surfaces.
- E. Other Tests are to be carried out as required by the Engineer to verify conformity with the Specification.
- F. Earthing Resistance Tests are to include measurement of earth electrode resistance at final points of circuits and continuity of protective conductors.
- G. Results of tests are to be recorded on site and signed by witness parties.
- H. Test Equipment and Labour: Provide equipment and labour including instruments and complete provisions for carrying out tests.

END OF SECTION

Section 16570

Architectural Lighting Control Systems

SECTION 16570**ARCHITECTURAL LIGHTING CONTROL SYSTEMS**
(CENTRAL SYSTEM)**PART 1 GENERAL****1.01 SUMMARY**

- A. The following specifications detail the minimum performance and related criteria for a lighting control system proposed for this project. Any deviations from this specification must be documented in writing and submitted to the Architect prior to the issuance of any contracts and must also include all associated cost savings or additions, including but not limited to equipment, equipment installation, power wiring labor and materials, programming, documentation and project management.

1.02 SECTION INCLUDES

- A. Provide, install and test an architectural lighting control system as specified herein for the areas indicated on the drawings, specifications and load schedule(s).

1.03 RELATED SECTIONS

- A. Section 16150 (Wiring Devices/Lighting Controls)
- B. Section 16580 (Ballasts)

1.04 REFERENCES

- A. Underwriters Laboratories Inc.
- B. ISO 9001 Quality Standard
- C. Canadian Standards Association
- D. NOM Certification Mark
- E. Harmonized European Standard (CE)
- F. American National Standards Institute
- G. Institute of Electrical and Electronic Engineers

1.05 SYSTEM DESCRIPTION

- A. System shall consist of factory pre-assembled dimming and switching panels, centralized preset lighting control(s), low voltage wall stations and/or control interfaces, and solid-state high frequency fluorescent dimming ballasts (where applicable). Additional items may also be required and are described herein and/or shown on the drawings.

1.06 SUBMITTALS

- A. Shall include a load schedule, which indicates the actual connected load and load type per circuit, circuits and their respective control zones, circuits that are on emergency (if applicable), and the capacity, phase, and corresponding circuit numbers (per the electrical drawings).
- B. Shall include a complete schematic of the system.
- C. Shall include catalog cut sheets with performance specifications including historical testing data demonstrating complete compliance to all of the specifications herein.
- D. Shall include all exceptions taken to the Specification.
- E. Manufacturer shall provide any additional information or factory demonstrations as required by Specifier to demonstrate conformance with Part 2 of this specification. All demonstrations are to be at a location, time and in a manner chosen by the Specifier.

1.07 QUALITY ASSURANCE

- A. Manufacturer shall have a minimum of 10 years continuous experience in the manufacturing of lighting controls.
- B. Lighting control system shall be UL, CSA, NOM or CE listed (where appropriate) specifically for the required loads (i.e. incandescent, magnetic and electronic low voltage, fluorescent, etc.). Manufacturer shall provide evidence of compliance on request.
- C. Manufacturer shall have their quality system registered to the ISO 9001 Quality Standard, including in-house engineering for all product design activities. Due to the exclusion of the Design Control element, ISO 9002 Registration is not acceptable.
- D. Manufacturer shall have component quality program in place to reduce defective levels to less than 100 PPM and provide documentation on request.
- E. Lighting control system shall meet IEC801-2, tested to withstand a 15kV electrostatic discharge without damage or loss of memory.
- F. Manufacturer shall provide software to simplify the design and installation of all lighting controls.
- G. Manufacturer shall be Year 2000 compliant for both their corporate operating systems and lighting control products.
- H. Lighting control system shall be bid separately from all other lighting equipment. Packages of lighting equipment and dimming systems shall not be acceptable.

1.08 PROJECT/SITE CONDITIONS

- A. Lighting controls shall operate in an ambient temperature range of 0°C (32°F) to 40°C (104°F) and 90% non-condensing relative humidity without the requirement of a regularly scheduled maintenance program for air filtration components.

1.09 WARRANTY

- A. Manufacturer shall provide a full two-year warranty, limited eight-year warranty on all equipment supplied inclusive of commissioning by a factory-employed engineer. Warranty shall cover 100% of the cost to repair or replace any parts required over the first two years, which are directly attributable to the manufacturer.

1.10 COMMISSIONING

- A. The contractor shall provide the manufacturer with 10 working days notice of the scheduled commissioning date.
- B. Upon completion of the installation, the system shall be completely commissioned by a factory-employed engineer. The check-out will be performed after all loads have been tested live for continuity and freedom from defects and that all control wiring has been connected and checked for proper continuity. The factory-employed engineer shall demonstrate and educate the owner's representative(s) on the system capabilities, operation and maintenance.
- C. Manufacturer shall offer extended warranty based upon successful factory commissioning.

PART 2 PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. LUTRON
- B. The listing of a manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the electrical contractor to ensure that any price quotations received and submittals made are for products/systems that meet or exceed the specifications included herein.

2.02 POWER PANELS

- A. Panels shall be UL listed or CSA, NOM or CE approved (where appropriate). Panels shall be wall or floor mounted NEMA grade, gauge as required by UL508. Contractor shall reinforce wall as required for wall-mounted panels.
- B. Panels shall be completely pre-assembled and factory tested by the manufacturer. The contractor shall be required to provide input feed wiring, load wiring, and control wiring. No other wiring or assembly by the contractor shall be permitted. All input feed, load, and control terminals shall be front accessible without the need to remove dimmer assemblies or other components.
- C. Unless the panel is a dedicated feed-through switching panel or otherwise indicated, panels shall contain branch circuit protection for each dimming assembly. Branch circuit breakers shall have the following performance characteristics:

1. Be UL listed under UL 489 or meet IEC 60898 as a molded case circuit breaker for use on lighting circuits.
 2. Contain a visual trip indicator and shall be rated at 6000 AIC (230V), unless otherwise noted.
 3. Be thermal-magnetic in construction for both overload and dead short protection. The use of fully magnetic breakers shall not be acceptable, even when used in conjunction with individual dimmer thermal cutouts.
 4. Be replaceable without moving dimmer assemblies or other components of the panel.
- D. Activation of a circuit protection device shall affect only the single dimmer that it is wired to protect.
- E. Panels shall be equipped with an electronic BYPASS feature which electronically switches lighting loads to full light output from any level by toggling the individual branch circuit breakers (for individual circuits) or main breaker (for all circuits) when there is no intensity data available from the control system.
- F. Panels which allow the dimmers to be loaded to greater than 80% of the wiring ampacity as specified by NEC shall not be acceptable.
- G. Panels requiring the neutral feeder to be sized larger than any individual phase feeder shall not be acceptable.
- H. Panels shall be shipped with each dimmer in a mechanical BYPASS position via a jumper bar inserted between the input and load terminals to allow dimming panel to be used as a temporary lighting panel with no threat to the dimmer. These jumpers shall carry the complete load current and shall be reusable at any time.
- I. Panels shall be capable of maintaining dimmers at current light levels in the event of a control failure. Systems that fail to off during a control failure are not acceptable.
- J. Panels shall be passively cooled via free-convection, unaided by fans. Systems that are fan dependent or fan assisted, or which recommend regularly scheduled maintenance for air filtration components are not acceptable.
- K. Panels shall provide a minimum of 52 square inches of cooling surface area for each semiconductor.
- L. Panel shall provide capability to electronically assign each circuit to any zone in the dimming system. Panels using mechanical switches, rewiring, or EPROMS shall not be acceptable. All circuits shall be capable of being operated (dimmed or switched where appropriate) from the panel.
1. Where indicated on the drawings, dimming and switching panel(s) shall be capable of operating under two optically isolated control systems. Panel shall be capable of auto-detecting between manufacturer's control protocol and DMX512 protocol for each control system. Panel response to control changes shall take no more than 25 milliseconds. Panel shall be capable of assigning each dimmer to either control system on a circuit by circuit basis. Panel shall also be capable of conditionally changing assignment from one system to the other.
- M. Multiple panels shall be capable of operating in one system.

- N. For panels fed with a normal/emergency feeder, panel shall include electronics to bring all circuits to an emergency full-on condition upon the loss of normal power and the subsequent presence of emergency power. Designated circuits shall be controlled simultaneously with other lighting circuits within the designated control zone during the presence of normal utility or generator power.
1. Panels listed as emergency shall have all circuits immediately go to a full-on condition. All dimmers shall operate at 100% of input voltage, bypassing any high-end trim. All local control stations are inoperable during this period. Once normal power is restored, all lighting zones shall revert back to their status prior to the emergency condition without requiring any action on the part of the user. Restoration to some other "default" level is not acceptable.
 2. This type of emergency full-on may be used with either a normal/emergency generator, a UPS or IPS system with true sinewave output and maximum of 10% THD. The generator, UPS, or IPS system must be capable of operating under no load conditions or a constant hot secondary utility feed where the emergency transfer occurs on the line side (upstream) of the dimming panel and requires that only a single normal/emergency feeder be brought to the Emergency Dimmer Panel.
 3. System shall be capable of meeting local jurisdictions requiring special conditions such as minimum light levels during normal operation or full function, even during emergency power.

2.03 MODULAR DIMMING ASSEMBLIES

- A. Dimmer shall be capable of withstanding inrush current of 50 times operating current. In addition, under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20°C safety margin below the component temperature rating.
- B. A positive air gap switch shall be employed with each dimmer in the panel to ensure that the load circuits are open when the "off" function is selected from the control system.
1. Load shall be switched in a manner that ensures no arcing will occur at the mechanical contacts when power is applied to the load circuits.
- C. Each dimmer shall compensate for incoming line voltage variations such as changes in RMS voltage, frequency shifts, harmonics and line noise. Dimmer shall be capable of maintaining constant light level with no visible flicker under the following conditions:
1. $\pm 2\%$ change in RMS voltage/cycle
 2. ± 2 Hz change in frequency/second. Dimmers that do not regulate the dimmer output in real time shall be unacceptable.
- D. Each dimmer shall incorporate an electronic "soft-start" default at initial turn-on that smoothly ramps the lights up to the appropriate levels within 0.5 seconds.

- E. Once installed as part of a complete system, the semiconductor used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.
- F. One type of dimmer shall be used for all sources, line voltages, and frequencies. Systems requiring different types of modules shall not be acceptable. Dimmer shall be capable of electronic assignment to any source and any zone. Upon replacement of a dimmer, only that dimmer shall require replacement, and no re-programming shall be required.
- G. Filtering shall be provided for each dimmer so that current rise time shall be at least 350 μ sec as measured from 10-90% of the load current waveform and at least 525 μ sec as measured from 0-100% of the load current waveform at 50% rated dimmer capacity at a 90 \emptyset conduction angle. Current rise time shall be at least 400 μ sec as measured from 10-90% of the load current waveform and at least 600 μ sec as measured from 0-100% of the load current waveform at 100% rated dimmer capacity at a 90 \emptyset conduction angle. At no point should current rise faster than 30mA/msec.
- H. Dimmer output voltage shall be a minimum 95% of input voltage at maximum intensity setting.
- I. Dimmer shall include diagnostic LEDs to verify proper operation and assist in any system troubleshooting.

2.04 MODULAR SWITCHING ASSEMBLIES

- A. Assembly shall be capable of withstanding inrush current 50 times operating current. In addition, under fully-loaded operating conditions, all devices shall operate at a minimum 20 $^{\circ}$ C (68 $^{\circ}$ F) safety margin below the component temperature rating.
- B. A positive air gap switch shall be employed with each circuit in the power panel to ensure that the load circuits are open when the "off" function is selected from the control system.
- C. Relays shall be mechanically latching. Relays shall be of sealed construction type in order to prevent contact degradation.
- D. Once installed as a complete system, the relays used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to near lightning strike) as specified by

ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide the means to demonstrate conformance to this specification using the appropriate surge-generation equipment.
- E. Relays shall be rated for 16 Amps continuous duty, for the following load types: resistive, tungsten/incandescent, inductive (magnetic low voltage, neon/cold cathode, magnetic fluorescent lamp ballasts), and capacitive (electronic low voltage, electronic fluorescent lamp ballasts, high intensity discharge). Relays rated only for resistive loads shall not be acceptable.

- F. Load shall be switched in a manner that ensures no arcing will occur at the mechanical contacts when power is applied to the load circuits.
- G. Average rated life of relay shall be at least 1,000,000 cycles.
- H. Assembly shall include diagnostic LEDs to verify proper operation and assist in any system troubleshooting.

2.05 SOURCES

- A. Dimming assemblies shall operate the following sources/load types with a smooth continuous Square Law dimming curve. Dimmers that have visible "steps" of light intensity throughout the control range shall not be acceptable. Dimmers shall also be capable of operating the following sources on a non-dim basis. Dimmers shall be electronically assigned to the appropriate load type/dimming curve and can be reassigned at any time. Universal-type dimmers that do not adjust the dimming curve shall not be acceptable.
 - 1. Incandescent, Tungsten and Magnetic Low Voltage Transformer
 - a. Dimmer shall contain circuitry specifically designed to control and provide a symmetrical AC waveform to the input of magnetic low voltage transformers.
 - b. Dimmer shall not cause a magnetic low voltage transformer to operate above the transformer's rated operating current and temperature.
 - c. Dimmer shall contain circuitry to control dioded lamps.
 - 2. Electronic Low Voltage Transformer
 - a. Dimming shall not adversely affect sound rating of the electronic transformers. In addition, no flicker or interaction shall occur at any point in the dimming range.
 - b. Dimmers shall provide the ability to dim lamps down to 0% (blackout). Minimum light levels shall be user adjustable in order to compensate for different loading of each dimmer.
 - 3. Fluorescent Electronic Dimming Ballast
 - a. Dimming ballasts and controls shall be provided by same manufacturer.
 - b. Refer to general section 16580 for dimming ballast specifications and performance.
 - c. See fixture schedule and/or load schedule for specific ballast model numbers.
 - 4. Neon and Cold Cathode
 - a. Dimmer shall provide the ability to dim lamps down to 10% of full light output when used with normal (low) power factor transformers.
 - b. The lamp performance over the range specified shall be continuous and free of flicker or striations.

- c. Neon/cold cathode lamps shall be manufactured with strict attention paid to proper lamp pressurization and exclusion of any impurities to ensure best dimming performance.
- d. Transformers shall be sized per transformer sizing tables developed by the dimming manufacturer.
- e. The electrical contractor is responsible for proper neon or cold cathode lamp and wiring installation.

2.06 CONTROLS

- A. Definitions: A "scene" or "preset" is a specific look or mood created by different lighting zones set at different intensities. A "zone" is one or more lighting circuits which are controlled together as a group.
- B. Control shall provide power failure memory. Should power be interrupted and subsequently returned, the lights will come back on to the same levels set prior to the power interruption without requiring any actions on the part of the user. Restoration to some other default level is not acceptable, unless specifically noted elsewhere.
- C. Wiring from dimming and switching panel(s) to centralized preset lighting control and wall stations, preset local lighting controls, and control interfaces shall be low voltage type Class 2 wiring (PELV).
- D. Faceplate shall attach using no visible means of attachment.
- E. Controls shall be engraved with appropriate zone and/or scene descriptions, furnished to the manufacturer prior to fabrication. Size and style of engraving type shall be determined by the Architect. Any silk-screened borders, logos, graduations, etc., shall use a graphic process that chemically bonds the graphics to the metal faceplate, resisting removal by scratching, cleaning, etc..
- F. Manufacturer shall ensure the following items regarding product color:
 - 1. Product color matches NEMA standard WD1, Section 2, and the maximum color deviation from this standard shall not exceed $\Delta E=1$, CIE L^*a^*b color space units. For non-NEMA colors, color match coordination shall be provided on request.
 - 2. Color variation of any control in the same product family shall not exceed $\Delta E=1$, CIE L^*a^*b color units.
 - 3. Visible parts shall exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674-89. Manufacturer to submit proof of testing upon request.
- G. Controls shall provide an immediate, local LED response upon button activation to indicate that a system command action has been requested. LED will remain lit contingent upon receiving system confirmation of the successful completion of the command.

2.07 CENTRALIZED PRESET LIGHTING CONTROL

- A. Where indicated on the drawings, control shall provide preset lighting scenes for up to 512 zones—expandable to 8,192 zones when using multiple control processors—in any combination of groups or areas. System set-up shall be via personal computer running Windows 3.1, Windows 95, or Windows 98.
- B. System set-up shall provide capability to:
1. assign dimmers to specific zones
 2. determine the number of areas
 3. define the number of zones and scenes per area
 4. define wallstation functionality on a button by button basis
 5. set the astronomic timeclock based on longitude, latitude, and daylight savings schedule
 6. label all areas, zones, scenes, and wall stations. Each area, scene, and zone name shall be designated by an alphanumeric display of up to 24 characters.
- C. Operating software shall additionally provide the capability to:
1. view the status of all areas
 2. create scenes
- D. System shall support printing the following summaries:
1. area overview (inclusive of scenes, zones, and wall stations)
 2. scene summary by area (inclusive of light levels of all zones for each scene)
 3. wallstation summary by area (inclusive of specific function for each wallstation)
- E. Control shall allow design of system off site and downloading upon installation or modifications after installation.
- F. Control shall also be capable of interfacing to other equipment via integral RS232 interface and/or modem (by others).
- G. Control shall be capable of operating with up to 96 wall stations, preset local lighting controls, and control interfaces—expandable to 1,536 when using multiple processors. Where indicated on drawings, use wall stations, preset local lighting controls, and control interfaces as required.
- H. An integral timeclock shall execute any of the following events: select preset scenes, lockout control stations, or unlock control stations. Commands can be in either real or astronomic (relating to sunrise/sunset) time. Timeclock shall automatically correct for daylight savings time and leap year where appropriate. There shall be a total of 10 timeclock schedules available per room or area (one per day of each week, plus three special schedules). Any special schedules which have been programmed shall be capable of being stored in a "calendar" format on a screen up to a year in advance for easy reference. The timeclock shall be capable of executing up to 600 events per day. The timeclock can be enabled or disabled for any area via either the set-up computer or local wallstation/control interface.

- I. Programmable sequencing shall allow up to four automatic lighting sequences to be programmed for each area. A sequence shall be defined as a series of steps, while a step shall be defined as the recall of a scene. The sequence shall be capable of executing up to 600 steps. Each step interval is adjustable for 1 second to 60 minutes. Program shall be capable of sequencing in a continuous loop, of one complete sequence and holding at the last scene, or of one complete sequence and return to the pre-sequence scene.
- J. An integral room template shall allow on-screen control definition of partitionable spaces. Template shall allow user to define if room is independent or combined with adjacent room(s) and lockout/unlock control stations.
- K. In the event that any of the communication lines to any of the dimmer and/or switching panels is interrupted for any reason, the lights controlled by those panels shall remain at their current levels until the interruption is cleared. In the event of a control station failure or interruption of a communication line to any of the controls, the lights controlled by those stations shall remain at their current levels.
- L. The complete control system shall have a full internal battery backup that can store all system memory for 1 year without power. It shall not be necessary to re-boot the system manually nor use any tape or floppy disc/hard drive to restore the system once power has been restored—system shall automatically return to its previous state.

2.08 HANDHELD PROGRAMMER (S)

- A. Handheld programmer shall provide the ability to change intensity and fade time for each zone in the lighting control system without the use of a PC. Unit shall provide current light level indication and a thumbwheel for light level adjustment. Unit shall have a zone finder button for easy identification of the zone being programmed. Unit shall be equipped with a 25' (76.2m) cord.

2.09 WALL STATIONS

Wallstation functions are configured through software. Functions listed are typical.

- A. Two Button Wallstation(s)
Control shall be capable of turning lighting on/off, reflecting door status of one or two partitions, enabling/disabling wall stations, starting/stopping one sequence, enabling/disabling timeclock, enabling security override, and fine-tuning of zones. Buttons shall provide green LED status feedback.
- B. Four Button Wallstation(s)
Control shall be capable of recalling preset light levels for four scenes, reflecting door status of up to four partitions, and selecting daylight control banks. Buttons shall provide green LED status feedback.
- C. Five Button Wallstation(s)
Control shall be capable of recalling preset light levels for four scenes plus 'off', and starting/stopping one to four sequences. Buttons shall provide green LED status feedback.

- D. Five Button Wallstation(s) with Raise/Lower
Control shall be capable of recalling preset light levels for four scenes plus 'off' and of fine-tuning light levels with master raise/lower, and starting/stopping one to four sequences. Buttons shall provide green LED status feedback LED status feedback.
- E. Architrave Two Button Wallstation(s)
Control shall be capable of recalling preset light levels for two scenes, changing door status of one or two partitions, enabling/disabling wall stations, starting/stopping one sequence, enabling/disabling wall stations, enabling security override, and fine-tuning of light levels. Buttons shall provide green LED status feedback. Control shall be no wider than 1.75". Manufacturer shall supply wallbox.
- F. Architrave Seven Button Wallstation(s)
Control shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off' and of fine-tuning light levels with master raise and lower buttons. Control shall be no wider than 1.75". Manufacturer shall supply wallbox.
- G. Architrave Large Button Wallstation(s)
Control shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off' and of fine-tuning light levels with master raise/lower. Control shall be no wider than 1.75". Manufacturer shall supply wallbox.
- H. European-Style, Two Button Wallstation(s)
Control shall be capable of recalling preset light levels for two scenes, changing door status of one or two partitions, enabling/disabling wall stations, starting/stopping one sequence, enabling/disabling wall stations, enabling security override, and fine-tuning of light levels. Buttons shall provide green LED status feedback. Control shall be no larger than 3.38" (86mm) square. Manufacturer shall supply wallbox.
- I. European-Style, Six Button Wallstation(s)
Control shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off' and of fine-tuning light levels with master raise and lower buttons. Control shall be no larger than 3.38" (86mm) square. Manufacturer shall provide wallbox.
- J. European-Style, Ten Button Wallstation(s)
Control shall be capable of recalling preset light levels for eight scenes, each providing green LED status feedback, plus 'off' and of fine-tuning light levels with master raise and lower buttons. Control shall be no larger than 3.38" (86mm) square. Manufacturer shall provide backbox.
- K. Five Button Scene Selection Control(s) with Slim Buttons
Control shall be capable of recalling preset light levels for four scenes plus 'off', each providing amber LED status feedback, and of fine-tuning light levels with master raise and lower buttons -or- of recalling preset light levels for five scenes plus 'off' with full 'on' button.

- L. Ten Button Scene Selection Control(s) with Slim Buttons
Control shall be capable of recalling preset light levels for nine scenes plus 'off', each providing amber LED status feedback, and of fine-tuning light levels with master raise and lower buttons -or- of recalling preset light levels for ten scenes plus 'off' with full 'on' button.
- M. 15 Button Scene Selection Control(s) with Slim Buttons
Control shall be capable of recalling preset light levels for 14 scenes plus 'off', each providing amber LED status feedback, and of fine-tuning light levels with master raise and lower buttons -or- of recalling preset light levels for 15 scenes plus 'off' with full 'on' button.
- N. Six Button Scene Selection Control(s) with Large Buttons
Control shall be capable of recalling preset light levels for three scenes plus 'off' and of fine-tuning light levels with master raise and lower buttons -or- of recalling preset light levels for five scenes plus 'off', each providing amber LED status feedback.
- O. Nine Button Scene Selection Control(s) with Large Buttons
Control shall be capable of recalling preset light levels for six scenes plus 'off' and of fine-tuning light levels with master raise and lower buttons -or- of recalling preset light levels for eight scenes plus 'off', each providing amber LED status feedback.

2.10 PRESET LOCAL LIGHTING CONTROL(S)—INTEGRAL DIMMERS

- A. Dimmer shall be capable of operating at rated capacity without adversely affecting design lifetime.
- B. Dimmer shall mount individually in standard 2, 3, or 4 gang U.S. wallboxes.
- C. Dimmer shall incorporate an airgap switch which shall be operable without removing the faceplate. The airgap switch shall be capable of meeting applicable requirements of UL 20 and UL 1472 for airgap switches in incandescent dimmers.
- D. Dimmer shall meet IEC 801-2, tested to withstand 15kV electrostatic discharge without damage or loss of memory.
- E. Dimmer shall meet ANSI/IEEE Std. C62.41-1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage or loss of memory.
- F. Dimmer shall meet the UL 20 limited short circuit test requirement for snap switches.
- G. Dimmer shall compensate for incoming line voltage variations such as changes in RMS voltage, frequency shifts, harmonics and line noise. Dimmer shall be capable of maintaining constant light level with no visible flicker under the following conditions:
 - 1. $\pm 2\%$ change in RMS voltage/cycle
 - 2. ± 2 Hz change in frequency/secondDimmers that do not regulate the dimmer output in real time shall be unacceptable.

- H. Dimmer shall utilize an LC filtering network to minimize interference with properly installed radio, audio, and video equipment.
- I. Separate power booster/interface shall increase dimmer capacity. Capacity shall range from 1000W/VA to 30,000W/VA. Quantities and sizes of each type of power booster/interface shall be provided to control each type of load shown on the load schedule and/or the drawings.
- J. Dimmer shall operate the following sources/load types with a smooth continuous Square Law dimming curve. Dimmers shall also be capable of operating these sources on a full conduction non-dim basis.
 - 1. Incandescent, Tungsten, Magnetic Low Voltage Transformer
 - 2. Lutron Tu-Wire Electronic Fluorescent Dimming Ballast
 - 3. Neon and Cold Cathode
- K. Dimmer shall operate the following sources/load types with a smooth continuous Square Law dimming curve through separate power interfaces.
 - 1. Electronic Low Voltage Transformer
 - 2. Fluorescent Electronic Dimming Ballast
- L. Minimum light levels shall be user adjustable in order to compensate for different sources and loading.
- M. Control shall provide 4 preset lighting scenes and 'off' for up to 6 control zones. Control shall be capable of storing an additional 12 preset lighting scenes which can be accessed via wall stations and/or control interfaces. Preset shall be set via easy-to use raise/lower switches, one raise and lower switch per zone. The intensity for each zone shall be indicated via an illuminated barograph, one barograph per zone. More than one zone may be proportionately raised or lowered at the same time. Programming of preset scenes shall be accomplished without the use of an 'enter' or 'store' button. Additionally, one or more zones may be temporarily overridden without altering the scene values which are stored in memory.
- N. Lighting levels shall fade smoothly between scenes at time intervals of 0 to 59 seconds or 1 to 60 minutes. The fade time shall be separately selectable for each scene and shall be indicated by a digital display for the current scene. Pressing a scene select button will illuminate the corresponding scene LED and simultaneously begin changing the barograph levels to reflect the currently selected scene. In the event that a preset scene with a fade time greater than 5 seconds is initially selected from an 'off' condition, the programmed fade time shall be temporarily overridden, unless otherwise noted, and the lights shall fade up to that scene over a five-second time span.
- O. Control shall be capable of being set locally, through a handheld programmer, and/or through a PC.
- P. Controls shall incorporate built-in wide angle infrared receiver, providing control via a separate wireless remote control transmitter from up to 15 meters away.

- Q. Control shall provide tamperproof protection of scenes using a minimum of four levels of electronic 'lockout' which prevent alterations of scene values stored in memory. Highest level of 'lockout' shall be capable of disabling manual control at the preset control.

2.11 PRESET CONTROL UNIT(S)

- A. Control shall mount individually in standard 2, 3, or 4 gang U.S. wallboxes.
- B. Control shall provide 4 preset lighting scenes and 'off' for up to 24 control zones. Control shall be capable of storing an additional 12 preset lighting scenes which can be accessed via wall stations and/or control interfaces. Preset shall be set via easy-to-use raise/lower switches, one raise and lower switch per zone. The intensity for each zone shall be indicated via an illuminated barograph, one barograph per zone. More than one zone may be proportionately raised or lowered at the same time. Programming of preset scenes shall be accomplished without the use of an 'enter' or 'store' button. Additionally, one or more zones may be temporarily overridden without altering the scene values which are stored in memory.
- C. Lighting levels shall fade smoothly between scenes at time intervals of 0 to 59 seconds or 1 to 60 minutes. The fade time shall be separately selectable for each scene and shall be indicated by a digital display for the current scene. Pressing a scene select button will illuminate the corresponding scene LED and simultaneously begin changing the barograph levels to reflect the currently selected scene. In the event that a preset scene with a fade time greater than 5 seconds is initially selected from an 'off' condition, the programmed fade time shall be temporarily overridden, unless otherwise noted, and the lights shall fade up to that scene over a five-second time span.
- D. Control shall be capable of being set locally, through a handheld programmer, and/or through a PC.
- E. Controls shall incorporate built-in wide angle infrared receiver, providing control via a separate wireless remote control transmitter from up to 15 meters away.
- F. Control shall provide tamperproof protection of scenes using a minimum of four levels of electronic 'lockout' which prevent alterations of scene values stored in memory. Highest level of 'lockout' shall be capable of disabling manual control at the preset control unit.

2.12 SLIDER CONTROL(S)

- A. Control shall mount individually in standard 1, 2, 3, 4, 5, 6, or 7 gang U.S. wallboxes.
- B. Slider control shall provide 'on' and 'off' for up to 12 control zones. Where indicated, control shall be capable of storing preset lighting scenes. The intensity for each zone shall be indicated by the position of the slider. More than one zone may be proportionately raised or lowered at the same time. Programming of preset scenes shall be accomplished without the use of an 'enter' or 'store' button. Additionally, one or more zones may be temporarily overridden without altering the scene values which are stored in memory. Control shall provide option for Master slider and shall retain "dimming profile".

- C. Lighting levels shall fade smoothly between scenes at time intervals of 0 to 59 seconds or 1 to 60 minutes. The fade time shall be separately selectable for each scene and shall be indicated by a digital display for the current scene. Pressing a scene select button will illuminate the corresponding scene LED and simultaneously begin changing the barograph levels to reflect the currently selected scene. In the event that a preset scene with a fade time greater than 5 seconds is initially selected from an 'off' condition, the programmed fade time shall be temporarily overridden, unless otherwise noted, and the lights shall fade up to that scene over a five-second time span.

2.13 INFRARED CONTROL(S)

- A. **Four Scene Wireless Remote Control(s)**
Wireless remote control shall be capable of recalling preset light levels for four scenes plus 'off' and of fine-tuning light levels with master raise/lower. Wireless remote control shall be used in conjunction with a compatible infrared receiver and scenes recalled shall be dependent on that receiver. Wireless remote control shall operate up to 15 meters within line-of-sight to that receiver. Wireless remote control shall operate at a frequency of 40 kHz and shall be 'learnable' by other variable frequency remote controls.
- B. **Eight Scene Wireless Remote Control(s)**
Wireless remote control shall be capable of recalling preset light levels for eight scenes plus 'off' and of fine-tuning light levels with master raise/lower. Wireless remote control shall be used in conjunction with a compatible infrared receiver and scenes recalled shall be dependent on that receiver. Wireless remote control shall operate up to 15 meters within line-of-sight to that receiver. Wireless remote control shall operate at a frequency of 40 kHz and shall be 'learnable' by other variable frequency remote controls.
- C. **Ceiling-Mounted Infrared Receiver(s)**
Control shall provide means for Four Scene Wireless Remote Control(s) and Eight Scene Wireless Remote Control(s) to recall preset light levels for up to four or eight scenes (dependent on remote control) plus 'off' and of fine-tuning light levels. Control shall be ceiling-mounted and shall provide 360° reception range for wireless remote controls within 15 meters of the control. Manufacturer shall supply mounting collar which shall be no larger than 2.19" (56mm) square.
- D. **Five Button Wallstation(s) with Infrared Receiver**
Control shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off'. Control shall provide means for Four Scene Wireless Remote Control(s) and Eight Scene Wireless Remote Control(s) to recall preset light levels for up to four or eight scenes (dependent on remote control) plus 'off' and of fine-tuning light levels.
- E. **European-Style, Six Button Wallstation(s) with Infrared Receiver**
Control shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off' and of fine-tuning light levels with master raise and lower buttons. Control shall provide means for Four Scene Wireless Remote Control(s) and Eight Scene Wireless Remote Control(s) to recall preset light levels for up to four or eight scenes (dependent on remote control) plus 'off' and of fine-tuning light levels. Control shall be no larger than 3.38" (86mm) square. Manufacturer shall supply wallbox.

- F. European-Style, Ten Button Wallstation(s) with Infrared Receiver
Control shall be capable of recalling preset light levels for eight scenes each providing green LED status feedback, plus 'off' and of fine-tuning light levels with master raise/lower. Control shall provide means for Four Scene Wireless Remote Control(s) and Eight Scene Wireless Remote Control(s) to recall preset light levels for up to four or eight scenes (dependent on remote control) plus 'off' and of fine-tuning light levels. Control shall be no larger than 3.38" (86mm) square. Manufacturer shall supply wallbox.

2.14 CONTROL INTERFACE (S)

- A. Contact Closure Interface(s)
Control shall provide two way interface between controls and dry contact closure devices such as from Timeclock Inputs, Building Management Systems, Fire Alarm Systems, Security Systems, and Occupancy Sensors. Control shall provide a minimum of five input and five output terminals. Input terminals must be able to accept maintained or momentary inputs with a minimum pulse time of 40msec. Inputs must have an on-state saturation voltage less than 2.0VDC and an off-state leakage current less than 10mA. Outputs must be capable of controlling other manufacturers' equipment. Customer provided output indicators must not exceed 200mA at 30VDC. Following functions shall be available and shall be set up in software: scene selection, panic mode, occupancy response, sequencing, zone and scene lockouts, and partitioning.
- B. RS232 Interface(s)
Control shall provide integration of four scene preset control to user-supplied PC or digital audiovisual equipment using RS232 serial communication. Control provides access to scene selections, scene lockout (prohibits manual light level changes), sequencing, zone lockout (prohibits permanent scene changes), and fine-tuning of light levels with individual zone raise/lower. Control shall provide status monitoring through button feedback and scene-status updates. Control must be mounted within 15 meters of the RS232 source.
- C. DXM512 Interface(s)
Control shall be capable of converting 32 zone intensities to 32 continuous DMX512 outputs. For DMX input, see section 2.02 L. 1.
- D. Daylighting Control(s)
Control shall automatically select preset light levels in response to ambient daylight. Control shall provide four thresholds for selection of light levels and shall provide four banks of preset light levels to select. Control shall be capable of photocell calibration, of averaging response for up to three photosensors, and of providing means for photosensor(s) input to override manual scene selects to ensure optimum light levels and energy savings.
- E. Room Assignor Control Panel(s)
Control shall be capable of accepting up to 32 contact closure inputs. Following functions shall be available and shall be set up in software: scene selection, panic mode, occupancy response, sequencing, zone and scene lockouts, and partitioning. Control shall provide a visual status.
- F. Handheld Programmer Jack(s)
Control shall provide access to local programming of the lighting control system from hand-held programmers.

2.15 SOURCE QUALITY CONTROL

- A. Equipment shall be 100% tested for proper operation at three different levels—printed circuit board, end of line, and for two hours at 40°C (104°F) ambient—prior to shipment from the factory. Manufacturers sampling at end-of-line shall not be acceptable.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Equipment shall be installed utilizing manufacturer's catalogue cut sheets and installation instructions and in accordance with these specifications.
- B. Contractor shall furnish all equipment, labor, system setup and other services necessary for the proper installation of the products/system as indicated on the drawings and specified herein. System setup shall include defining each dimmer's load type, assigning each load to a zone and setting the control functions.

3.02 MANUFACTURERS' FIELD SERVICES

- A. Upon completion of the installation, the system shall be completely commissioned by a factory-employed engineer. The check-out will be performed after all loads have been tested live for continuity and freedom from defects and that all control wiring has been connected and checked for proper continuity. The factory-employed engineer shall demonstrate and educate the owner's representative on the system capabilities, operation and maintenance.
- B. Manufacturer shall offer upgraded warranty based upon successful field commissioning.
- C. Manufacturer shall provide toll-free technical support hotline 24 hours per day, 7 days per week.
- D. Manufacturer shall be capable of providing on-site service support within 24 hours anywhere in the continental U.S.A., and within 72 hours anywhere in the world, except where special visas are required.
- E. Manufacturer shall offer a renewable service contract on a year to year basis which will include parts and factory labor as well as annual training visits.
- F. Service Contracts will be available for up to ten years from date of system commissioning.

END OF SECTION

Section 16670

Lightning Protection System

SECTION 16670**LIGHTNING PROTECTION SYSTEM****PART 1 - GENERAL****1.1 Related Documents**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

This section specifies the furnishing of all labor, materials, appurtenances and inspections required for a comprehensive lightning protection system for this facility. The required lightning protection system shall include all new structures.

1.3 Reference Standards

Comply with the latest edition of the following reference standards.

1. NFPA No. 78 - Lightning Protection Code.
2. UL 96A - Master Labeled Lightning Protection System, Installation Requirements.

1.4 Submittals

1. Shop Drawings: Detailed plan drawings shall be prepared to 1:100 scale which indicate all work to be performed. Details of all component mounting and connections shall be included on separate detail drawings. Manufacturer's catalog numbers and generic identification shall be indicated for all components shown on the drawings. Drawings shall be on A0 Size plans and 3mm-high lettering.
2. Product Data: Submit complete descriptive information on all materials and installation methods.
3. Approvals: Secure formal approval of shop drawings and product data prior to ordering material. Secure approvals in sufficient time to allow installation of concealed system components without delaying the project.

1.5 Subcontractor

The subcontractor for the work covered by this specification shall be one that is recognized as being regularly engaged in the installation of lightning protection systems. The subcontractor must be listed by Underwriters' Laboratories, Inc., and must employ competent personnel fully qualified in the field of lightning protection.

PART 2 - PRODUCTS

2.1 General

The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems. Listing of the manufacturer in the lightning protection section of the current edition of Underwriters' Laboratories, Inc., Electrical Construction Materials List will be accepted as compliance with this requirement. Materials used in connection with the installation of the lightning protection system shall be approved for lightning protection systems by the Underwriters' Laboratories, Inc.. No combination of materials shall be used that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture. Where unusual conditions exist which would cause deterioration or corrosion of conductors, conductors with suitable protective coatings or oversize conductors shall be used. If a mechanical hazard is involved, the conductor size shall be increased to compensate therefore, or suitable protection shall be provided. The conductors may be protected by covering them with molding or tubing and preferably made of nonmagnetic material.

2.2 Conductors

All conductors shall be copper and of the grade ordinarily required for commercial electrical work generally designated as being 98 percent conductive when annealed. Conductor minimum sizes are listed in Tables 3-4 and 3-5 of NFPA 78 (25x3mm copper). Main conductor and secondary conductor cable sizes shall be the same.

2.3 Air Terminals

Air terminals shall be nickel-plated solid copper with tapered bullet point tips (in lieu of sharp point tips). Minimum air terminal size shall be 18mm diameter by 750mm long. Where air terminals longer than 750mm are required, solid copper rods of the appropriate length with threaded ends may be securely attached to the air terminals for extensions. Provide a three-leg tripod brace for each air terminal at an open roof location. Secure the triangular brace to the roof in a manner approved by the structural Engineer. All other air terminals shall have a bipod brace. Conductor connections to air terminals shall be bolted.

2.4 Ground Rods

Ground rods shall be copper-clad steel, 200mm diameter by 3m in length or longer.

2.5 Connectors

All below-ground and concealed connections shall be made with exothermic welded connections. Visible connections shall be made with cast bronze bolted pressure connectors which utilize stainless steel or silicon bronze bolts. Connectors shall include 101.6mm (4-inch) parallel clamps for conductors, bonding plate and heavy duty cross-run clamps.

2.6 Roof Penetration

Roof penetrations shall be accomplished with through-roof fittings specially designed for this purpose. Through-roof fittings shall utilize solid rods with appropriate hardware. Fittings shall incorporate a positive means for sealing around the rod.

PART 3 - EXECUTION

3.1 General

Install a complete lightning protection system consisting of air terminals, conductors, connectors, attachments, grounding and necessary appurtenances to comply with minimum requirements listed in the referenced standards and to meet the local jurisdiction codes requirements. The system shall be installed in a neat workmanlike manner and without interfering with other building systems.

3.2 Conductors

Downlead conductors are required. All downlead conductors must be installed in PVC conduit which is embedded in the concrete columns. Secure conductors to the roof or other structure at a maximum interval of 1 meter on center.

3.3 Air Terminals

Air terminal installations shall be designed and braced for 160 km winds with 200km gusts.

3.4 Antennae

All antennas and satellites shall be grounded.

3.5 Ground Rods

A counterpoise ground system shall be installed. The extent of the counterpoise ground system is indicated in the project drawings. Lightning protection system downleads shall be connected to the counterpoise loop. New ground rods shall comply with the requirements listed in specification Section A Ground System.

3.6 Connections

At the completion of the project, all bolted pressure connectors shall be checked for proper bolt torque.

3.7 Roof Attachments and Penetrations

Air terminals, conductors and appurtenances for the lightning protection system require attachment to building roof. Downleads may require penetration of roof surfaces. All attachments to or penetrations through roofs must be in strict accordance with the roof manufacturer's recommendations. The lightning protection contractor shall submit details of all roof attachments and penetrations to the structural Engineering for approval prior to installation. Once the lightning protection system installation is complete, the lightning protection contractor shall engage the appropriate roof manufacturer to inspect all roof attachments and penetrations on that manufacturer's roof. Subsequent to the inspection, the roof manufacturer shall furnish the Engineer with a letter indicating that all lightning protection system component roof attachments and penetrations are satisfactory and that such attachments and penetrations will not in any way reduce the manufacturer's warranty on the roof. Any fees for services or inspections provided by the roof manufacturer to accomplish the above related requirements shall be at the expense of the lightning protection contractor.

3.8 Cover-up Inspection

Prior to cover-up of concealed components and connections, notify the site Engineer, so that a cover-up inspection can be performed. Correct any deficiencies prior to concealment of components and connections.

3.9 Conflicts

In the event a conflict exists between this specification and any of the referenced standards, the requirements of this specification shall be regarded as secondary and the necessary corrections shall be made.

END OF SECTION