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REPUBLIC OF LEBANON
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION
BEIRUT - LEBANON

CHHIM GOVERNMENTAL OFFICES BUILDING
(PHASE 2)

ELECTRICAL SPECIFICATIONS
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CHHIM GOVERNMENTAL OFFICES BUILDING**CHHIM – LEBANON****ELECTRICAL WORKS**
SPECIFICATIONS
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SECTION 13100- LIGHTNING PROTECTION**PART 1- GENERAL:****1.01 SUMMARY**

- A. This Section includes furnishing and installing a complete lightning protection system, consisting of Faraday Cage or modifications to an existing lightning protection system, in accordance with the NFPA standards and NFPA 780 codes. BS 6651, 1999 shall also be approved. An integral system is required, consisting of air terminals mounted directly on the structure to be protected.
- B. This section including also furnishing and installing a complete internal lightning protection system including lightning & over voltage arrestors. Class B Lightning arrestors shall be installed at the main distribution panels (DS, DP, PP) Class C over voltage arrestors shall be installed at the secondary distribution panel. (LP, MSP, PCP) Class D over voltage arrestors shall be installed as close as possible from the equipment to be protected (when necessary) as applicable.
- C. The lightning protection work shall be coordinated with water proofing of this project as applicable in order not to damage the waterproofing system component and with concrete contractor.
- The Contractor shall very carefully study all waterproofing problems and accessibility of earth rods.
- D. The lightning protection work shall be coordinated with electrical earthing requirements and supplemental surge protection of electrical service(s), telephone service, antenna cables, etc.
- E. Related Sections - Refer to the following sections for related work:
1. Section 02200, "Earthwork" for excavation and backfilling for counterpoise and buried conductors.
 2. Section 16010,16051 "Basic Electrical materials and Methods and General Information Requirements".
- F. Lightning protection design approaches such as "dissipation array" and "early streamer" systems are not acceptable.

1.02 REFERENCES

Comply with the following applicable standards and codes:

1. National Fire Protection Association (NFPA)
 - a. NFPA 70 - National Electrical Code (NEC)
 - b. NFPA 780 - Lightning Protection Code

2. Underwriters Laboratories Inc. (UL)

a. UL 467 - Standard for Electrical Grounding and Bonding Equipment

- A. Where differences arise between the specified standards and codes, the installation shall comply with the more rigorous and demanding requirements, whether or not shown on the drawings. Similarly, comply with the more stringent requirements of this specification and drawings.

1.03 SYSTEM DESCRIPTION

- A. The extent of lightning protection work is indicated and detailed on drawings (if furnished), and by requirements of this specification. The types of lightning protection system components specified include the following:

1. Conductors
2. Air terminals
3. Connectors
4. Splicers
5. Ground rods (Stainless Steel Only).
6. Bonding plates

- B. New Construction: Protect entire building (or structure) including roof projections, chimneys, exhaust stacks, vents, antennas, roof-mounted equipment, ladders, cranes, cooling towers and equipment or structures adjacent to the building.

1.04 SUBMITTALS

- A. Product data: Submit product data for each component. Include data for roof adhesive when used. Where applicable, also include recommended method(s) of installing air terminals, conductors, etc., to single-ply membrane roofs.

- B. Shop Drawings: Submit scaled drawings of the lightning protection system and components for approval. Show conductor routing and accessories layouts including accessible ground wells and ground rods, counterpoise, air terminals, splicers, fasteners and connectors.

- C. The Contractor shall submit and complete risk analysis and calculation sheet.

Verifying and conforming the proposed lightning system layout along with spacing/dimensions of air terminals and number of down conductors.

The number of down conductors shall take into account the accessibility of the conductors at ground floor level due to constraints imposed by neighbouring lots.

The use of risk analysis method of BS 6651 is authorized.

- D. Certification: Upon completing installation, system shall be inspected by certified Lebanese Bureau de Controle.

1.5 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of lightning protection equipment, of types and sizes required, whose products have been in use for not less than 3 years. All components of the lightning protection systems shall be new and suitable for the application in accordance with the specified standards and shall be UL listed and labeled.
- B. Installer's Qualifications: A firm with at least 3 years of successful installation experience on projects with lightning protection work similar to that required for this project. The installer shall be a current UL Listed company.
- C. Underwriters' Laboratories, Inc. Certification
1. All structures with lightning protection systems require a UL "Inspection Letter Report".
- D. Field Measurements
1. Resistance-to-ground measurement shall be made using the "three point" or "fall of potential" method.
 2. Measurements shall be taken for all new lightning protection systems at new or existing structures containing explosives or flammable materials to confirm that the resistance-to-ground is not greater than 10 ohms. For other installations the contract documents will indicate when these measurements are required.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Handle lightning protection components carefully to avoid damage. Do not install damaged components; replace and remove damaged units from project site. Store components in original wrappings and protect from dirt, weather and construction work traffic.

1.07 WARRANTY

- A. Lightning protection equipment shall be guaranteed against defective design, materials, and workmanship for the full warranty time, which is standard with the manufacturer or supplier, but in no case less than one year from the date of system acceptance

1.08 APPROVED MANUFACTURERS

Approved manufacturers for lightning protection and surge arrestors are:

- Dehn (Germany)
 - Furse (UK)
 - Thomson (USA)
 - Helita (France)
 - Franklin France (France)
- Or approved equal

PART 2 – PRODUCTS**2.01 MATERIALS**

- A. Only copper conductors, air terminals, etc., and suitable hardware shall be used.
- B. The following material types, sizes, etc., shall be utilized except as noted otherwise on the contract documents:
1. Conductors: Conductors shall be bare stranded copper in the following sizes:
 - a. Underground counterpoise (ground loop) -- #4/0 AWG minimum (107.20. mm²), Class B stranding.
 - b. Main conductors (roof level between air terminals and down leads):
 - (1) Class I Materials - 24 strands of 14 gauge (2.08 mm²) braided smooth twist; 98,500 circular mils (50 mm²); 320 lbs. per 1000 ft. (145.2 kg per 304.8 meters) or larger, or equivalent size solid copper strip.
 - (2) Class II Materials - 28 strands of 0.0689 inches (0.175 cm) diameter, copper wire, rope lay, 131,500 circular mils (66.6 mm²); 420 lbs. per 1000 ft. (190.5 kg per 304.8 meters) or larger or equivalent size solid copper strip.
 - c. Bonding conductors (including solid and flexible strips of equivalent circular mil size) for large roof mounted equipment (HVAC units, etc.) and miscellaneous metallic items: Use same conductors as specified in item “b” above.
 - (1) Bonding conductors for items such as roof drains, windows, etc., that are not generally subject to physical damage, may be of smaller size than stated above but not less than the equivalent UL.
 - (2) Lead coated conductors shall be used in atmospheres corrosive to copper.
- C. Air Terminals (Both Class I and Class II): Air terminals shall be solid copper, minimum 1/2-inch (12.7 mm) diameter, nickel plated tip, and a minimum of 24-inches (60 cm) long. For corrosive locations (e.g. smoke stacks) use stainless steel air terminals. Air terminals for single-ply roof mounting shall have bases especially designed for this application (see Section 3.02.A.2).
- D. Stainless Steel Ground Rods as per UL467 9.2.1, 9.2.2 and 9.2.6: Ground rod material shall be solid copper with a stainless steel jacket not less than 0.015 inches thick at any point. The stainless steel jacket shall be formed of an austenitic stainless steel of the 18% chromium 8% nickel type. Ground rods shall be not less than 3/4" (19.05 mm) in diameter and not less than 12 ft. (3.6 m) long. The exact length of the rod shall be determined after ensuring that the minimum length of rod being buried inside natural soil is not less than 120 cm.

E. Connectors and Fittings:

1. Use only heavy-duty bronze connectors, splicers, bonding plates, etc., with maximum available contact surface between this hardware and each conductor or equipment. If heavy-duty connectors and fittings are not available from supplier submit alternates for SNL approval before installation.
2. Each conductor shall be held in place with at least two hex head bolts.
3. Bonding plates shall have a minimum of 8 sq. inch (412.90 cm²) of contact surface.
4. For pipes, railings, fence post, etc. up to approximately 4 1/2" (11.43 cm) in diameter use heavy-duty bronze pipe clamps, where available, in lieu of bonding straps.
5. All main size connections shall contact cable for a length of 1.5" (3.81 cm) minimum.
6. Split-bolt type connectors shall not be used.
7. Connections below grade and all inaccessible splices shall use the exothermic welding process. Where shown on the drawings, exothermic welds shall be used above grade, particular for connections to building steel and similar items.

F. Transient Overvoltage Protection for Main Power Distribution System

Transient overvoltage protectors should be installed on all power cables entering or leaving the building, in order to protect equipment connected to the power distribution system against transient overvoltages coming into the building from outside.

Protectors should also be installed at all power distribution boards in order to protect these against transients generated downstream of the previously mentioned protectors on incoming and outgoing power cables.

Protectors shall be tested in accordance with the requirements of BS 6651:1992, BS 2914:1972 and IEEE C62.41-1991.

The protectors must not interfere with or restrict the system's normal operation. They should not corrupt the normal main power supply, break or shutdown the power supply during operation, or have an excessive earth leakage current.

The protectors shall be rated for a peak discharge current of not less than 10KA (8/20microsecond waveform).

G. Protectors for All Low Current Systems:

The protector should have continuous indication of its protection status (full protection present, reduced protection or no protection).

Remote indication of status should also be possible via a volt free contact.

The status indication should warn of protection failure between all combinations of conductors, including neutral to earth.

The protector shall be supplied with detailed installation instructions. The installer must comply with the installation practice detailed by the protector manufacturer.

Transient overvoltage protectors shall be provided on all data communication/signal/telephone lines entering or leaving the building, in order to protect equipment connected to the line, against transient overvoltages.

Protectors shall be tested in accordance with the requirements of BS 6651 and CCITT IX K17.

Protectors shall be rated for location Category C-High Exposure Level (as defined by BS 6651).

The protector must not impair the system's normal operation. It should not suppress the system's normal signal voltage, restrict the system bandwidth or signal frequency, introduce excessive in-line resistance or cause signal reflections or impedance mismatches.

The protector shall have a low transient let-through voltage for tests conducted in accordance with BS 6651 Category C – High (5KV 10/700microsecond test).

The let-through performance shall be provided for all combinations of conductors (signal line to signal line and signal line to screen/earth).

The protector shall be supplied with detailed installation instructions. The installer must comply with the installation practice detailed by the protector manufacturer.

The protector manufacturer should allow for the facility to mount and earth large numbers of protectors through an accessory combined mounting and earthing kit.

I. Class I (B) Arrestor:

Lightning current arresters for main distribution switchboard or main distribution panel or main power panel (as applicable as PP or DP may in some cases be secondary panels depending on hierarchy of connection) should be of Class I (B) non-exhausting (encapsulated) with the following specifications:

Class I (B) surge arrester

$U_p < 2.5 \text{KV}$

$U_c = 255 \text{V}$

$I_{imp} = 50 \text{KA}(10/350) / \text{pole}$

$I_f = 50 \text{Karms}$

$\text{TOV Voltage} = 335 \text{V for } 5 \text{s}$

Encapsulated
Includes remote signaling possibility
Includes operating voltage indication lamp
Response time <100ns
Energy coordinated with Class II arresters without the use of inductance
Serial & parallel connection possibility
Includes possibility of arrester readiness remote signaling
Part Number DEHN DBM255 L 900026

Only class I (B) lightning current arresters with spark gap technology shall be accepted. Varistor based class I (B) SPD shall not be approved.

Class B Lightning current arresters shall be installed inside each main distribution panel(s) (MDB). TT installation configuration with N/PE arrester shall be used.

J. Class II (C) Over voltage arresters

Class II (C) arresters: To be installed at the power secondary distribution panel (PP, LP, PCP or MSP as applicable to the arrangement of power distribution) with the following specifications:

3 Stage protection: Green for Ready, Yellow for Module Exchange recommended, RED for Module damaged, replace immediately

$I_{max} = 65KA(8/20)$ / pole

$I_n = 20KA (8/20)$

$U_c = 275V (AC), 350V (DC)$

Voltage protection level at I_n $U_p < 1.25KV$

TOV Voltage = 335V for 5s

Response time <25ns

Max. mains-side overcurrent protection: 160A Gg/GI

Short Circuit withstand capability at max. mains-side overcurrent protection = 20KA_{rms}

Includes possibility of arrester readiness remote signaling

Ready for installation in TT (TNS) installation without additional wiring

Part Number DEHN Dehnguard TT H230 LI 950150

Class II (C) overvoltage arresters shall be using MOV technology with thermodynamic disconnection in case of fault.

Class I (B) and Class II (C) arresters shall be installed according to manufacturer recommendation in order to provide energy coordination. Cable connections to arresters shall not allow 180° bends. When Combined arresters are used, devices should comply to the following specifications:

- Encapsulated, non-exhausting creepage discharge spark gap, with patented RADAX-Flow-Technology for the limitation and extinction of follow currents.

- Energy-coordinated with surge arresters, Class C and D with out additional Decoupling coils as well as directly with terminal units in Overvoltage Category I at $U_N = 230 \text{ V ac}$.
- Low voltage protection level
- Double terminals for all conductor connections as well as output multifunctional terminal for conductors and bus bars
- Optional remote signalization
- Integrated indication of voltage presence
- Ready for TT or TNS installations

With the following technical specifications:

- Continuous Operating voltage	255V/50-60Hz
- Follow current extinguishing capability	50KA rms
- Lightning Impulse Current (10/350)	25/100KA
- Voltage protection level at limp	<1.5KV
- Response Time	<100ns
- back Up fuse	125A serial connection 315A parallel connection
- Short Circuit withstand capability at max. backup fuse	50KA rms
- Enclosure material	Thermoplastic UL94-V0
- Approved by	KEMA, VDE

K. Class III (D) arrester:

Class III (D) arresters shall be installed the equipment to be protected with the following specifications:

(On branch breakers feeding all main power supply of central low current system panels).

- Continuous operating voltage	255V AC / 50Hz
- Tested to	DIN VDE 0110 part 1
- Nominal discharge current	2.5KA (L(N)/PG), 5KA (L,N/PG)
- Voltage protection level Up	< 1.5KV
- Response time	<100ns(L(N)/PG), <25ns(L/N)
- Approved by	UL or KEMA

Class III arresters shall have a visual functional indication (Green) and fault visual indication (Red) with possibility of remote signaling

L. SMATV Arrester:

SPD shall be installed at the input of each coaxial cable such as of CATV and satellite reception systems with the following specifications:

- Include measuring output for dB loss Testing
- Combined lightning current and surge arrester for high discharge capacity & low voltage protection level
- $I_{imp} = 0.2\text{KA}$ (10/350)
- $I_n = 1.5\text{KA}$ (8/20)
- $U_c = 24\text{V}$
- $I_n = 2\text{A}$
- Frequency range: DC, 5-3000Mhz
- Insertion Loss 5-862Mhz = 1.2dB
- Insertion loss 862-2400Mhz = 1.4dB
- Insertion loss 2400-3000Mhz = 2dB
- Return Loss (5..47Mhz) $\geq 14\text{dB}$
- Return Loss (47..3000Mhz) $\geq 18\text{dB}$
- Response time $< 1\text{ns}$
- Connection (input/output): F connector
- Degree of Protection : IP30

Antennas masts shall be bonded to external lightning protection system through isolating spark gaps.

M. Data Network Protection

Data network (Token ring, ethernet, 10 base T, 100 Base TX, Coaxial ethernet, RS485, RS232, RS422, IBM Twinax, and ISDN primary multiplex terminals), CCTV coaxial cables (external Cameras), telephone lines, low voltage control lines, & PLCs shall be protected by suitable protectors as per the manufacturer recommendation.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine surfaces and conditions affecting performance of the lightning protection system. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Ordinary Structures:

1. Install lightning protection systems, including modifications to existing systems, as indicated on the drawings and according to manufacturer's written instructions, UL 96A, and NFPA 780 and other referenced codes and standards.

3.03 EXAMINATION

Verify that surfaces are ready to receive work.

Verify dimensions and measurements shown on shop drawings with field conditions.

Verify that all systems that may influence the lightning protection system design are included or referenced on the shop drawings.

Verify adequate guards against implement are in place or will be implemented as required by job progress.

Verify required procedures to prevent voiding of roofing warranty.

3.04 PREPARATION

Project elements under other sections from damage or disfiguration during work under this section.

Coordinate all below grade lightning protection system installation with the general contactor.

1. Install air terminals as high as possible and such that the zone of protection is at least 10 inches (25 cm) higher than the structure, equipment, etc., that they are protecting. For air terminals on single-ply roofing use adhesive recommended by manufacturer of air terminals and approved by manufacturer of roofing material. Comply with adhesive manufacturer's installation instructions.
2. A ground loop (counterpoise) of 70 mm² bare copper conductor minimum and ground rods shall be installed below ground finish level around the structure periphery due to constraints of building lot boundary. Install marking tape 1 ft. (0.30 m) below grade above ground loop. Ground rods shall be installed at all corners of the building or structure and around the building or structure with maximum spacing of 35 ft. (10.67m) between ground rods. The separation between any two ground rods shall be at least the length of the longer rod. To reduce resistance-to-ground, unless shown otherwise on drawings, connect reinforcing steel of the concrete slab in contact with soil (or vertical wall when a basement is provided) to the ground loop at each corner of the structure and at intervals of approximately 35 feet (10.67 m) around the structure with a main size conductor. Use exothermic weld connections for connecting reinforcing steel together and to the ground loop.
3. For concrete structures, bond reinforcing steel to down conductors and roof conductors as required by NFPA 780 and UL. 96A.
4. Bond all metallic underground services entering the structure, and other underground and above ground metallic objects within 25 ft. (7.62 m) of the structure, together with the ground loop using the same size of conductor as the ground loop.

If exceptionally the reinforcing steel bars of buildings columns are used as down conductors, an earth pit shall be provided for each column.

Roof and down conductors shall be supported with fasteners spaced at no more than 900 mm centers horizontally and vertically sharp bends in down conductors should be as minimum as possible and should be executed in a way to avoid lightning discharge from jumping across.

In order to avoid side flashing all metallic bodies on or around the roof structure and all structures must be bonded to the lightning system with appropriate cable lugs and protectors. No part of the roof within the air termination network should be more than 5 m from a conductor.

A network mesh shall be provided as required by code/Regulations on roof floor: Different roof termination networks should be provided for different roof heights. The lower roof network shall be joined to the down conductors of the taller portions of the structure.

5. Except specifically noted on the contract documents do not utilize structural steel framework as a main conductor. Make the steel framework of buildings or structures electrically continuous by bolting, riveting, or welding the steel frame, unless a specific method is noted on the drawing. Where a water system enters the building, connect the structural steel framework and the water system at the point of entrance by a ground connector. Secure connections to pipes by means of ground clamps with lugs. Secure connections to structural framework by exothermic welding. Secure all connections between bottom of columns and ground connections to ground loop from not less than one-half of all the columns distributed equally around the perimeter of the structure. When no water system enters the structure, extend ground connections from all steel columns.
6. Joints in conductors shall be as few as possible wherever joints are unavoidable, the joints shall be mechanically strong and provides adequate electrical conductivity by on area not less than double the cross section area of the conductor.
7. For externally routed down conductors protect each conductor from possible damage with an 8 ft. (2.44 m) long wooden or PVC pipe protector above grade level. Where conductors are run through metal pipe, or otherwise protected by metal strips, the conductor shall be bonded to each end of the metal pipe, etc.

Down conductors shall be installed behind external marble cladding behind external marble cladding. Contactor shall ensure provision of an access panel 200cm above ground level in order to make necessary measurement at the test / junction clamp, square type wall mounted. To avoid dislodging of the metal cladding during a shock wave discharge contactor shall ensure that there is sufficient movement of free air between the outside frame of the structure and the decorative cladding.

8. Bond ladders at top and bottom and bond handrails at each end but not more than 50 feet (15.24 m) apart. Protect handrails, ladders, HVAC equipment, etc., with air terminals and main conductors when metal thickness is less than 3/16 inch (4.76 mm). Attach lightning protection components to HVAC equipment and roof and wall metallic items with sheet metal screws. Apply sealant to prevent ingress of moisture around screws. Placement of air terminals on roof equipment is identical to that of roof (e.g. air terminals must be within 2 ft, 0.61 m, of corner of equipment). Connect guy wire supports for exhaust stacks and poles to the lightning protection system at their lower ends.

9. All reinforcing steel in roofs, walls, floors, and slabs of building or structure shall be tied tightly together with metal ties such that they are in electrical contact at least every 3 feet (0.91 m) in each direction. Also each level of reinforcing steel at roofs, floors, and slabs shall be similarly tied to the reinforcing steel of exterior walls at least every 3 feet (0.91 m) along the length of the wall.
10. Concealment: Do not conceal any portion of the lightning protection system, including counterpoise and reinforcing steel bonding, until approved by the Local Lebanese UL Inspector.
11. Concrete inspection pit cover shall be provided above each 20cm sleeve embedded in cap beam. Size of cover shall be adequate to ensure access to ground rod and earth bar installed inside sleeve.
12. Every down conductor to have test clamp above ground for testing earth termination network.
13. Maximum permissible value of the resistance to the earth termination network shall not exceed 10 ohms.

3.05 **FASTENERS**

Fasteners shall spaced not more than 900 mm apart on all conductors. Nails, screws, or bolts employed to secure the fasteners shall be of the same material as the fasteners. Galvanized or plated steel nails, or bolts are not acceptable.

Masonry anchors shall have a diameter of not less than 0.6cm and shall be set with care. Holes to receive the shank of the fastener or fitting shall be of correct size, made with proper tools and preferably made in the stones rather than in the mortar joints, when set the fit shall be tight against moisture and capable of withstanding a pull test of 40kg.

3.06 **SPLICERS**

Bronze pressure type cable splicers shall be provided where necessary at intersection of main and branch conductors. Splicers shall be furnished complete with required bolts and washers. Cables shall be clamped so as to get maximum strength.

3.07 **COORDINATION**

The lightning protection contractor will work with other trade contractors to ensure a correct, neat and inconspicuous installation. It shall be the responsibility of the lightning protection contractor to assure a proper bond to the appropriate grounded utilities, such as the electric service ground, telephone ground, incoming water and gas pipe.

Note: The roofing contractor will be responsible for sealing and flashing all lightning protection roof penetrations as per the roof manufacturer's recommendations. The lightning protection roof penetrations and or method of conductor attachment should be addressed in the roofing section of the specifications.

3.08 INSPECTION AND CERTIFICATION

The installing contractor and a representative of the owner shall complete the Underwriter's Laboratories Inc. application for inspection. The owner's representative will witness and sign for the concealed grounding portion of the system. The installer and owner's representative will sign the form to signify the information being submitted is correct and their authorization of a completed project inspection by a U.L representative.

Any items of product, design or installation noted by the Underwriter's Laboratories Inc. field inspector as not being in compliance with current code requirements shall be corrected by the installer at no additional charge to the owner. The project shall not be considered complete until final approval is received from UL.

Inspection:

Inspect down conductors prior to being covered by interior, exterior, or other installations.

Inspect lightning protection system grounds and connections prior to burial.

Manufacturer's Field Services:

Apply for and obtain the UL Mater Label; at the time of application for UL Master Label send a copy of the application to the Owner's representative.

Attach the UL Master Label to the structure at the location specified by the Owner.

Field Quality Control

Manufacturer shall arrange and pay for field services as follows:

1. Obtain the services of Underwriters Laboratories (UL), Inc. to provide the inspection and certification of the lightning protection system under the provisions of UL 96A.
2. Certify that surge protection is installed on the electrical service.
3. Certify that surge suppression is installed on the antenna, telephone, radio and television lead wires.

Re-inspection

The owner shall develop a program of inspection and maintenance in association with the installer and / or the material manufacturer to insure the future integrity of the lightning protection system. As a minimum on the fifth anniversary of the original installation and a successive three year intervals, the system shall be re-inspected against defect by the original installation company or trained maintenance personnel of the owner. The inspection shall include a visual check of all exposed components of the lightning protection system analog with continuity and ground testing as accessible to verify the concealed equipment. Any alteration to the exterior structure, such as building addition, new process lines, venting equipment or reproofing many necessitate additional items for incorporation into the lightning protective system. The system shall be maintained current to the requirements of the NFPA 780 Standard.

END OF SECTION

SECTION 13745
INTEGRATED SECURITY SYSTEM

PART 1 -GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 13700 sections 13700, 13715 and 13725, apply to this Section.

1.2 CODES AND STANDARDS:

- A. Work shall be performed in accordance with the applicable international, federal, state, and local codes or standards current at the commencement of installation. The following list summarizes applicable standards:
1. UL 294, UL 1076, ULC.
 2. CE.
 3. FCC – Part 15, Part 68.
 4. NFPA70, NEC.
 5. IEEE, RS170 variable standard.
 6. PAL (color camera broadcast, Europe).
- B. Where more than one code or regulation is applicable, the more stringent shall apply.
- C. Cable installation, identification and termination shall be performed in accordance with the Manufacturer's technical installation guidance, in addition to the applicable codes above.
- D. In the absence of the Manufacturer's recommendations on conductor application, the Contractor shall ensure that the cable selected meets all technical requirements of the equipment to be installed.

1.3 SUMMARY:

- A. This section includes an Access Control, Door Monitoring and CCTV systems that consists an integrated security system which is designed to :
1. Display on the CCTV console and record on NVRs all the cameras indicated on the drawings.
 2. Display on the security management server and workstations all the access control activities as well as all the cameras.
- B. Photo ID Badging.

FUNCTIONAL SPECIFICATIONS:

- A. The Integrated Security Management System (ISMS) shall be a modular, networked access control system capable of handling large proprietary corporations with multiple remote sites, alarm monitoring, video imaging, badging, paging, guard tour, digital video servers and CCTV switcher control. The system shall allow for easy expansion or modification of inputs, outputs, and remote control stations.
- B. The system control at the central computer location shall be under a single software program control, shall provide full integration of all components, and shall be alterable at any time, depending upon the facility requirements. Reconfiguration shall be accomplished online through system programming, without hardware changes.
- C. The software program shall be a true 32-bit, 3-tier client/server, ODBC compliant application based on Microsoft tools and standards. The software program shall operate in one of the following environments; Windows 2003 Server, Windows Vista Business, Windows XP Professional SP2, Windows 2000 Professional or Server using Service Pack 4.
- D. The software program shall consist of multiple servers including, but not limited to, Database Server, Communications Server, and Client Workstation Server. The Servers shall be capable of being installed on one or more PCs across a network providing a distribution of system activities and processes.
- E. The system shall support multiple communication servers on a LAN/WAN, to provide distributed networking capabilities, which significantly improve system performance.
- F. The database architecture shall be MSDE 2000 as standard with the capability to utilize Microsoft SQL Server 2005; SQL Server 2005 Express Edition or SQL Server 2000.
- G. The system shall have the capability to communicate with the control panels via LAN/WAN connections utilizing industry standard communication protocol.
- H. The system software shall allow support for multiple accounts allowing separate access to the card database, badge layout, operator access, and reporting. Physical hardware may be filtered by operator level into sites. Sites may reside in multiple accounts. The system shall allow control of common areas between accounts. Access levels and time zones shall be global to allow for easy administration. The global access levels and time zones shall be capable of being used by several accounts. Administrators shall have the ability to move cardholders from one account to another. When moving cardholders in such a manner, access level information shall not be transferred automatically in order to ensure proper security settings are made upon changing the status of the cardholder.
- I. The software program shall use Abstract Devices (ADV) for representing hardware devices in the system. The ADVs shall be used in Floor Plans to provide the user interface to control and monitor the system, and shall also be used in the Data Trees to organize, display, and control system information.

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- J. The system shall support both manual and automatic responses to alarms entering the system. Each alarm shall be capable of initiating a number of different actions, such as camera switching, video pop-up, activation of remote devices, door control, and activation of WAV files.
- K. The system shall provide both supervised and non-supervised alarm point monitoring. Upon recognition of an alarm, the system shall be capable of switching and displaying a view from either the CCTV camera or video from the digital video server camera that is associated with the alarm point. The system shall be capable of arming or disarming alarm points both manually and automatically, by time of day, and by day of week.
- L. Access control functions shall include validation based on time of day, day of week, holiday scheduling, site code and card number verification, automatic or manual retrieval of cardholder photographs, and access validation based on positive verification of card, card and PIN, card or pin, pin only and Site Code only.
- M. Camera functions such as pan/tilt, lens control, limits, and home position shall be supported by the system. Unless specific programming dictates otherwise, an operator shall be able to control these functions for all cameras so equipped.
- N. Live video from a CCTV system and/or digital video server shall be able to be displayed on the computer screen. The live video window shall allow the user to change its size and location on the computer screen. Video controls (pan, tilt, zoom, camera/monitor selection) shall be able to be sent to the CCTV system and/or digital video server from the live video window. The user shall have the ability to freeze and save a single frame of video from the CCTV system to a file.
- O. Alarm events with defined priorities shall be able to pop-up automatically in an Alarm event window for operator attention. The pop-up shall display the name of the event (reader, alarm point, cardholder or system alarm), time, date, site, account, if a card event the card number, type of event and cardholder name. An event counter shall also display the number of times the event was reported to the Alarm event monitor prior to Acknowledgement or Clearing the event. Event instructions shall be made available by double clicking on the event. The event shall also display an icon to indicate that video is available for events so programmed.
- P. The Alarm event window shall allow the operator to initiate a physical response to the event as well as a written response. Responses shall include but not be limited to: acknowledge, clear, open a pre-programmed floor plan, energize, de-energize, pulse, time pulse, add comment, retrieve event video, and bring up live video, shunt or un-shunt.
- Q. Assigned passwords shall be possible to define the levels of system operation for each individual operator. System operation for individual operators shall include, but not be limited to, restricted time periods for login, available accounts and default language selection at login. Operator actions range from no view or control rights to basic monitoring including the ability to block the viewing of card and or personal identification numbers, to full control of the system including programming.

- R. The system programming shall be user friendly, and capable of being accomplished by personnel with no prior computer experience. A quick start wizard shall allow the operator to easily program a system including basic time zones, access panels (IP connection, Modem Pools or direct connections to an RS-232 port), card activation to a general purpose access area and deactivation date. The software shall utilize drop boxes for all previously entered system-required data. The programming shall be MENU driven and include online “Help” or “Tutorial” information, as well as online data entry examples. The Help shall be available by using the F1 key. When using the F1 help access, the help menu will provide detailed information relative to the operation that the user is performing without the need to key in additional search parameters. An operation Tutorial shall also be provided with the access control software. The contents of the Tutorial shall include, but not be limited to: Floor plan setup and control, Visitor management integration, Digital video integration, and Intrusion integration and operation.
- S. After installation, the Customer shall be able to perform hardware configuration changes. These hardware configuration changes shall include, but not be limited to, door open time, door contact shunt time, point and reader names, when and where a cardholder is valid, and the ability to add or modify card databases as desired; For the intrusion system, any function that can be programmed from a physical keypad shall also be available from the system’s virtual keypad, without the services of the Contractor or Manufacturer.
- T. Equipment repair shall be able to be accomplished on site, by module replacement, utilizing spare components.
- U. All control components shall utilize “Distributed-Processing” concepts. The distributed processing shall include the ability to download operating parameters to any field panel, thus allowing the field panel to provide full operating functions independent of the access control system computer

PART 2 - PRODUCTS**2.1 MANUFACTURERS AND WARRANTY:**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified hereafter:

Access Control:

1. Honeywell.
2. Cardax.
3. Simplex
4. Approved or equal

Cameras and NVRs:

1. Honeywell.
2. Vision.
3. GE.
4. Approved or equal

Server, Workstation

1. IBM
2. HP
3. Approved or equal

Patch panel, switches and accessories

1. Cisco
2. 3Com
3. Approved or equal

Console

1. Winstead
2. Approved or equal

- B. the subcontractor shall provide a starting from handing over date a 2 years warranty 24hours, 7 days/week; intervention time shall not exceed 3 hours from receiving a call.
- C. the subcontractor shall present the list of the spare part list that he will keep in his stores (4% from each item and shall not be less than 1unit)

2.2 SYSTEM REQUIREMENTS:

- A. The quantities of components shall be determined and installed by the Contractor based on the requirement to provide a fully operational Integrated Security Management System (ISMS), as per the intent of the specification, and as shown on the drawings and recommended by the Manufacturer.
- B. The following list of main items to be installed:

1. Security management software.
 2. Intelligent controller (IC).
 3. Single reader module (SRM).
 4. Dual reader module (DRM).
 5. Alarm input module (AIM).
 6. Relay output module (ROM).
 7. Contactless smart card reader.
 8. Electric strike.
 9. Magnetic Lock.
 10. Egress Button.
 11. Magnetic door contact.
 12. Siren.
 13. Autodialer.
 14. Cameras.

 15. Lenses (Fixed, Zoom, and Auto Iris).
 16. Camera Accessories (Mounts, Enclosures, and Pan/Tilt Motors).
 17. LCD Screen.
 18. Digital Video servers/switchers and multiplexers.
 19. Video Motion Detectors.
 20. Pan/Tilt and Zoom Controllers.
 21. Central Processing Unit (CPU).
 22. Modems and all related communications equipment.
 23. Patch panels and data switches.
 24. A4 color laser Printer.
 25. All power supplies or transformers.
 26. Master desk/Work Station unit.
 27. Upright equipment consoles.
 28. Client/workstation Computers (latest specifications).
 29. Badging printer/badging camera.
- C. Provide and install all equipment, components, wire, cable, antennae, and mounting hardware as required to meet manufacturer's specifications and documented installation procedures.
- D. All materials and equipment shall be standard, regularly manufactured equipment. All systems and components shall be thoroughly tested and proven in actual field use. Where possible, all system components shall be from one manufacturer. Whenever components are included from sources other than the manufacturer of the system, the Contractor shall demonstrate and verify that the components are compatible, prior to system acceptance, and shall provide to the Customer that use of such components will not void or impair the system warranty.

2.3 CENTRAL CONTROL AND SYSTEM MANAGEMENT SOFTWARE CAPABILITIES

The following functional capabilities are considered essential for the system described in this specification. The capabilities are to be considered standard, without the need for add-on software or hardware.

2.3.1 General

-
- All databases will have the ability to Add, Delete, Report, View or Edit information.
- Provide storage of all system transactions in a retrievable file.
- Log all events by time and date.
- Provide capability to store all or selected system transactions to a disk file.
- Provide ability for Customer to make any system configuration changes such as, but not limited to door open time, door contact shunt time, point and reader names, when and where a cardholder is valid, and the ability to add or modify card databases at any time.
- Support “Global Anti-pass back”, allowing cardholder to enter/exit any such defined card reader on the same intelligent control panel or RS-485 drop-line consisting of 2 and 4 door controllers.
- Anti-pass back modes shall include hard (no forgiveness), soft (allows access but generates an alarm event) and timed for all readers on the intelligent controller, on specified reader or card for a definable period of time up to 32,000 seconds.
- Duress feature where a PIN is used in conjunction with a card read, the numbers of digits are selected at the keypad where the PIN number is a value of one different from the normal PIN.
- Two card holder rule, where two valid, non-identical “cards” must be used within a 20 second period of time to grant access.
- Ability to display when a card holder who uses the reader has accessed (opened) the door or if the card was used but the door was not opened.
- Ability to select appropriate doors to remain locked even though it is programmed by time zone control to be unlocked, until the first valid card read is seen during the door’s time zone at which time the door will remain unlocked for the duration of its defined time period.
- Latch mode operation where the first card read unlocks the door and the second causes it to lock the door.
- Provide mode of system operation that stores system commands that were not accepted by the hardware.
- Provide mode of system operation that requires the operator to enter a response to an event when acknowledging it from the alarm view window.
- Provide mode of system operation that allows acknowledged alarms to be automatically cleared.
- Provide mode of system operation where un-acknowledged events will cause the computer to continuously emit a pulsating beep until all un-acknowledged alarms are acknowledged. A momentary silence feature shall allow the beeping to cease for up to 60 seconds. The silence feature shall also provide a visual count down to when the beeping will begin again.
- Provide mode of system operation where when an acknowledged, but not cleared event will be reissued requiring acknowledgement when the event changes to an alarm or trouble state.
- Provide mode of system operation that does not allow the operator to clear an alarm prior to it being restored to normal.
- Provide ability for manual operator control of system output relays. The manual functions shall include the ability to energize, de-energize, return to time zone, or pulse the output relay. The pulse time shall be a programmable setting.

- Provide ability for manual operator control of system doors. The manual functions shall include the ability to Lock, Un-Lock, Disable, Card only, Card-Pin only, Pin only, exit only and site code only.
- Provide ability to automatically display stored “video image” of cardholder, and switch real-time camera from CCTV or digital video server to card reader location for specific card usage.
- The cardholder “video image” pop-up shall be activated based on a priority level set to the cardholder or reader. Information in the pop-up shall include, but not be limited to the card holder’s primary image a live video pop-up showing the person who initiated the pop-up, entrance name, time, date, cardholder name, and status. User shall be able to display up to 40 note fields. The size of the pop-ups shall be adjustable by the operator.
- Support multiple card reader technology including:
 - Proximity.
 - Wiegand effect.
 - Biometrics.
 - Magnetic stripe.
 - Bar Code.
 - Keypad.
 - Card/keypad (PIN).
 - High-speed long range Vehicle ID.
 - Smart Card.
- Provide a means for scheduled automatic backups of any or all database system files. A means to restore these files from a simple menu shall exist.
- Provide the ability to address up to 255 serial communication ports per communication server, where each port can be configured for either hardwired or dial-up. When configured for dial-up, any one port can support multiple dial-up locations.
- Communication from the access control communication server to the remote intelligent control panels shall be selectable. Communication options shall be RS-232 directly to the intelligent control, via RS-485 converter, dial-up, leased line from a defined communication port or by LAN/WAN using an IP address for direct connection to the intelligent controller via network interface card. When using IP addressing it shall be unacceptable to use a communication port converter device on the communication server side of the transmission. A minimum of 255 such IP connections shall be allowed per communication server.
- All commands and updates to the panels shall be verified and shall automatically retry if communications have failed.
- Provide a system scheduler that shall automatically:
 - Call remote locations to retrieve history transactions and update panel information, including time and date.
 - Activate or deactivate cards locally or at remote dial-up sites.
 - Initiate a pre-programmed command event/action.
 - Synchronize system to intelligent controller time.
 - Run a pre-defined (template) History report.
 - Run a pre-defined (template) Card Holder report.
 - Card frequency report defined by reader(s), over a defined period of time with disposition options to automatically report or report and de-activate card or change the access level of the card.
 - Frequency shall be defined as Never, Now, Once, Hourly, Daily, Weekly, Once per 2 weeks, and Monthly.
- Provide drop boxes for all system-required information that the user has previously entered.

- Provide the ability to initiate an email (via SMTP) or page to a paging system based on a transaction state. A transaction state shall be defined as but not limited to Normal, Alarm, Trouble, Ajar, Trace, Not Found, Anti-Pass back Violation, PIN Violation, Time Zone Violation, Site Code Violation, Door Used, Duress, No Second Card Presented, Trace Card or Expired Card, and System Alarms including, Panel Com, Panel Power Failure, Modem Pool, Guard Tour, and Tamper. Intrusion partition events including but not limited to: Alarm, Alarm Cancel, Arm Away, Arm Stay, Auto Arm, Auto Disarm, Bypass, Disarm, Early Arm, Early Disarm, Fail to Arm, Fail to Disarm, Normal, Not Ready, Part Arm, Quick Arm, Recent Close, Remote Arm, Remote Disarm, Unbypass, User Code Added, User Code Deleted, user Code Edited. Intrusion zone events including but not limited to: Alarm, Alarm Restore, Bypass, Fault, Fault Restore, Normal, Trouble, Trouble Restore, Unbypass. Intrusion output events including but not limited to: Alarm, Communication Loss, Normal, Tamper, Tamper Restore. Intrusion panel events including but not limited to: Access Denied, Automatic Test, Comm Fail, Comm Restore, Faults, Faults Restore, Line Restore, Line Trouble, Manual Test, Pager Restore, Pager Trouble, AC Restore, AC Trouble, Alarm, Battery Low, Battery Low Restore, Disarm, Normal, Recent Close, Reset, Panic Alarm, Power Up, Program begin, Program Changed, Program End, System Shutdown, System Shutdown Restore, Tamper Alarm, Tamper Restore, Test End, Test Start, Time/Date changed.
- A host grant mode of operation shall exist that requires the host computer to grant accesses to “valid” cards. An alternate host grant mode shall allow the card access information to be downloaded along with unlocking the door for “valid” cards.

2.3.2 Card Database

- Provide a simple card and card holder database import utility. The utility shall be password protected and accessible only to administrators of the access control system. Information that can be imported shall include but not be limited to: First Name, Last Name, card number, activation date, de-activation date, status, up to 40 note fields and photo images. A simple CSV (comma separated value) file shall be used for the importing of data and image file names.
- Cardholder information shall include unique card number up to 15 digits and optional Personal Identification Number.
- Allow multiple cards per cardholder.
- Allow for up to 32 access levels to be assigned to a card, or a single “precision” access level. When using “precision” access levels it shall be possible to create a unique access level per card using an existing access level as a baseline template. This customized card access level shall have both beginning and ending dates.
- Provide 40 user definable fields.
- Each card holder note field shall allow the option to be entered as free form data or structured data. Structured data shall be by use of a template or drop list. The template and drop list shall be created by the operator. The capacity of the template shall allow for up to 65,000 characters.
- Provide special card options that include, but are not limited to:
 - Time zone reference, which defines valid time.
 - Visitor use, which provides a specified activation date and expiration date (spanning years).
 - Trigger control value, which can initiate a predefined procedure at the intelligent control independent from any control function from the system computer.
- Provide a card “Trace” function. The Trace function shall allow normal access control, but will provide a tracking alarm at the system monitor.

- Provide ability to store digital images of cardholder or other digital images such as property or family members. Up to 99 such images shall be associated with the cardholder.
- Provide ability to store a written signature of the cardholder or other signatures such as family members. Up to 99 such signatures shall be associated with the cardholder.
- Provide the ability to prioritize specific card usage from 1 to 99 with separate priority options shall included but not be limited to Anti-pass back, Trace, PIN Violation, Normal, Not Found, Expired, Host Grant, Site Code and Time Zone card activities or violations.
- Allow the user the ability to assign an operator message per card event state and a procedure for the intelligent control shall perform per event state.
- Allow the user the ability to send an email message, selectable per card event type.
- Upon editing card information, the updated information shall be sent automatically to the appropriate access control panel, when hardwired, with no other user intervention. If the port is dial-up, the entry will be stored on disk and shall be updated when connection is made to the remote loop. If the scheduler is used, then card updates shall be sent based on scheduling.
- In a traditional (Wiegand) 5 digit card database, the numbers 0 and 65,535 shall not be valid card numbers as some devices transmit these numbers on an improper read.
- In a 15-digit card database, the number 0 shall not be a valid card number as some devices transmit this number on an improper read.
- A card shall have the ability to be allowed to access one or selected accounts up to all available accounts.

2.3.3 Access Levels

- Provide the ability to define specific times of access.
- Provide the ability to define specific readers for access.
- Provide a template of a defined access level detail, where changes can be made to the template and saved as a new access level detail.
- Provide an access control tree structure that allows groupings of entrances. User shall have the ability to group program all entrances on the branch or make specific changes to individual entrances.

2.3.4 Camera Control

- Provide ability to interface to a microprocessor-based matrix video switcher via a system communication port or LAN connection.
- Provide ability to program descriptions and camera titles for all system cameras.
- Provide ability to manually switch any camera in the system to any monitor in the system.
- Provide ability to automatically switch any camera in the system to any monitor in the system based on any alarm point or system alarm.
- Provide ability to manually control the pan, tilt, and lens functions (zoom, iris and focus).
- Provide ability to set and clear the movement limits of the pan and tilt mechanisms so equipped.
- A “live view” from the CCTV switcher shall be displayed on the system computer. The view shall include pan, tilt, zoom, camera/monitor selection, and the ability to send user programmed information to the video switcher. The ability to change the size and location of the view shall exist. The ability to capture store a single frame of video shall exist.

2.3.5 Digital Video Server

- Provide ability to interface to a network of digital video servers.
- Provide ability to program descriptions and camera titles for all system cameras.
- Provide ability to manually access live video from any camera on any defined digital video server.
- The viewer windows shall allow at least 16 live videos to be displayed at one time.

- The viewable size of the viewer window shall be adjustable by using the common “click and drag” method. When adjusting height or width, the image shall retain the correct aspect ratio.
- Provide ability to automatically pop-up any camera in the system based on any alarm point, system alarm or cardholder video image pop-up.
- Provide ability to manually control the pan, tilt, and lens functions (zoom, iris and focus) of cameras so equipped.
- A “live view” from the Digital Video Server shall be displayed on the system computer without the use of any add in video capture card.
- Live views shall allow for the change in image resolution or aspect ratio to optimize the viewing quality to the native video.
- The view shall include controls for pan, tilt, zoom and the ability to select a “live” view or a view based on selected time and date.
- The ability to change the size and location of the view shall exist.
- The digital video server window shall also supply the ability to select a digital video server, camera, live, from stored video using user defined time and date.
- A filter option shall allow the operator to define a date, time, transaction type, device(s), card holder, card number, note field, card event type and alarm status. Once filtered all events will be displayed in a listing. The listing shall include on the same event line if the event has an associated video clip. By clicking on the event, the time, date, camera and digital server shall be preloaded in the manual selection boxes allowing the operator to simply click on the sorted event and then click on “show” to display the recorded event.

2.3.6 Alarm Monitoring – Alarms Only View

- Report alarm point activity.
- Provide color for each specific alarm point action of “Alarm”, “Normal” and “Trouble”, conditions.
- Provide the ability to access the default floor plan graphic for any active alarm point by a right click option.
- Live video pop-up from the digital video server(s) shall follow the alarm event pop-up. The number of live camera views in the pop-up window shall be no less than 16. The live pop-up window shall allow the user to define the quantity of views from 1 – 16. The ability to adjust the size of the live pop-up window shall exist.
- Provide ability to bypass alarms in the system.
- Execute alarm notification in all modes of operation.
- Provide ability to acknowledge any intrusion alarm, event alarm, system alarm, card, or reader activity based on priority.
- Provide display of system activity with the higher priorities displayed at the top of the list with identical points stacked with a frequency count of each point’s change of state.
- Provide a video icon for events that have video associated with it. Right clicking on such an event shall allow the option to retrieve recorded video or view “live”. The stored video clip shall playback by default a minimum of 2 seconds before the actual event without any adjustment.
- Viewable alarms shall include but not be limited to access control related events such as Door Normal, Door Alarm, Door Trouble, Door Ajar; Card events such as Trace, Not Found, Anti-Pass back Violation, PIN Violation, Time Zone Violation, Site Code Violation, Door Used, Duress, No Second Card Presented, Trace Card or Expired Card, and System Alarms including, Panel Com, Panel Power Failure, Modem Pool, Guard Tour, and Tamper. Intrusion partition events including but not limited to: Alarm, Alarm Cancel, Alarm Away, Alarm Stay, Auto Arm, Auto Disarm, Bypass, Disarm, Early Alarm, Early Disarm, Fail to Arm,

Fail to Disarm, Normal, Not Ready, Part Arm, Quick Arm, Recent Close, Remote Arm, Remote Disarm, Unbypass, User Code Added, User Code Deleted, user Code Edited. Intrusion zone events including but not limited to: Alarm, Alarm Restore, Bypass, Fault, Fault Restore, Normal, Trouble, Trouble Restore, Unbypass. Intrusion output events including but not limited to: Alarm, Communication Loss, Normal, Tamper, Tamper Restore. Intrusion panel events including but not limited to: Access Denied, Automatic Test, Comm Fail, Comm Restore, Faults, Faults Restore, Line Restore, Line Trouble, Manual Test, Pager Restore, Pager Trouble, AC Restore, AC Trouble, Alarm, Battery Low, Battery Low Restore, Disarm, Normal, Recent Close, Reset, Panic Alarm, Power Up, Program begin, Program Changed, Program End, System Shutdown, System Shutdown Restore, Tamper Alarm, Tamper Restore, Test End, Test Start, Time/Date changed.

- Provide ability for the operator to acknowledge and clear alarms from display. Prior to acknowledgment, the user shall be allowed to enter a response per alarm. The system shall offer a means to require acknowledgement of an alarm before it can be cleared.
- Provide a display of the most current transactions in real time.
- Provide the ability for dynamic alarm monitoring of alarm points in real time on the system computer's video display terminal.
- Provide an alarm view filter that is structured as a tree allowing the operator to select individual devices or groups of devices to be viewed.
- Provide a "System" alarm upon a loop integrity violation.
- Provide a "Panel Not Responding" alarm if communication to a panel is lost.
- Provide real time printing of alarms as they occur by line printing with a dot matrix printer or provide printing of alarms, one page at a time, using typical Windows page printing.

2.3.7 Alarm Monitoring/System Control – Tree View

- Provide the ability for dynamic alarm monitoring of alarm points in real time on the system computer's video display terminal.
- Provide color and icon shapes for each specific alarm point action of "Alarm", "Normal", "Trouble", and "Shunted".
- Access control panels in the alarm tree, like alarm points, shall also indicate if they are in the buffered mode of operation as well as any "system" related alarm such as "Tamper" or "Primary Power Loss" or Loss of communication.
- Devices connected to the communication server shall provide additional popup information as to the communication port or IP connection the device is programmed for.
- Provide a means to launch a Virtual keypad from an intrusion panel partition to monitor the physical keypad remotely and to administer programming changes via the Virtual keypad.
- The control tree shall be created by the user and allow for manual of control of all system devices. By right clicking on a device in the tree the operator is able to initiate the appropriate action from a pick list. Actions shall include but not be limited to: Acknowledge All Alarms, Clear All Alarms, Send Time & Date, Send Camera Titles, Camera to Monitor Switch, Control Camera P/T/Z, Focus, Iris, Live Video, Retrieve Video from Clip, Run Command File, Lock, Unlock, Shunt, Unshunt, Pulse, Timed Pulse, Restore to Time Zone (Door Mode), Override Online Door Mode, Initialize, Cancel Initialization, Buffer, Unbuffer, Connect Remote and Disconnect Remote from remote site. For partitions monitored by the intrusion panel the control shall include but not be limited to arm away, arm stay, disarm, refresh and provide a virtual keypad for the partition. For zones monitored by the intrusion panel the control shall include but not be limited to bypass, unbypass and refresh. Intrusion panel output control shall include activate, deactivate and refresh.

2.3.8 Operator Database

- The software shall allow the assignment of operator levels to define the system components that each operator has access to view, operate, change or delete.
- The ability to view, edit or delete cardholder sensitive information such as note fields, card number and PIN shall be definable by field per operator.
- Define the accounts that the operator has access to.
- Provide the ability to log operator actions in the history files.
- Provide default language to be used based on operator's login.
- Provide specified time periods that the operator can log in.

2.3.9 Panel

- Provide ability to program Action Messages and assign an alarm event priority. A specific action message may be displayed for each alarm, system alarm (communication, ground fault, power, panel reset, low voltage, panel tamper), card, or reader usage state. States shall include but not be limited to: Incorrect Password, Panel Configuration Error, Panel Remote Dial-up Failed, Panel Remote Dial-up Successful, Poll Response Alarm, Poll Response Normal, Primary Power Failure, Primary Power Normal, Tamper Switch Alarm, Tamper Switch Normal, Unsupported Panel Version, Anti-Pass back Violation, Anti-Pass back Violation Door Not Used, Anti-Pass back Violation Door Used, Card Not Found, Door Normal, Door Alarm, Door Trouble, Door Ajar, Door Locked, Door Unlocked, Duress Request Denied, Duress Request Door not Used, Duress Request Door Used, Forced Open, Free Egress Door Not Used, Free Egress Door not Verified, Free Egress Door Used, Host Grant Card Downloaded, Host Grant Door Unlocked, Invalid Format, Invalid Format Reverse Read, Invalid Pin, Invalid Site Code, Invalid Time zone, Issue Code, Never Allowed at this Door, No Second Card Presented, Site Code Verified Door Not Used, Site Code Verified Door Used Trace Card, Valid Card Door Not Used, Valid Card Door Used. Intrusion partition events including but not limited to: Alarm, Alarm Cancel, Alarm Away, Arm Stay, Auto Arm, Auto Disarm, Bypass, Disarm, Early Arm, Early Disarm, Fail to Arm, Fail to Disarm, Normal, Not Ready, Part Arm, Quick Arm, Recent Close, Remote Arm, Remote Disarm, Unbypass, User Code Added, User Code Deleted, user Code Edited. Intrusion zone events including but not limited to: Alarm, Alarm Restore, Bypass, Fault, Fault Restore, Normal, Trouble, Trouble Restore, Unbypass. Intrusion output events including but not limited to: Alarm, Communication Loss, Normal, Tamper, Tamper Restore. Intrusion panel events including but not limited to: Access Denied, Automatic Test, Comm Fail, Comm Restore, Faults, Faults Restore, Line Restore, Line Trouble, Manual Test, Pager Restore, Pager Trouble, AC Restore, AC Trouble, Alarm, Battery Low, Battery Low Restore, Disarm, Normal, Recent Close, Reset, Panic Alarm, Power Up, Program begin, Program Changed, Program End, System Shutdown, System Shutdown Restore, Tamper Alarm, Tamper Restore, Test End, Test Start, Time/Date changed.
- Provide ability to program descriptions, shunt times, and momentary shunt times for all system alarm points.
- Provide ability to program descriptions, pulse times, and energize times for all system output relays used for door control and other auxiliary functions.
- Provide ability to program descriptions for all system card readers.
- Monitor both supervised and non-supervised alarm points with the ability to select by point which point shall be supervised and define if the point is a normally closed or normally open point contact.
- Provide ability to interlock any alarm point condition to an output relay.
- Provide ability to interlock any alarm point condition to another alarm point.

- Provide ability to interlock any alarm point to switch a camera to a system monitor.
- Provide ability to program alarms and associate incoming alarms with related outputs.
- Provide a programmable “delay” setting up to 255 seconds for all system alarm points. The system shall not report the alarm condition until the delay setting has expired.
- Allow for up to 8 different site codes to be used in the system.
- Support up to 16 readers per Intelligent Control Module.

2.3.10 Reports

- Provide reporting capability for printing of selected system transactions from the disk files by specific time and date selection, range from time and date to time and date, or from start time to end time each day of the selected date range.
- Provide feature to generate a history report for an alarm point(s) state. An alarm point state shall be defined as Normal, Alarm, Trouble, or Ajar.
- Provide feature to generate a history report of system alarms. A system alarm state shall be defined by panel and include any of the following information: communication, ground fault, power, panel reset, low voltage, panel tamper, and loop communication.
- Provide feature to generate a history report for a card(s) state. A card state shall be defined as Normal, Trace, Not Found, Anti-Pass back Violation, PIN Violation, Time Zone Violation, Site Code Violation, or Expired card. Additional search criteria shall include cardholders that meet up to at least 3-note field restriction and filter the report with defined reader location(s).
- Provide feature to generate a history report for system operator(s) activities. The report shall include time, date, operator name the device associated with the action and the type of action performed by the operator. Activities shall include but not limited to: acknowledged and cleared transactions, camera control, door mode, door and relay control such as unlock, lock; door and input control such as shunt, unshunt; login, logout, panel initialization, panel buffer and panel unbuffer.
- Provide complete database reporting of all data programmed into the system data files.
- Provide a means to define how long a card holder has been in a defined area. This report shall allow the time to be accumulated representing an attendance report. The definable filters shall include time/date range, reader(s) definition, card number, card holder and note field. The output of the report shall allow sort options to include First Name, Last Name, Event Time, and Card Number. The sorted data shall be selectable as Alpha or Numeric sorting and Ascending or Descending.
- Provide feature to generate a report based on the frequency of usage of a card. The report shall allow the operator to define a time/date period, a minimum and maximum usage limit, a means to define which reader or readers should be used to filter the report and the ability to further define the type of card to be reported on based on note field selections. This report shall also provide a disposition function. The cards meeting the filtering criteria shall be acted upon based on the disposition setting. Disposition settings shall include but not be limited to: Report only, De-activate the card or Re-assign to a specified an access level. This report shall be available in the event scheduler. When defining when to run the report an option to select the number of previous days to run the report against shall be provided. As an example a scheduled weekly report for the last 14 days could generate allowing for an overlap of time if desired.
- Provide a means to create report templates. Report templates shall include, but not be limited to, History and Card Holder information. The templates shall be able to be assigned to a scheduler to run automatically per the scheduler settings.

2.3.11 Tracking/Muster Report

- A tracking feature shall allow the system operator to identify an area and the person(s) in that area.
- Areas shall be defined by readers representing an IN or OUT read status.
- Defined areas shall provide an automatic update of how many cardholders are in the area.
- An area defined as an exit shall remove the person from the tracking area.
- A view displaying all card holders in a defined tracking or muster area shall have the ability to be sorted in columns where by clicking on the column the data in the column shall be sorted. At a minimum, the columns can be sorted by: Card Number, Status, Card Holder, Reader, and Time/Date.
- A Muster area shall be defined by a reader(s) used to “muster” individuals in the event of an emergency.
- Reports can be generated for the defined muster or tracking area.
- Reports can be generated for all muster or tracking areas in the system.
- Reports can be sorted on time and date, card number, card holder name or matching note field. When sorted on notefield, a page break between fields shall allow the report to be easily handled for departmental uses.
- Tracking areas can include “nested” areas. Nesting allows for various reports from a large area to smaller areas within the large area.
- A Tracking and Muster area screen shall be continually updated with the most recent card activity, therefore minimizing the time required generating a report.
- A history priming feature shall load history activities for the defined amount of hours when the software is started. This priming feature shall be implemented in the event that the system computer is offline when a muster call is initiated, thereby allowing the implementation of the tracking and muster features of the software. The history priming time shall be operator selectable in 1-hour increments up to 99 hours.

2.3.12 Time Zones

- Time zone definitions shall include Starting time, Ending time, Days of the week, and Holiday override.
- Time shall be definable in either AM/PM or 24-hour (military) time.
- Minimum time zones that can be assigned to a panel shall be 63.
- Maximum time zones that can be defined in a system shall be unlimited.
- Holidays shall be definable in two different time zones allowing different time schedule to be programmed for each holiday type.

2.3.13 Floor Plan Graphic

- Provide the ability to import floor plan graphics stored in a WMF format.
- Provide the ability to associate all ADV's (access, intrusion and video) to floor plan graphics allowing the user to control and monitor the system.
- Provide the ability to link floor plan graphics together in a hierarchy fashion.
- Allow multiple floor plan views to be displayed simultaneously.

2.3.14 Remote Locations

- Provide capability to place remote control panels in an offline mode. In the offline mode, the remote control panels shall retain all panel history events. The amount of historical events shall be limited to the panels' buffer capacity.
- Provide capability to place remote control panels in an offline mode where the remote panel will automatically call to the communications computer to report system alarms or upload buffered events.
- Ability to manage at least 250 remote locations.
- Provide a user-definable schedule that will automatically add cards to any number of sites.
- Provide system time schedules that the computer will use to automatically start uploading or downloading information to the remote sites. Information to be sent to the panel shall include, but not be limited to, card database changes, time, date, and buffer condition. Information received from the panel shall include all buffered events. While connected to the remote site, the system software shall poll, verify, and report any loss of panel communication. If a site's communication time is longer than expected, the system will automatically adjust the time schedule to allow all selected sites to be updated.
- Attaching a site to an auto-dial schedule will allow the system to automatically dial the remote site at a predetermined time. The auto-dial schedule is programmed with the ability to dial Once, Now, Hourly, Daily, Weekly, Two Weeks, Monthly, or Never to the remote site.
- Provide the ability for the operator to program when the next scheduled update will occur, based on time and date.
- Communication to remote dial-up sites shall be accomplished through the use of password protection. The remote site provides the system with a site ID; the system responds with the appropriate password. No commands or transactions occur until the communication link is verified.
- The System shall be able to receive or send information to remote access control panels on demand.
- The ability to configure how many redial attempts from the remote location shall be definable from 1 to 5.
- The ability to pause between redial attempts shall be programmable from 1 to 120 seconds.
- The ability to pause before disconnecting shall be programmable from 1 to 30 seconds.
- Communication rates shall be 38.4k baud.

2.3.15 Guard Tour

- Guard Tour shall allow the operator to program a series of guard check points that must be activated to accomplish the task of a Guard Tour.
- The check point shall be either reader points or alarm contact points or a mixture.
- The Guard Tour can be timed sequential allowing travel time between points with +/- tolerance. This type of tour shall allow alarms to be generated for early, missed or late events.
- The Guard Tour can be un-sequenced with no time parameters.
- The Guard Tour shall be started by two methods, Manual or Scheduled by the access control system scheduler.

2.3.16 ID Badging System/Video Image System

- Allow any card data fields to be assigned to a badge.
- Allow a stored cardholder image to be associated to any background. Each cardholder shall have any one of the background layouts associated to it.
- Provide the ability to create temporary or permanent badges.
- Badges shall be printed without the need to assign an access level or access control card number. Numbers and access levels may be assigned after the print process.
- Provide image export capability. Image shall be exported utilizing the cardholder's name as the file name in .jpg format.
- Provide unlimited custom badge layouts (only limited by the hard disk capacity).
- Provide 24-bit (16.7 Million) color palette for background design or foreground text.
- Provide ability to implement all fonts supported by Windows.
- Provide import capabilities of background information by video camera or via BMP, JPG, or TGA files.
- Provide import capabilities of video images from compatible BMP, JPG, PCX, or TGA file formats.
- Provide for multiple bitmap images to be imported onto the badge layout.
- Provide video capture capability from a compatible TWAIN device.
- Provide video capture capability from a DirectX device.
- Provide video capture capability from a compatible video capture device, such as a high-resolution color camera.
- Provide badges in horizontal or vertical format.
- Provide capability for printout of cardholder badge by video or standard printers supported by Windows.
- Provide ability for multiple card enrollment/badging stations on networked system.
- Allow text fields up to 255 characters per field.
- Allow merging of data field from card database to text field.
- Allow a field to be defined for bar code usage merging data from the card database.
- Allow up to 99 different photos of the cardholder to appear on the same badge.
- Provide line, rectangle, rounded rectangle, and ellipses to be created on the backdrop with provisions for line thickness and color.
- Provide signature capture or import capability for up to 99 signatures that can be previewed in the cardholders badge or printed on the cardholder's card.
- Provide the capability to have a front and back layout selected for a cardholder and the ability to print the card in one step (requires suitable printer) without the need to reinsert the card.

- Provide the capability to encode a magnetic stripe with information from any of the card data fields to include, but not be limited to: First Name, Last Name, Card Number, Activation date, Expiration Date or any data from the card holders note field.
- Information shall be encoded on track 1, 2, or 3 (requires suitable printer) without the need to reinsert the card. With suitable printer each track shall be encoded with ABA, IATA, or TTS format.

2.3.17 Networking

- Provide networking capabilities (LAN or WAN) as allowed by the computer's operating system license.
- The access control software shall support two networking methods. By default, Domain controlled networks shall be the standard configuration providing secure networking communications. The ability to work on less secure peer-to-peer (Workgroup) networks shall be allowed for lower security installations. The functionality shall be one or the other and not run in both modes at the same time.
- Provide the ability for a network system to support concurrent users up to the license limit, i.e., one station adding cards and making badges, another station monitoring alarms, yet another running data base reports, another controlling door openings and alarm shunting, and so on.
- The workstation shall have the same UI (user interface) functionality as the Server, except the workstation shall not be able to perform database maintenance functions.

2.4 Intelligent Controller (IC)

The IC shall link the security management system software to all other field hardware components (card reader modules and input and output control modules). The IC shall provide full distributed processing of access control and alarm monitoring operations.

Access levels, hardware configurations, and programmed alarm outputs assigned at the administration workstation shall be downloaded to the IC, which shall store the information, and function using its high-speed, local Freescale ColdFire 5282 processor. All access granted/denied decisions shall be made at the IC to provide fast responses to card reader transaction. The System shall provide the user the capability to query the IC to get a snapshot of memory availability, stored transactions and events, etc.

- IC Networking - The IC shall include a network-based interface module. The module shall be 10/100 MBPS Ethernet-based and capable of residing on a LAN or WAN without connectivity to a PC serial port. The IC network interface module shall be able to communicate back to the database server though industry standard switches and routers.
- Off-line operation - In the event that the IC loses communication with System software, it shall continue to function normally (standalone). While in this off-line state, the IC shall make access granted/denied decisions and maintain a log of the events that occur. Events shall be stored in local memory and uploaded to the System software after communications are restored.
- IC Features
 - Integrated Ethernet—The IC shall include integrated Ethernet providing for fast downloads.
 - Embedded Web Server—The IC shall include embedded Web Server for ease of configuring key hardware attributes.

- Web Server shall be password protected with specific user account.
- User names and passwords for Web Server access shall be downloadable from the host.
- Web Server shall optionally be disabled. On by default, off by option.
- Communications—The IC shall include a primary and a secondary port for the purpose of communication to the host computer. The following communication formats shall be supported:
 - RS232 at a speed of 38.4 KBPS
 - RS485 at a speed of 38.4 KBPS
 - Ethernet at a speed of 10 MBPS or 100 MBPS (10baseT, RJ45)
- Ethernet—IC device shall appear as a SNMP compatible device on the Ethernet network, reporting status, name and address. It shall have the option of disabling this support.
- IP Addressing—The IC shall support static and dynamic IP addressing models.
- FIPS—The IC shall provide FIPS support of 128-bit credentials
- Encryption—The IC shall support FIPS 197 encryption.
- Memory—The IC shall include 32 MB RAM and 16 MB Flash. Real time program updates and overall host communications shall utilize flash memory. The standard IC shall accommodate a card database of up to 300,000 cards and a transaction buffer capable of storing 50,000 transactions.
- Additional ports—Shall be provided for connecting card readers and data gathering panels via RS485 multi-drop wiring configuration. The IC shall have 2 logical and 2 physical RS485 ports supporting 4000' in two directions. Additional ports shall be supported utilizing special multiplexer. Each IC shall support up to a combined total of 32 boards connected in any combination.
- Devices—Up to 32 devices consisting of reader interface modules, alarm input modules (AIM), and relay output modules (ROM) shall be supported. The devices shall be connected in any combination.
- Processor—The IC shall include a Freescale ColdFire 5282 Processor.
- Readers Capacities—Reader functionality and connectivity will be achieved through reader modules, and not directly to the IC. The IC will, however, support at a minimum the following:
 - Up to 8 card formats and facility codes
 - Multiple card technologies
 - Biometrics interface support
 - Smart card interface support
 - Integration with other manufacturers' card readers
 - Issue code support for both magnetic and Wiegand card readers
 - Up to 8 digit PIN codes.
- Real-Time Clock—The IC shall include real-time clock supporting:
 - Geographic Time Zones
 - Daylight Saving Time
 - Leap Year
 - 4-bit parallel accurate to 50 ppm

- Redundant Communication—The System shall provide a redundant or secondary means of communications with System intelligent controllers configured on a communication channel. A channel provides the connection between a regional/local server and a panel or hardware device. The System shall support various types of channels to support numerous hardware devices, however, only a System intelligent controller shall be configurable for redundant communications support.

If the primary method of communications fails, the System shall automatically switch over to the secondary method. The possible primary/secondary combinations shall include:

- TCP/Dial Out
- TCP/TCP
- TCP/Hardwired
- Hardwired/Dial Out
- Hardwired/TCP
- Hardwired/Hardwired
- Electrical Power—Primary input power shall be 12 VDC +/- 10% @ 400 mA with an operating range of 10 VDC to 16 VDC. The IC shall be equipped with an uninterruptible power supply (UPS) and backup battery.

2.5 Single Reader Module (SRM)

The SRM shall provide an interface between the IC and the card readers. The SRM shall operate with any card reader that produces a standard Wiegand (Data 1/Data 0 or Clock and Data) communication output. A single IC shall be able to multi-drop up to 32 SRMs on four separate RS485 ports. The following requirements shall also apply:

- Up to 32 SRMs shall be connected to each IC, distributed across the four RS485 ports.
- Each SRM shall include 2 supervised inputs and 2 relay outputs.
- Up to 8 unique card formats shall be supported.
- The SRM shall support an integrated card reader/keypad.
- The SRM shall support 3 access modes upon loss of communication with the IC. These modes shall be locked, unlocked, or facility code.
- Input power shall be 12 VDC +/- 10% @ 400 mA with an operating range of 10 VDC to 16 VDC.

2.6 Dual Reader Module (DRM)

The DRM shall provide an interface between the IC and the card readers. The DRM shall operate with any card reader that produces a standard Wiegand (Data 1/Data 0 or Clock and Data) communication output. A single IC shall be able to multi-drop up to 32 DRMs on four separate RS485 ports. The following requirements shall also apply:

- Each DRM shall support 2 card readers, each of which may be up to 500 feet from the DRM.
- Up to 32 DRMs shall be connected to each IC, distributed across the 4 RS485 ports.

- Each DRM shall include 8 supervised inputs and 6 relay outputs.
- Up to 8 unique card formats shall be supported.
- The DRM shall support an integrated card reader/keypad.
- The DRM shall support 3 access modes upon loss of communication with the IC. These modes shall be locked, unlocked, or facility code.
- Input power shall be 12 VDC +/- 10% @ 400 mA with an operating range of 10 VDC to 16 VDC.

2.7 Alarm Input Module (AIM)

The AIM shall monitor all System alarm inputs. The following requirements shall apply:

- The AIM shall provide up to 16 supervised alarm inputs to monitor and report fault conditions (open, short, ground, or circuit fault) alarm conditions, power faults, and tampers. Upon alarm activation, the associated alarm condition shall be reported to the IC and subsequently to the System alarm monitoring workstation.
- Light emitting diodes (LED) shall indicate the status of the 16 alarm zones, cabinet tamper, and power fault.
- The alarm input modules (AIM) shall operate independently and in conjunction with the relay output modules (ROM), which shall send an output signal to a corresponding output device upon alarm activation. Upon alarm activation, the AIM shall activate any or all alarm outputs within the ROM. The OM shall provide 16 Form C outputs rated at 5A @ 30 VDC. Upon receipt of an alarm input from the AIM, the ROM shall transmit an activating signal to a corresponding output device.
- Up to 32 AIMs shall be connected to an available IC via RS485 cabling.
- Diagnostic light emitting diodes (LED) shall indicate IC communication, input zone scanning, and AIM heartbeat.
- The AIM shall contain the following features:
 - Alarm contact status scanning at up to 180 times per second for each zone.
 - Eight configuration DIP switches to assign unit addresses and communications speed.
 - A low power CMOS microprocessor.
 - Filtered data for noise rejection to prevent false alarms.
 - Two form C, 2A @ 28 VDC contacts for load switching.
 - Two dedicated inputs for tamper and power status.
 - Individual shunt times (ADA requirement).
 - Input power shall be 12 VDC +/- 10% @ 350mA with an operating range of 10 VDC to 16 VDC.
- All inputs shall be completely configurable by the System operator for inclusion in logical device definition. Inputs shall not be defaulted by the System for unalterable designation. For example, input #1 defaults as door contact for door #1, input #2 defaults as request-to-exit device for door #1, etc. Systems that do not allow for user definition of all input points shall be unacceptable.

2.8 Relay Output Module (ROM)

The ROM shall incorporate 16 output relays that are capable of controlling a corresponding output device upon any input activation or on command from the System. Relay outputs shall be capable of responding to:

- Input alarms from within the same IC.
- Commands from a System operator.
- Time zone control commands for automatic operation.
- Output relays shall be capable of:
 - Pulsing for a predetermined duration that shall be programmable for each relay individually.
 - Following any input point an AIM attached to the same IC (ON with alarm, OFF when clear, or as required).
 - Responding on command from the System operator to pulse, command on, command off, or reset to normal state.
 - Each ROM shall provide 16 Form C relays rated at 2A @ 28 VDC. The ROM shall control the relays via digital communication. Upon receipt of input from the AIM or command from the System operator, the AIM will transmit an activating signal to the corresponding relay.
 - Input power shall be 12 VDC +/- 10% @ 400 mA with an operating range of 10 VDC to 16 VDC.
- All outputs shall be completely configurable by the System operator for inclusion in logical device definition. Outputs shall not be defaulted by the System for unalterable designation.

2.9 Card Readers

Card readers and/or keypads shall be provided at the specified locations. These shall be installed at the height shown on the drawings. The cabling to the readers shall be shielded and grounded as per the manufacturer's instructions. Care should be taken to avoid errant contact between the shield and doorframe.

Contactless Smart Access Control Readers

The System shall support the Smart Card reader. The readers shall utilize cards that conform to ISO14443A, 14443B or 15693 standards. The contactless smart cards shall provide card read distances similar to 125 KHz proximity readers and provide large data storage densities from 2K up to 64K bits, extremely high security, and the ability to support multiple applications on each card at the same time. The reader shall support the following key features:

- Typical read range: 4" (10 cm)
- Mullion size
- ADA-compliant built-in audible buzzer
- Host LED control
- Tamper detect output (can erase security keys)

- Hidden mounting screws deter vandalism
- Potted for superior weather resistance
- Selectable Wiegand, Clock & Data, or serial output
- The reader shall include three covers included with every reader; black, charcoal and ivory

2.10 Enclosure

- Cabinet: The controller enclosure shall be suitable for wall mounting, with knockouts. The cabinet shall have a hinged cover, tamper switch, and key lock.
- Dimensions: The dimensions shall not exceed 15" (38.1 cm) in height, 14.2" (36.1 cm) in width, and 7.6" (19.3 cm) in depth.
- Capacity: The enclosure shall hold up to 9 control modules, a 4 A power supply and a self-contained replaceable backup battery.

2.11 Electrical Power Requirements

- System Power: The System shall operate using standard 230 VAC, 50/60 Hz power. The connection to the main building power supply shall be performed in accordance with the general terms and conditions of this contract. This shall include connection to and provision of Uninterrupted Power Systems (UPS) when specified.
- Enclosure Power: A separate power supply enclosure shall be directly connected to a convenient dIConnect panel, preferably connected to the building emergency power supply. The dIConnect breaker shall be clearly marked.
 - An inline transformer, rated at 12 VDC, 4 A continuous power shall provide power.
 - The power enclosure shall be provided with LED indicators showing normal operating conditions, loss of AC power-standby battery supplying power, loss of AC power, discharged or no standby battery, and no DC output.
 - The enclosure shall include a 12 VDC, 7 A hour battery securely fastened to the enclosure to prevent the accidental removal of the battery. It shall be capable of providing backup from 1 to 5 hours depending on module configuration.

2.12 Environmental Conditions

- The System shall be designed to meet the following environmental conditions:
 - Storage Temperature: The System shall be designed for a storage temperature of 14° to 158°F (-10° to 70°C).
 - Operating Temperature: The System shall be designed for an operating temperature of 36° to 109°F (2° to 43°C).
 - Humidity: The System shall be designed for normal operation in an 85% relative humidity, non-condensing environment.
 - Electromagnetic Interference: The System shall meet or exceed the requirements of FCC Part 15, Class B devices, FCC Part 68, IEC EMC directive.

2.13 ELECTRIC STRIKE

- Symmetrical door release
- Open-circuit (power to open)
- Adjustable release housing
- Adjustable latch and reduced aperture offset
- Microswitch at end of bolt travel
- Symmetrical construction
- Door status sensor (door closed/open)
- Latch adjustable by 3 mm
- No lateral cut-out needed for latch
- Improved aesthetics
- Break-in resistance greater than 500 kg
- Steel screws

2.14 Surface Electro Magnetic Lock 550kg

- Holding force : 550KG
- Removal prevention device.
- Extremely reliable.
- Without residual magnetic.
- Easy fitting.
- E-plates technology.
- Low consumption.
- Built in protective devices.
- With built in hall contact.
- Protection index IP42.

2.15 Door Contact

- Magnetic contact recessed type.
- Operating temperature : from - 20° C to + 70° C
- Protection index : IP 68
- Fine adjustment of the trigger threshold
- Vandal-proof mounting

2.16 Egress Button

- With key symbol
- With NO/NC contact
- Maximum switching voltage : 250 V / 10 A
- Protection index : IP 20

2.17 Siren

- Compatible with all alarm control panels
- Acoustic signal - piezo buzzer.
- Optical signal - 5W/12V light bulb
- 3 different sounds available
- Highly resistant polycarbonate housing

- Tamper protection
 - against opening
 - against pull - off
- Galvanized steel inner cover
- Impregnated electronic circuits

2.18 **Telephone dialer**

- Send alarm messages using analog telephone lines
- 3 inputs.
- Telephone monitoring.
- 2 monitoring stations, 2 account numbers.
- Transmission formats -3/1 – 4/2
- Messaging
 - 6 telephone numbers.
 - 1 or 2 voice messages.
 - 1 text message sent as SMS or to pagers.
- Call answering
 - Confirmation of armed status and lack of alarms since last call.
- Voice message or alarm signal after alarm.
- Built in microphone for recording voice messages.
- Telephone signal recognition.
- Constant line status supervision.
- Non volatile settings and voice message memory.

Housing

- Vandal-resistant and outdoor-proof, with built-in heater and fan.
- Metal base and polycarbonate transparent cover
- Impact resistant casing 1000 kg (2200 lb.)
- IP66-rated

Surge Arrestor

The camera should be supplied with data and power surge arrestors from the 2 sides on the ones installed in the outdoor area.

2.19 **PTZ CAMERA (IF APPLICABLE)**

The Type PTZ Camera consists of the following:

- High-speed day/night dome camera with 35x zoom.
- Housing/bracket.
- Power supply as recommended by manufacturer
- Surge arrestor for video, control and power from the 2 sides (for outdoor application)

The minimum requirements are:

- Built-in RS-485 receiver driver, multiple protocols selectable by switch
- S/N More than 48dB,BLC
- Integrate high speed pan/tilt, Pan speed 0- 300°/S, tilt speed 0- 20°/S,continuously rotate 360°.
- 128 preset, 180 ° auto tilt.
- 4 alarm input and 1-relay output.
- Power supply AC 24V
- Double protect housing.
- Auto temperature control function
- Available for various mounting (Indoor/Outdoor ceiling mounting, Indoor/Outdoor wall mounting, Indoor/Outdoor corner mounting, Indoor/Outdoor side mounting, Indoor/Outdoor pole mounting)
- Signal System : PAL /NTSC System
- Image Sensor : 1/4 " Ex-View HAD Colour CCD.
- Active pixel : 752(H) × 582(V)
- Horizontal resolution : 550 TV Lines (Day) / 680 TV Lines (Night)
- Min. scene illumination : 0.01Lux (W/B Mode)
- Focus Length : 3.6mm ~ 126mm
- Zoom Ratio : 35 × Optical zoom with auto focus (12 × digital zoom).
- Tilt angle : 0° ~ 90°
- Pattern : 1 Pattern (record user control up to 40sec)
- Tour : 6 guard tours
- Speed : Manual control speed 0° ~ 300°/sec(Pan); 0° ~ 120°/sec(Tilt)
- Power : Nominal 24VAC.

2.20 **FIXED CAMERA**

A. **DOME TYPE, WALL TYPE , WALL TYPE OUTDOOR CAMERAS**

The Camera shall consist of the following:

- Box (for wall mount) or Fixed Dome (for pendant or ceiling mount) 3 Megapixel Camera.
- 2.6~12 mm MP varifocal auto iris IR lens.
- Housing/bracket.
- IR illuminator
- Power supply as recommended by manufacturer
- Surge Arrestors from the two sides on the ones installed in the outdoor areas.

The minimum requirements are:

Imaging:

- 3 megapixel CMOS image sensor
- 2048(H)x1536(V) pixel array.
- ½” optical format
- 2.6~12mm MP varifocal auto iris IR lens.
- RGB filter
- Minimum illumination of:
 - Color: 0.2 [Lux@F1.4](#)
 - Day/Night: 0 Lux, IR sensitive
- Wide Dynamic range
- Maximum SNR 45dB

Full Field of view resolutions:

- 2048(H)x1536(V) 3 megapixel
- 1024(H)x768(V) ¼ resolution

Cropped Field of view resolution

- 1920x1200 WUXGA
- 1920x1080 ADTV-1080p
- 1600x1200 2MP
- 1280x1024 1.3MP
- 1280x720 HDTV-720p
- 1024x768 XGA
- 800x600 SVGA
- 640x480 VGA

Data Transmission

- Video frame rate up to:
 - 15fps @ 2048x1536
 - 20fps @ 1920x1200
 - 22fps @ 1920x1080
 - 24fps @ 1600x1200
 - 32fps at 1280x1024
- Compression type:
 - H.264 (MPEG4, Part 10)
 - Motion JPEG.
 - 21 levels of quality
- TFTP, HTTP, RTSP, image transmission protocols
- 100 Base-T Ethernet Network interface
- Data rate
 - Bit rate control from 100Kbps to 10Mbps
 - Bit rate control available for full view, multiview and archive
 - Unthrottled data rate in MJPEG Up to 55Mbps

Programmability

- Auto exposure (AE) and gain control (AGC) >120dB
- On-camera real-time motion detection with 64 detection zones
- Programmable backlight compensation
- Auto multi-matrix white balance
- 50/60Hz selectable flicker control.
- Electronic pan, tilt, zoom (PTZ)
- Electronic image flip-180 degree rotation
- Resolution windowing down to 32x32 pixels window
- Programmable shutter speed to help control motion blur
- Moonlight mode-extended exposure and proprietary noise cancellation
- Programmable resolution, brightness, saturation, gamma, sharpness, tint
- Picture-in-picture: simultaneous delivery of full field of view and zoomed images
- Bandwidth & storage savings by running at ¼ resolution
- Electrical:
 - Opto-coupled alarm or trigger input, opto-coupled alarm and flash sync output
 - Power over Ethernet or external 12VDC.

Housing

- Vandal-resistant and outdoor-proof, with built-in heater and fan.
- Metal base and polycarbonate transparent cover
- Impact resistant casing 1000 kg (2200 lb.)
- IP66-rated

Surge Arrestor

- The camera should be supplied with data and power surge arrestors from the 2 sides on the ones installed in the outdoor area.

IR Illuminators

- They shall provide unique flexibility to alter the angle of on site illumination to suit specific security needs, and to match the network camera's field of view.
- They shall allow adjustment of the light angle from 10 to 180 degrees in distances up to 150 meters.
- They shall be used for both fixed and PTZ network cameras.
- They shall be high-efficiency LEDs (light-emitting diodes) with advanced control methods for extremely low energy consumption. Based on solid state LED technology, illuminators are highly energy efficient allowing for huge savings in long-term operational and maintenance costs compared to traditional light bulbs.
- Providing exceptional durability, the new surface-mount technology LED's have a life-cycle of up to 10 years. No light bulbs need to be replaced.
- lens protection for indoor and outdoor use to make these illuminators the ideal choice for security installations
- Power Input : 100-240 VAC (auto-sensing)
- Consumption : less than 100 W
- Type 850 nm semi-covert
- Environmental IP66-rated vandal-resistant casing and polycarbonate
- Angle 120° to 180°

- Distance 64 to 42 m
- Operating conditions -50 to +50 °C
- Accessories included:
 - U-bracket
 - Power supply with adjustable photocell, adjustable power output for the LED and telemetry control

2.22 **DIGITAL RECORDING AND TRANSMISSION SYSTEM**

2.22.1 NETWORK VIDEO RECORDER

- A. Features:
- Up to 64 IP channels per server (fully scalable)
 - Easy and cost-efficient to add additional IP camera licenses
 - Multiple IP camera support (Honeywell, Axis, Sony, Arecont Vision, Panasonic, IQeye, ACTi, CBC America Corp., Vivotek and GE...)
 - Supports high resolution Megapixel IP cameras
 - Digital PTZ feature adds PTZ-like functionality to all cameras in live and recorded mode. Digital zoom box allows for quick zooming on selected areas.
 - Intuitive user interface (client) requires little to no training
 - Unlimited client software copies available at no cost
 - All systems can be accessed from a single client
 - Bandwidth throttling
 - Easy-to-use, powerful export features
 - Multiple monitor (client) display--drag and drop cameras from multiple clients
 - RAID 5 option available

General Information

- Input Voltage: 220 VAC
- Power Consumption: 500 watts
- Video: IP Video stream from supported cameras
- Hard disk size: 8000GB RAID5
- Resolution: CIF, 2CIF, 4CIF, multi-megapixel
- Compression; MPEG-4 or MJPEG (hardware) by camera
- Serial Connections: RS-232
- NIC: 1Gbit 1000Base T RJ-45
- USB2 Ports: 5 (2 front, 3 rear)
- Audio Inputs: Supported IP Camera audio
- DVD/CD RW: front panel access
- Operating System: Windows XP Pro or Linux
- Operating Temperature: 40 - 95 degrees F (4.5 - 35 degrees C)
- Relative Humidity: 5 - 95% RH (non-condensing)
- Regulatory: CE (Class A), FCC (Class A)
- Warranty: 3 years, parts and labor

CLIENT WORKSTATION - full remote operation from most PCs

- Operating System: Windows XP or Vista

- Processor: 2 Ghz Celeron (min.)
- Memory: 512 MB RAM
- VGA: Standard high performance
- SOFTWARE FEATURES:
- Intuitive user-interface
- Multi-monitor support
- SmartSearch
- Multi-camera recorded video playback
- Pre/Post alarm recording
- Event notification
- Text insertion / search
- Activity log
- Privacy Video Block
- Complete Remote Administration
- Graphic search display
- Soft Triggers
- Image Cropping

2.23 **ID CARD PRINTER**

1. Print Method: Dye-Sublimation / Resin Thermal Transfer
2. Resolution: 300 dpi (11.8 dots/mm)
3. Colors: Up to 16.7 million / 256 shades per pixel
4. Print Ribbon Options:
 - Full-color, YMC*, 700 prints
 - Full-color with resin black, YMCK*, 250 or 500 prints
 - Full-color with two resin black panels, YMCKK*, 400 prints
 - Full-color with resin black and heat seal panel for difficult-to-print surfaces,
 - YMCKH*, 400 prints; extra wide for over-the-edge printing on CR-100 cards
5. Film Options:
 - Clear (1,250 prints)
 - Standard Holographic
 - Custom Holographic, special order
 - Overlamine Options:
 - Thermal Transfer Overlamine, .25 mil thick
 - PolyGuard Overlamine, 1.0 mil and .6 mil thick
 - All overlaminates available in clear, holographic globe design or custom holographic design. PolyGuard available in CR-80, CR-90 and CR-100 patch sizes.

6. Print Speed:** Batch Mode:

- 32 seconds per card / 112 cards per hour (YMC with transfer)*
- 38 seconds per card / 94 cards per hour (YMCK with transfer)*
- 66 seconds per card / 54 cards per hour (YMCKK with transfer)*
- 40 seconds per card / 90 cards per hour (YMCK/lamination)*
- 72 seconds per card / 50 cards per hour (YMCKK/lamination)*

7. Accepted Standard : CR-80 (3.375”L x 2.125”W / 85.6mmL x 54mmW)
8. Card Sizes: CR-80 (3.375”L x 2.125”W / 85.6mmL x 54mmW)
9. Print Area: Over-the-edge on all accepted standard card sizes listed above
10. Accepted Card Thickness: Print only: .030” (30 mil) to .070” (70 mil) / .762mm to 1.778mm
11. Print/Lamination: .030” (30 mil) to .040” (40 mil) / .762mm to 1.02mm
12. Accepted Card Types: ABS, PVC, PET, PETG, proximity, smart and mag stripe cards, optical memory cards
13. Input Hopper Card Capacity: 200 cards (.030” / .762mm)
14. Output Hopper Card Capacity: 100 cards (.030” / .762mm)
15. Security Features: SmartGuard Printer Security
16. Memory: 8MB RAM; upgradeable to 32MB
17. Display: User-friendly, SmartScreen LCD Control Panel; LED Display Card Lamination Module
18. Software Drivers: Windows 2003 Server, Windows Vista Business, Windows XP Professional SP2.
19. Interface: Centronics Parallel, IEEE 1284 compliant
20. Operating Temperature: 65° to 80° F / 18° to 27° C
21. Humidity: 20-80% non-condensing
22. Supply Voltage: 100-240 VAC, 3.75A
23. Supply Frequency: 50 Hz / 60 Hz

2.24 LCD SCREEN

1. KEY FEAYURES

- Flat panel type :LCD
- Screen size :32 inch.
- Digital TV standard : HDTV monitor/ HDTV-ready
- Display resolution :1024x768 pixels

2. DISPLAY CAPABILITIES

- Display format :1080i (HDTV), 480p (EDTV), 480i (SDTV)
- Aspect ratio :4:3, 16:9 enhanced

3. REMOTE CONTROL

- Remote control : Universal

4. IMAGE QUALITY

- Comb Filter : 3DYC/3D digital
- Display resolution :1024x768 pixels.
- Adjustable color temperature: without adjustable color temperature.

5. AUDIO FEATURES

- Audio Output : Variable/ Fixed.

6. INPUTS/OUTPUTS

- Rear input connectors :Audio (RCA)x2, Compositex1, S-Videox1.
- Front input connectors : Audio (RCA)x1, Compositex1, S-Videox1.
- Rear output connectors :audio (RCA)x1.

7. SCREEN TEXT

- OSD Languages :French, English.

2.25 CONSOLE DESIGN REQUIREMENTS

- A. Switching Cabinets are to comprise freestanding 19 -inch racks inside enclosed cabinets. Standard holes are to be provided for panel mounting of control equipment and cable distribution terminal boards, which are to be easily accessible for maintenance. Cabinets are to be galvanized sheet steel box construction with joints welded on inside. Multi-formed mounting channels are to be standard gauge cold rolled steel, with secondary classes providing infinite front -to -back adjustment. Base section is to be minimum 1.5mm thick cold rolled steel. Blower panels are to be installed in base section of each cabinet to provide filtered air to zero static pressure. Depth of unit is to allow cable access through bottom and back of racks.
- B. Central Console Design and Components: modular design and contemporary styling, solid welded steel construction with concealed mounting screws, having laminated desk top and monitor / graphics panel turret housing, and containing the following:
1. Monitors
 2. Digital Recorder
 3. Graphics display unit
 4. Keyboard for camera control
 5. Space future use
 6. Telephone set
 7. Auxiliary equipment as specified herein and shown on the drawings.

- C. Central Console Construction: console is to have louvered side panels and interface styling throughout. Sections are to include face mounted 40mm drop edge wiring surfaces with radius corners. Surface is to include one pair (per section) of support arms 550mm deep. Supervisor cabinets are to include locking sliding drawer. Surface top and three sides are to be finished in gray line 1/16-inch thick texolite laminate. Cabinet is to include down point cabinet sections to house closed circuit monitors. Units are to be divided and are to provide good picture quality.
- D. Finishes: steel cabinet and console are to be phosphotized and treated with one weatherproof base coat and two coats of epoxy paint or approved air-drying enamel of color to be selected by the engineer.

END OF SECTION

SECTION 16010– BASIC ELECTRICAL MATERIALS AND METHODS

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 the following:
1. Electrical equipment coordination and installation.
 2. Sleeves for raceways and cables.
 3. Sleeve seals.
 4. Common electrical installation requirements.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
B. EPDM: Ethylene-propylene-diene terpolymer rubber.
C. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS.

- A. Product Data: For each type of product indicated.

1.5 QUALITY ASSURANCE.

- A. Test Equipment Suitability and Calibration: Comply with NETA ATS, “Suitability of Test Equipment” and “Test Instrument Calibration.

1.6 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 3. To allow right of way for piping and conduit installed at required slope.
 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 8 Section “Access Doors and Frames.”

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. In other Part w articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturer: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated “wall pipe”, equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052 – or 0.138-inch (1.3-or 3.5mm) thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section “Through-Penetration Firestop Systems.

2.3 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers:
 - a. Advance Products and Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - e. Or approved equal.

2. Sealing Elements: (EPDM) or (NBR) interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Stainless steel include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure plates to sealing elements. Include one for each sealing elements.

PART 3 – EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busway penetrate concrete slabs, concrete or masonry walls, or fire rated floor and wall assemblies.
- B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section “Through-Penetration Firestop Systems”.
- C. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- E. Rectangular Sleeve Minimum Metal thickness:
 1. For sleeve cross-section rectangle perimeter less than 1270mm and no side greater than 40mm, thickness shall be 1.3mm.

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2. For sleeve cross-section rectangle perimeter equal to, or greater than, 1270mm and 1 or more sides equal to or greater than 40mm, thickness shall be 3.5mm.
- F. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- G. Cut sleeves to length or mounting flush with both surfaces of walls.
- H. Extend sleeves installed in floors 50mm above finished floor level.
- I. Size pipe sleeves to provide 6.4mm annular clear space between sleeve and raceways or cable unless sleeve seal it to be installed.
- J. Seal space outside of sleeves with grout for penetrations of concrete and masonry (and with approved joint compound for gypsum board assemblies).
- K. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.
- L. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with Division 7 Section "Through –Penetration Firestop Systems".
- M. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- N. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 25-mm annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- O. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 25-mm annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceways or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make water tight seal.

3.4 FIRE STOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7 Section “Through-Penetration Firestop Systems”.

3.5 FIELD QUALITY CONTROL

- A. Inspect installed sleeve and sleeve-seal installations and associated firestopping for damage and faulty work.

END OF SECTION

SECTION 16051– GENERAL INFORMATION AND REQUIREMENTS**1- SCOPE OF WORK**

1.1 ELECTRICAL WORK, unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the Drawings and/or described in the Specification together with all associated ancillary work, support work and builders work in connection.

1.2 EDL SUPPLY

The following incoming Power Supply and Connection shall be provided by EDL:
MV (20kV) power supply for landlord services including MV meter

Coordination with EDL shall include:

- * Determining exact tie-in point with nearest MV supply manhole of EDL in order to install necessary ducts with corresponding civil works connection to oil sump by Ø50mm pipe and natural ventilation openings (by Civil Contractor).
- * Providing the necessary services to transformer room as required by EDL (ventilation, opening / grill LV power supply if required by EDL).

It shall be the full responsibility of the Contractor to coordinate with EDL, and with existing nearest tie-in manhole of MV network in order to ensure all necessary electrical connection between EDL MV network and the transformer room of the project. No variation order shall be accepted with respect to interface with EDL after contract award.

1.3 TELEPHONE PUBLIC EXCHANGE LINES will be connected the premises by the Lebanese MPT. Contractor shall do necessary follow up with local MoC Authority and secure the required MoC approvals for the telephone system.

1.4 MOTORS AND OTHER ELECTRICALLY OPERATED EQUIPMENT:

All electrical work from and including motor control centers/panels to and including motors and other electrically operated equipment, which is included in the Specification for Mechanical Work or other work, does not form part of the Electrical Work, unless otherwise noted.

Power supply to motors and other electrically operated equipment, which are not connected to a motor control centre/panel, is included in the Electrical Work and comprises power supply to terminal box on equipment or nearby disconnecting or starting device, and includes the disconnecting device, if individually provided, but not the starting device or combination starter.

1.5 CONTRACTOR will undertake detailed design of the systems that are specified in the form of "performance specifications" in accordance with the criteria stated in the Specifications and as shown on the Drawings. Detailed design drawings / shop drawings / as built drawings design will be submitted for approval.

Contractor will also undertake all necessary coordination with relevant authorities having jurisdiction prior to completing the design.

1.6 The Contractor shall also:

- The contractor has to visit the site and liaise with concern Ministry Departments for verification of any existing Buried services such as Electrical Underground cables / Communication cables etc and with Ministry of Archaeology for any constraints on cable routing due to special conditions of Archeological site and should such services exist, within the Project Site layout limits, then the contractor has to include such prices in the tender for REROUTING of such services. No any claims for the damages or rerouting of services or any delays for obstruction of construction works, will be accepted after awarding the contract.
- Temporary electrical supply during construction of works
- Contractor has to arrange the necessary Authority approvals and ASBUILT DRAWING Approvals from the Ministry of Energy, Ministry of Communication and Ministry of Fire Brigade etc,
- Arranging and carry out the necessary Ministry Inspections and Approvals for the Electrical Installations , Communication Installations and Fire Alarm & Fire fighting Installations.
- Arranging Permanent Electrical Power supply and Allow for adequate & Appropriate Cable glands & Lugs etc for Ministry Power cables connections for the Electrical substation.
- Builders works, Ducts, Inserts, sleeves etc required for work.
- Co-ordination with all other related trades and services
- Asbuilt drawings, Operation & Maintenance manuals, Spares, other related project record documentations during Handing over of the project
- Training of Employers Staff for the operation of each systems are installed.

2. GENERAL REQUIREMENTS

2.1 INSTALLATION GENERALLY:

Carry out electrical work in accordance with the Drawings, Specification and Regulations, ensuring compliance with design and performance requirements, to provide safe and protected systems with equipment readily accessible for operation, maintenance and repair. Installations are to be complete, ready for operation and fully integrated and coordinated with all other work.

Installations are to be carried out by qualified personnel

Provide accessories necessary to complete the installations, of the types specified or recommended for the purpose by the manufacturer of the equipment or accessories.

2.2 EQUIPMENT SPACES AND ROOMS: check that dimensions, structure, ventilating and cooling arrangements and other provisions in equipment spaces and rooms are suitable for installation, operation and maintenance of proposed equipment. Note any discrepancies on the shop and construction drawings.

2.3 POWER SUPPLY : liaise with the EDL to confirm.

Characteristics of supply and system grounding.

Space requirements and associated builders work for the Authority's installations.

Make necessary arrangements at the earliest opportunity to ensure connection as and when required, and inform the Engineer in the event of any foreseen delay.

2.4 KWH-METERING: liaise with the EDL and provide required necessary instrumentation, enclosures and accessories to effect a complete kwh-metering installation.

2.5 TELEPHONE PUBLIC EXCHANGE LINES: liaise with the Local Lebanese MPT Authority to confirm location of connection of public telephone exchange lines into the premises.

2.6 SYSTEMS USED BEFORE SUBSTANTIAL COMPLETION: for the benefit of the Contractor are to have all consumable elements, such as lamps etc. and defective equipment replaced by new, within 7 days prior to the date of substantial completion.

3. DESIGN CONDITIONS

3.1 NOMINAL CHARACTERISTICS OF POWER SUPPLY AND DISTRIBUTION

are as follows:

medium voltage	:	20kV currently three phase, 3 wire low resistance neutral grounding 500 MVA
low voltage	:	380/220 V, three phase, four wire, 50Hz.
Solidly ground neutral frequency	:	50 Hz.

3.2 DISTRIBUTION SYSTEMS are to be supplied or derived from the voltage system previously described, as shown on the Drawings, or as otherwise specified.

3.3 EQUIPMENT: is to be designed for the system voltage and frequency previously described, unless otherwise specified. Special provisions are to be made for equipment sensitive to power supply frequency and voltage variations and for equipment operated at other voltages/frequencies or by direct current sources. **CLIMATIC CONDITIONS:** equipment, including transformers, switchgear, cables, relays, lighting fixtures, motors etc., is to be designed and derated for continuous and trouble free service under the following climatic conditions:

3.3.1 REGULATIONS: Carry out electrical work in accordance with the current issue of the local codes of practice the IEC 60304, where not in contradiction with the local codes of practice and regulations, herein referred to collectively as 'the Regulations'.

Maximum ambient temperature summer	: 40 deg . C (in the shade).
Minimum ambient temperature winter	: 5 deg. C
Maximum ambient temperature in plant room	: 40deg. C
Maximum ambient temperature in plant room with A/C	: 25deg. C
Maximum sun radiation corresponding to 33deg. Latitude (Beirut)	: 245Btu-hur /ft2
Minimum relative humidity	: 95%
Atmospheric conditions	: marine atmosphere plus sand and dust storms with particles of 0.1 microns diameter

3.4 CONFLICT should an instance occur in this specification or on the drawings in which material or construction methods called for is less than minimum requirement of the Regulations, the Engineer shall be immediately informed in writing. Consequent to Engineers approval, supply the materials and perform the work as though called for to minimum code standards.

3.5 STANDARDS: unless otherwise specified, equipment and materials are to be manufactured and installed in compliance with the relevant recommendations of the following:

NFPA: National Fire Protection Association (USA)

NEMA: National Electrical Manufacturer Association (USA)

ANSI: American National Standard Institute.

UL: Underwriter's Laboratories.

IEC The International Electro-technical Commission

ISO: The International Standardization Organization

CCITT: +-+The International Telephone and Telegraph Consultative Committee

CCIR: The International Radio Consultative Committee

CISPR: The International Special Committee on Radio Interference

or other equal and approved standards, herein referred to as 'the Standards'. Local standards, where enforced and relevant, are to have precedence over the Standards.

4. THE DRAWINGS

4.1 EQUIPMENT LOCATIONS shown on the Drawings indicate the approximate locations and general layout of equipment. Exact and final locations and layouts together with dimensions, weights, mounting methods and accessories, where relevant, are to be shown on the shop and construction drawings.

4.2 WIRING LAYOUTS shown on the Drawings are to be used as a guide only to defining basic positions, circuiting, loading and switching arrangements. Actual layouts and details of routing of circuits are to be shown on the shop and construction drawings.

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- 4.3 **WIRING LAYOUTS** shown on the Drawings for work not included in the Electrical Work, such as motor control centers/panels, cables to motors and other similar electrically operated equipment are shown for convenience and reference only.
- 4.4 **SYMBOLS:** in order to provide sufficient detail and a minimum degree of clarity on the drawings, the symbols used for the various electrical devices, particularly wall-mounted devices, take up more space on the drawings than the device does on the wall. Because of drafting limitations these locations must be considered as being symbolic rather than exact physical locations of the devices. The devices shall be installed with prime regard for convenience of operation and the proper usage of the wall space rather than to coincide with the scaled locations of the symbols. In locating the outlets, follow the criteria provided on detail drawings where provided, and coordinate with furniture. Do not scale from design drawings.
5. **EQUIPMENT AND MATERIALS:**
- 5.1 **AVAILABILITY:** confirm availability of equipment and materials proposed for use in the work prior to submission for approval. If, after approval, equipment or materials cease to be available, submit alternative items of equal quality and type for approval.
- 5.2 **ACCEPTANCE BY AUTHORITY:** confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other authorities having jurisdiction and are acceptable to them. Inform the Engineer of any modifications necessary to comply with the Local Power Authority's requirements.
- 5.3 **MANUFACTURERS' STANDARDS:** equipment is to be the latest standard product of the manufacturer. Component parts are to be the product of a single manufacturer, unless otherwise approved and provided that components made by other manufacturers are of a standard design and are interchangeable.
- 5.4 **APPROVED MANUFACTURER'S:** listing of approved manufacturers in the Specification does not necessarily constitute approval of their standard products as equal to those specified. Ascertain that listed manufacturers are able to supply equipment and material in conformity with the Specification.
- 5.5 **FACTORY ASSEMBLY:** equipment generally is to be supplied in complete factory assembled units ready for installation on site. Dis-assembly necessary for transportation or other purposes is to be arranged to limit site work to simple re- assembly and inter-wiring of control and power cabling.
- 5.6 **STORAGE OF MATERIALS:** equipment and materials are to be stored in an approved location, under cover, free from humidity, dust, debris and rodents. Equipment sensitive to heat and humidity is to be kept in climatically conditioned areas until installed and handed over.
- 5.7 **DEFECTIVE EQUIPMENT:** the Employer reserves the right to operate operable defective equipment during the Defects Liability Period until it can be removed from service for repair or replacement.

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- 5.8 WARRANTY:** where required by the Specification, provide a warranty, signed by the manufacturer (including his agreement to replace promptly, defective equipment or parts thereof, as instructed by the Engineer) covering materials and workmanship for the period stated in the Specification, starting at substantial completion. The Contractor is to assign the benefits of such warranty to the Employer.
- 5.9 SPARE PARTS:** not later than the date of substantial completion, provide spare parts required by the Specification, together with suitable means of identifying, storing and securing same.
- 5.10 TOOLS AND INSTRUMENTS:** not later than the date of substantial completion, provide sets of tools and instruments required by the Specification, together with suitable means of identifying, storing and securing same.
- 5.11 LABEL AND IDENTIFY** all equipment, instruments, control and electrical devices etc. to indicate duty, service or function, to the satisfaction of the Engineer. Labels are to be laminated plastic or anodized aluminum discs with black surface and white core with incised lettering in Arabic & English. Alternative methods of labeling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent surfaces or as approved by the Engineer.
- 5.12 EQUIPMENT NAMEPLATES** are to be non-corroding, robust metal, inscribed in English, and firmly fixed to equipment at factory. Nameplates are to indicate name and address of manufacturer, model, serial number, basic characteristics and ratings of equipment and are to include elementary diagrams etc., all in accordance with the Standards.
- 5.13 FIREPROOFING:** Where cables, cable trays, bus ducts or conduits pass through floors and fire rated walls, pack space between wiring and sleeve full with materials and seal with approved caulking compound.
- 6. SUBMISSION:**
- 6.1 GENERALLY:** submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.
- 6.2 COORDINATION STUDY:** and deliverables required from contractor a short circuit and protection coordination study, for the electrical distribution network, is to be carried out by the contractor and submitted to the Engineer for approval.

Contractor shall submit the following as per IEC:

- Cable sections calculations.
- Voltage drop (maximum permissible value being 5% at last outlet.
- Short circuit interrupting capacity values.

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- 6.3 TECHNICAL LITERATURE** is to include detailed manufacturers' specifications and original catalogues or catalogue cuts, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy the Engineer that proposed equipment and systems are suitable and adequate.
- 6.4 SHOP AND CONSTRUCTION DRAWINGS** are to demonstrate to the Engineer that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings are to clearly state the name and location of the work, the names of the Engineer and Contractor, submission date, cross- references to the Drawings and Specification and the specific reference number, location, service and function of each item.
- 6.5 SHOP AND CONSTRUCTION DRAWINGS** are to be submitted at a scale of 1:100 for general layout plans, and 1:10, 1:20 or 1:50 as approved by the Engineer for sections, details, elevations, congested layouts, etc. Drawings shall include but not be limited to the following:
- Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for passage through floor structure.
- Composite construction drawings fully dimensioned, in metric, showing locations of cables, conduits, bus ducts, shafts, mechanical and electrical equipment rooms, ceiling spaces and all other critical locations
- Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
- Plans, sections and elevations of electrical spaces to illustrate compliance with Standards for allocation of spaces for maintenance, movement, installation... etc.
- 6.6 LIST OF PROPOSED MANUFACTURERS** of all equipment and materials, including all items for which choice of manufacturer is at the discretion of the Contractor, is to be submitted for approval.
- 6.7 ASSEMBLED EQUIPMENT** any assembled equipment to be supplied for the project is to be assembled by the manufacturer or his authorized assembler. Contractor is to submit the necessary documents to substantiate the above including the assembler staff training, quality control, etc. The Engineer reserves the right to reject any local assembler if the information submitted is not sufficient. The Engineer's decision in that respect is final and not subject to discussion.
- 6.8 TEST CERTIFICATES AND REPORTS:** submit manufacturers type and routine test certificates and reports for equipment and devices. Complete test results are to be submitted in clearly identified and organized booklets, indicating item of equipment, make, model, type, date of tests, type of tests, descriptions and procedures. Include in the test reports the Quality Assurance Certification, the standards to which the equipment comply, and the standards to which the equipment was tested.

- 6.9 FACTORY TESTING:** for locally manufactured/assembled equipment is to comply with the relevant standards recommendations and are to be witnessed by the Engineer. If the manufacturers test certificates/tests are not complying with the standards, then independent laboratory tests are to be carried out on equipment in accordance with the Specification and the Standards, and as required by the Engineer. The Engineer's decision in that respect is final and not subject to discussion.
- 6.10 SPARE PARTS SCHEDULES:** submit with the Tender itemized schedules of spare parts to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.
- 6.11 TOOLS AND INSTRUMENTS SCHEDULES:** submit with the Tender itemized schedules of tools and instruments to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.
- 6.12 LABELING SCHEDULE:** submit for approval, prior to installation, a schedule of all equipment and devices to be labeled and the suggested details, lettering, position and fixing methods of each label indicating its application.
- 6.13 SAMPLES:** submit samples of all equipment and materials for approval. Major items of equipment for which samples cannot be submitted are to be demonstrated in existing installations or by manufacturers information, test certificates and reports

7. SPECIAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

- 7.1 CONSTRUCTION:** electronic components of communication systems, MATV and CCTV systems and special systems as well as electronic components forming part of the power distribution system are to be solid-state integrated construction, unless otherwise approved.
- 7.2 TEMPERATURE LIMITS:** manufacturer is to indicate maximum and minimum ambient temperatures acceptable for the equipment to operate continuously and normally and beyond which electronic components may suffer permanent damage. Contractor is to coordinate the air conditioning requirements for the rooms where the equipment are located. Inform the Engineer of any special requirements or discrepancies for a decision.
- 7.3 ALTERNATIVE ELECTRONIC EQUIPMENT:** maybe submitted for approval, provided such equipment meets or exceeds the functional capabilities and/or performance parameters of the equipment specified. Proposals for alternative equipment will be considered only if accompanied by the following information:

List of operational characteristics and performance parameters

List of differences in operation and performance between proposed and specified equipment

List of changes required and resulting implications

Drawings indicating changes required to system wiring

Statement of advantages of proposed equipment over that specified.

- 7.4 PROTECTION:** solid-state equipment under normal conditions of operation is to withstand any surges, which might be produced by sudden mains or standby power switching operations. Protective devices are to be provided to protect against surges, failure of output stages due to open circuit, short-circuit or miss-match. Comply with IEC standards and/or with IEEE standard 472 (ANSI/IEEE C37.90 Guide for Surge Withstand Capability Tests". System/equipment which may be adversely affected by short duration power blackouts shall be capable of riding through such a disturbance by having an internal battery back up to the memory / microprocessor, etc.
- 7.5 INDICATOR LIGHTS** other than LV pilot lamps are to be light emitting diodes (LEDs).
- 7.6 ELECTROMAGNETIC RELAYS** and control/small power transformers are to be designed to withstand the 500 V a.c. test voltage between winding and winding or winding and core.
- 7.7 DUST COVERS**, easily removable for inspection and servicing, are to be provided for all relays and sensitive elements.
- 7.8 OUTDOOR EQUIPMENT:** is to be designed for maximum ambient temperature in direct sun and is to be protected/enclosed, as applicable, against dust and weather conditions.
- 7.9 EXTERNAL INTERFERENCES** carry out field investigations and tests to determine possible interference from outside sources. Design electronic equipment to ensure trouble - free operation.
- 7.10 SEGREGATION OF WIRING:** design wiring so that low current circuits are segregated from power wiring, using different conduits and wireways for the purpose.

Composite wiring is acceptable for the same system in accordance with the relevant codes.

Cable insulation is to be same grade for all conductors in a common enclosure.

- 7.11 POWER SUPPLY UNITS:** for low current systems which are fed from the LV supply are to be independently fused on the live conductor and are to have front panel mains indicator light, on/off switch and standard cartridge type fuse holder. Blown fuse indicator lamp is to be provided when fuse does not have an indicator.

8. TESTS ON SITE RECORDS

TRAINING AND MAINTENANCE

8.1 TESTS ON SITE

- 8.1.1** carry out inspection and acceptance tests on site on each complete system, before final placement into service, in accordance with the Regulations and Standards, as described in the Specification and required by the Engineer.
- 8.1.2** **TEST SCHEDULES AND PROCEDURES** are to be submitted for approval and are to include details of testing equipment to be provided.
- 8.1.3** **WITNESSING:** inspection and acceptance tests are to be carried out in the presence of the Engineer, and when required, by an authorized representative of the Local Power Authority.
- 8.1.4** **VISUAL INSPECTION:** visually check proper installation, connections and nameplate data before testing.
- 8.1.5** **INSULATION RESISTANCE** test the feeders, lighting and power circuits, motors and other power equipment of low voltage installations with a megger of not less than 500 V d.c. for installations rated up to 500 V (r.m.s. value of a.c. supply) and 1000 V d.c. for installations rated above 500 V up to 1000 V. and as required by the particular Section of the Specification.
- 8.1.6** **INSULATION RESISTANCE:** unless otherwise specified or approved, test the circuit insulation resistance related to communications and security systems with a megger of not less than 500 V operating voltage, with equipment disconnected.
- 8.1.7** **CONTINUITY:** test all feeders and circuits for continuity.
- 8.1.8** **OPERATIONAL TESTS:** carry out operational tests on all equipment and complete systems to verify proper performance in compliance with the Specification. Tests are to be carried out under normal operating conditions for not less than 3 days and as required by the Engineer.
- 8.1.9** **SPECIFIC TESTS:** carry out specific tests required by the Specification and any other tests required by the Engineer to verify compliance of the installations with the Specification.
- 8.1.10** **VOLTAGE CHECKS:** perform voltage checks throughout the building and if directed by the Engineer, adjust the transformer tap settings where a transformer is provided on the supply end, or report to power authority for adjustment necessary.
- 8.1.11** **CURRENT CHECKS:** In cooperation with the mechanical sub-contractor, take clip-on ammeter readings on all phases of all mechanical equipment motors with motors operating under full load conditions. Test readings shall be submitted to the Engineer.

9. RECORDS:

9.1 GENERALLY: not later than the date of substantial completion, provide the Engineer with the required copies of all approved as-installed drawings, test records, manufacturers' guarantees and warranties, operating and maintenance manuals and other records required by the Specification.

9.2 PRESENTATION OF RECORDS: is to be in A4 size, plastic covered, loose-leaf ring binders or other approved binders with hard covers, that are indexed, divided and appropriately cover titled. Drawings larger than A4 size are to be folded in the binders so that they may be unfolded without being detached.

9.3 AS-INSTALLED DRAWINGS: are to contain the complete assembled information included on the construction drawings, prepared in the same manner, and up-dated to indicate the systems, labeling, referencing, mounting methods, routing etc. as installed. Submit complete drawings for approval. Drawings are to include but not limited to:

Layout plans including all conduiting and wiring installations for all systems

All changes to the work during construction including corrections that are made on floor plans and riser diagrams and detail drawings etc., as applicable.

Exact dimensioned location of all services embedded in the structure

Invert of all services entering and leaving the building and at property lines.

Dimensions and elevations of underground services in relation to building at key points of every- run.

Riser diagrams for all systems

10.1 TEST RECORDS are to include test certificates of type tests, routine tests, site tests, commissioning and performance tests and all other tests on equipment and installations described in the Specification and required by the Engineer. Information is to include test procedures and results, conditions under which tests were carried out including set points, temperatures and the like, dates, location and attendance by authorized representatives etc.

10.2 OPERATING AND MAINTENANCE MANUALS: are to contain the following:

Technical description of each system and item of equipment installed, written to ensure that the Employers staff fully understands the scope and facilities provided

Diagrammatic drawings of each system indicating principle components and items of equipment

Schedules (system by system) of equipment installed giving manufacturer, catalogue list numbers, model, rating, capacity and operating characteristics; each item is to have a unique code and number, cross- referenced to the diagrammatic drawings and layout drawings

Name, addresses, telephone, e-mail and fax numbers of the manufacturer of every item of equipment

Name, address, telephone and e-mail and fax numbers of equipment agents/representatives for emergency services and procedures

Manufacturer's service manual for each major item of equipment, assembled specifically for the project, including detailed drawings, illustrations, circuit details, operating and maintenance instructions, modes of operation, control provisions, sequences and interlocks and preventative maintenance program

Schedules of all fixed and variable equipment settings established during commissioning Procedures for fault finding, where applicable, data or recommended maintenance procedures, maintenance intervals and maintenance tools.

All test results conducted on the relevant equipment whether at the manufacturer's place or at site.

Manufacturers' lists of recommended spare parts for items subject to wear and deterioration, giving expected running period and indicating specifically those items, which may involve extended deliveries.

END OF SECTION

SECTION 16060
EARTHING SYSTEM (GROUNDING AND BONDING)

PART 1 - GENERAL

1.01 Description Of Work

Complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TNS system arrangement as defined in IEC60304, including:

Main earthing terminals or bars

Exposed conductive parts of electrical equipment

Extraneous conductive parts

1.02 Regulations And Standards

Carry out work in accordance with the following:

Local codes and regulations (if any)

IEC publications 364-3 and 364-4-41 Electrical Installations in Buildings

Latest edition of IEE Regulations for Electrical Installations in Buildings - London.

1.03 Definitions Of Terms

Used on the Drawings and in the Specification are as follows:

A. Earth

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

B. Earth Electrode

Conductor or group of conductors in initial contact with and providing electrical connection to Earth.

C. Exposed Conductive Part

Any part which can be readily touched and which is not a live part, but which may become live under fault conditions.

D. Extraneous Conductive Part

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

E. Protective Conductor

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

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

Protective conductor shall be equal to phase conductor for all phase conductors up to and including 16 mm. sq. Protective conductor shall be equal to half size (or next standard to half size) phase conductor, for phase conductor equal or larger than 25 mm. sq.

F. Electrically Independent Earth Electrodes

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

G. Main Earthing Terminal or Bar

The terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.

H. Equipotential Bonding

Electrical connection to put exposed and extraneous conductive parts at a substantially equal potential.

I. Earthing Conductor

Protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.04 SUBMITTALS

- A. Product Data: Prior to ordering materials, submit data for approval including, but not limited to manufacturer's catalogues for each type of product indicated including the following:
1. Ground rods
 2. Connecting clamps
 3. Earthing conductors, protective conductors, and bonding conductors
 4. Connectors and other accessories
 5. Exothermic welding kits and tools
 6. Samples of conductors connectors, or any other accessories as requested by the engineers.
- B. Qualification Data: for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects / engineers and owners, and other information specified or required by Engineer.
- C. Field Test Reports: Submit written test reports to include the following:
1. Test procedures used and test conditions
 2. Test results that comply with requirements
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.05 Shop And Construction Drawings

Submit drawings for approval including, but not limited to, the following:

1. Exact location of earth pits, rods and details of installation and connections.
2. Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.
3. Cross sectional area of all earthing, protective and bonding conductors.
4. Layout and details of earthing provisions at substations, generator rooms, switch distribution panel boards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.
5. Records: Submit the following:
 - Scaled drawings, as installed, showing actual layout and specification of all components of earthing system.
 - Nature of soil and special earth arrangements etc.
 - Date and particulars of soil conditioning method and agents if used.
6. Samples: submit samples of conductors, as requested by Engineer

1.06 Quality Assurance

- A. Installer qualifications: engage an experienced installer who has specialized in installing lightning protection systems similar in material, design and extent o those indicated for this Project and whose work has resulted in installations with a record of successful in-service performance.
- B. Standards: carry out work in accordance with the following:
 - 1. IEC 60364-1, IEC60364-51, IEC60364-5-55 and IEC 60364-4-41; electrical installations in buildings.
 - 2. Latest edition of the IEE wiring regulations BS 7671
 - 3. BS 7430: Code of Practice for earthing
 - 4. TIA J-STD-607-A: Commercial Building Grounding and Bonding Requirements for Telecommunications.
- C. Comply with BS EN 62305 when interconnecting with lightning protection system

PART 2 – PRODUCTS**2.01 MANUFACTURERS:**

- A. Approved manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
 - 1. Dehn (Germany)
 - 2. Copperweld (USA)
 - 3. Furse (UK)
 - 4. Wallis (UK)

2.02 PRODUCTS AND SYSTEM**Earthing System (Type TN-S)**

- A. **General Requirements**
- B. **Component Parts** of earthing system are to include the following:
 - 1. Earth electrode (rods, tapes etc.)
 - 2. Main earthing terminals or bars
 - 3. Earthing conductors
 - 4. Protective conductors
 - 5. Equipotential bonding conductors
 - 6. Accessories and termination fittings, bonding, welding kits and other materials.

- C. **Earth Electrodes** is to consist of one or more earth rods, interconnected by buried earthing tape or cable, installed under finish of floor or surface mounted. Earth electrode shall have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, **not** exceeding 5 ohms. If it is difficult to get the obtained 5 ohms add Macronite conductive aggregate in place of sand to the cement. Distance between two rods is not to be less than the length of one rod, or 3 m minimum.

All electrodes in basement shall have double flange seal with following specifications:

– **Inspection Pit:**

Earth rod seals shall be designed for use with the Furse high performance light weight inspection pit, PT205 (supplied separately) which provides a number of benefits:

- The pit provides adequate space for the termination of conductors to the rod, and has the facility for locating an earth bar should multiple connections be necessary.
- The lid has a safe working load of 5000kg and is capable of withstanding slow moving vehicular traffic.
- It fits quickly and neatly on to the seal assembly, thus avoiding the need for shuttering.

– **Sealing Kit**

The sealing arrangement, consisting of the improved compression rings and neoprene “O” rings has been pressure tested to 80psi or 5.5bar.

The earth seals, as supplied, will accommodate a range of copperbond, solid copper and solid stainless steel earth rods.

Please specify rod diameter when ordering, to ensure that the correct kit is supplied.

– **Main Flange and housing:**

This consists of two pieces high density polyethylene moulding, accommodating the sealing kit and protective tube of the earth rod electrode.

– **Protective tube:**

Made from non-degradable high impact ABS and supplied in 300mm 1200mm lengths. They shall be able to be cut to size as required, to suit the applications.

- D. Main earthing bar is to be provided at point of service entrance, main MV or LV distribution rooms, electrical substations, generator room, low current and communication rooms and as described in the specification or shown on the drawings, to which all earthing conductors, protective conductors and bonding conductor are to be connected. Provide two insulated main earthing conductors, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160deg. C. for at least 5 seconds. Main earthing conductors are to be minimum 120mm² or as otherwise required by the particular section of the specification.
- E. Testing joints (test links) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar and earth electrode.
- F. Protective conductors are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes.

Selection of sizes is to be in accordance with IEE regulations.

Protective conductors are not be formed by conduit, trunking, ducting or the like. Where armored cable is specified and armor is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the drawings.

- G. Continuity of protective conductors: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and / or brazing to continuous protective conductors which are to be insulated by molded materials.
- H. Earth fault loop impedance: for final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on over-current occurs within 0.4 seconds. For final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds.

Use appropriate tables and present same for approval by the Engineer (IEE Wiring Regulations).

- I. Supplementary Equipotential bonding: Connect all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armor to nearest earthing terminals by equipotential bonding conductors. Cross section of protective bonding conductor shall not be less than half of the protective conductor connected to respective earthing terminal with a minimum of 4-mm².

- J. Main equipotential bonding: main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry / exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premise side of the meter. Cross sections of conductors are not to be less than half that of the earthing conductor connected thereto, and minimum 16mm².
- K. Identification: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labeled in accordance with the regulations, as follows:

Safety electrical connection – Do No Remove.
- L. Identification: Protective and earthing conductors are to be identified by combination of green-and-yellow colors of insulation or by painting bar conductors with these colors, as approved.
- M. Identification: Source conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labeled “neutral earthing”

2.03 GROUNDING CONDUCTORS

- A. Buried earth conductors: annealed stranded copper conductors 120mm² cross-section unless otherwise indicated on drawings.
- B. Earthing conductors: insulated or bare copper conductor as described in the specification for the particular application.
- C. 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.
- D. Protective bonding conductors: Bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in Article “General Requirements” hereof.
- E. Main earthing bar: hard drawn copper, 40 x 4mm where formed into a closed loop, and 50x10mm where open-ended. Earth bar is to be labeled “main 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.
- F. 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.

2.04 CONNECTOR PRODUCTS AND EARTHING ACCESSORIES

- A. Copper or copper alloy, purpose made of approved design, compatible with points of connection and of adequate cross-section and current carrying capacity.
- B. Bolted connectors and clamps: bolted-pressure-type connectors and clamps, or compression type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.
- C. Welded connectors: exothermic welded type, in kit forms, and selected per manufacturer's written instructions.

2.05 GROUNDING ELECTRODE

- A. Ground Rod: 16mm diameter high strength, low carbon steel core of high tensile strength (600N /mm²) with 99.99% pure electrolytic copper molecularly bonded into steel core, 0.25mm minimum thickness. Driving head is to be high strength steel. Couplings are to be long length silicon bronze, internally threaded. Threads are to be rolled onto rod to ensure uniform layers of copper and strength. 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.

Minimum lengths of Rod: 2.4m, extendible as necessary to obtain required earth resistance.

- B. Tape Mats (Earth Lattice): where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4m apart, welded together by exothermic welds to form a 600x600 grid. Tape is to be 25x3mm strip conductor.
- C. Earth pit: precast, square or circular section concrete handhole (minimum 450mm internal diameter) with concrete cover, and extending to about 150mm below top of earth rod. Earth pit is to be provided for each earth rod where connect to an earthing conductor. Cover is to have inset brass plate with inscription “ earth pit – do not remove.
- D. Functional Earth Electrode is to be provided separately from, but interconnected to, other earth electrode(s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.
- E. Alternative Earth Electrode other types of earth electrode may be used, after approval, including:
 - Cast iron pipes with special surround material
 - Copper plate(s)
 - Tape mats (strips)

- F. Earth Fault Loop Impedance for final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on over current occurs within 0.4 seconds, and for final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds. Use appropriate tables and present same for approval by the Engineer (IEE Regulations: Tables 41A1 and 41A2, Appendix 7 and regulation 543).
- G. Supplementary Equipotential bonding all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable Armour are to be connected to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor is not to be less than half that of the protective conductor connected to respective earthing terminal and minimum 4 mm².
- H. Main Equipotential Bonding main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premises side of the meter. Cross-sections of conductors are not to be less than half that of the earthing conductor connected thereto, and minimum 6 mm².
- I. Identification connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labeled in accordance with the Regulations, as follows:

"SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE".
- J. Identification protective and earthing conductors are to be identified by combination of green-and-yellow colors of insulation or by painting bar conductors with these colors, as approved.
- K. Identification source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labeled, 'neutral earthing'.

2.06 TRANSFORMER SUBSTATION EARTHING

This paragraph applies to both EDL substation with oil filled transformers and private dry type transformer substation. For EDL substation, contractor shall coordinate with EDL to abide by their requirements if different from the specifications.

MV SWITCHGEAR is to have separate main earthing bar connected to framework or earth bar of each item by bare conductor and the earth-electrode by two insulated earthing conductors, one at each end of bar, via testing joints. Earthing conductor is to be minimum 50 mm².

LV SWITCHGEAR is to have separate main earthing bar connected to framework or earth bar of each item by bare conductor and the earth electrode at two extreme ends by two insulated earthing conductors through testing joints. Earthing conductor size is to be minimum 120 mm².

TRANSFORMER EARTHING TERMINAL is to be connected to LV main earthing bar by bare copper earthing conductor not less than 20 mm² per 100 KVA of transformer rating, with a minimum of 35 mm².

TRANSFORMER NEUTRAL (STAR POINT) is to be connected by insulated earthing conductor (colour black) to LV side main earthing bar. Neutral earthing conductor is to be sized for maximum earth fault current for 5 seconds with final conductor temperature not exceeding 160 deg. C or sized not less than 30 mm² per 100 KVA of transformer rating, and with a minimum of 50 mm². Where a neutral is directly connected to earth electrode, an insulated disconnecting device is to be provided at the transformer.

LIGHTNING ARRESTERS are to be directly connected to earth electrode, following the shortest path. Each lightning arrester is to be connected at a dedicated earth rod.

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

MAIN EARTHING BAR is to be provided in main distribution room and connected to earth electrode by two insulated conductors (minimum 120 mm²) via testing joints.

EARTHING BARS OF MAIN DISTRIBUTION BOARDS are to be connected, by bare earthing conductor, directly to main earthing bar at main distribution room and by protective conductor run with incoming feeder from respective supply point.

DISTRIBUTION, LIGHTING AND POWER PANELBOARDS are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main distribution board earthing bar.

SOCKET OUTLETS are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.

FINAL RING SUBCIRCUITS: protective conductor of every final ring sub-circuit is to be in the form of a ring having both ends connected to earth terminal at origin of circuit in panelboard.

LIGHTING FIXTURES AND OTHER EXPOSED CONDUCTIVE PARTS of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panelboards.

2.08 **MATERIALS AND PRODUCTS**

EARTH ROD: copper steel, 25 mm diameter, 3 m length, extendible as necessary to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to cannal cables terminated thereto.

BURIED EARTH CONDUCTORS: bare annealed copper strip conductors 25 x 2.5 mm, or annealed stranded copper conductors 70 mm² cross-section.

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

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

EARTHING CONDUCTORS: insulated or bare copper conductor as described in the Specification for the particular application.

TESTING JOINTS (TEST LINKS): copper or copper alloy, with bolted end connections, disconnect able by use of 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.

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, colour coded.

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

PROTECTIVE BONDING CONDUCTORS: bare copper strip conductors, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in sub-section.....

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.

2.09 MANUFACTURERS and SUPPLIERS

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Furse (UK)
2. BICC (UK)
3. Wallis (UK)
4. Dehn (Germany)

PART 3 – EXECUTION

3.01 **FIELD AND INSTALLATION WORK (INSTALLATION)**

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

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

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

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

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

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

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

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

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

3.02 TESTS ON SITE AND RECORDS

- A) Combined Resistance of earth electrodes is to be measured during dry season and checked against specified resistance.
- B) Electrical Continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.
- C) Earth Fault Loop Impedance of all circuits is to be measured and checked against calculated impedance figures.
- D) Records: submit the following:
 - 1. Scaled drawings, as-installed, showing actual layout and specification of all components of earthing system.
 - 2. Nature of soil and any special earth arrangements etc.
 - 3. Date and particulars of soil conditioning method and agents if used.
 - 4. Test conditions and results obtained.
- E. OPERATING AND MAINTENANCE MANUALS are to contain the following:
 - 1. Technical description of each system and item of equipment installed, written to ensure that the Employer's staff fully understand the scope and facilities provided
 - 2. Diagrammatic drawings of each system indicating principle components and items of equipment
 - 3. Schedules (system by system) of equipment installed giving manufacturer, catalogue list numbers, model, rating, capacity and operating characteristics; each item is to have a unique code and number, cross- referenced to the diagrammatic drawings and layout drawings
 - 4. Name, address, telephone, telex and fax numbers of the manufacturer of every item of equipment

5. Name, address, telephone and telex numbers of equipment agents/representatives for emergency services and procedures
6. Manufacturer's service manual for each major item of equipment, assembled specifically for the project, including detailed drawings, illustrations, circuit details, operating and maintenance instructions, modes of operation, control provisions, sequences and interlocks and preventative maintenance programme
7. Schedules of all fixed and variable equipment settings established during commissioning
8. Procedures for fault finding, where applicable
9. Manufacturers' lists of recommended spare parts for items subject to wear and deterioration, giving expected running period and indicating specifically those items which may involve extended deliveries.
10. Prepare two temporary copies with provisional record drawings and preliminary performance data and make available at time of testing and commencement of commissioning to enable the Employer's staff to familiarize themselves with the installations. Temporary copies are to be in the same format as the final manuals with temporary insertions for items, which cannot be finalized until installations are commissioned, and performance tested.

3.03 TRAINING

OPERATION AND MAINTENANCE TRAINING: before the date of substantial completion, explain and demonstrate to the Employer's maintenance staff the purpose, function and operation of the installations including all items and procedures listed in the operating and maintenance manuals.

END OF SECTION

SECTION 16073 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Nonmetallic slotted support systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Nonmetallic slotted channel systems. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS.

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - Allied Tube & Conduit.
 - ERICO International Corporation.

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- Thomas & Betts Corporation.
 - Unistrut; Tyco International, Ltd.
 - Or approved equal.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 4. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 5. Fitting and Accessory Materials: Same as channels and angles
 6. Rated Strength: Selected to suit applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) MKT Fastening, LLC.
 - 3) Or approved equal.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 1) Hilti Inc.
 - 2) MKT Fastening, LLC.
 - 3) Or approved equal.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 6. Toggle Bolts: All-steel springhead type.
 7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 5 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 6 mm in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, may be supported by openings through structure members, as permitted in NFPA 70.

- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 90 kg.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. To Light Steel: Sheet metal screws.
 - 6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 5 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 100 mm larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete.
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Comply with requirements in Division 9, painting Sections, for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 16075 - ELECTRICAL IDENTIFICATION

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 the following:
 - 1. Identification for raceway and metal-clad cable.
 - 2. Identification for conductors and communication and control cable.
 - 3. Underground-line warning tape.
 - 4. Warning labels and signs.
 - 5. Instruction signs.
 - 6. Equipment identification labels.
 - 7. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Color for Printed Legend: Each system will have its own and unique color as specified by the consultant.
 - 1. Legend: Indicate system or service and voltage, if applicable.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 50 mm long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 50 mm wide; compounded for outdoor use.

2.2 CONDUCTOR AND COMMUNICATION AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 0.08 mm thick by 25 to 50 mm wide.
- B. Every cable sheath shall be permanently identified with its item designation code. Labels shall be fixed at each end and at entry/exit points of ducts, buildings, etc. Where cable gland is not normally visible, and additional label shall be fitted inside the panel. Labels shall give cable usage (power, control, lighting, etc.), and brief load description and shall be fixed over cable entire length at every fifteen (15) meter.
- C. Cable markers shall comprise semi-rigid black PVC carrier strips fitted with flat, hollow white or yellow ferrules with black lettering. Carrier strips shall be fixed using 2 No.1 black PVC ratchet straps.

2.3 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 - 1. Not less than 150 mm wide by 0.102 mm thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 6.4-mm grommets in corners for mounting. Nominal size, 180 by 250 mm.
- D. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 915 mm."

2.5 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1.6 mm thick for signs up to 129 sq. cm and 3.2 mm thick for larger sizes.
 - 1. Engraved legend with black letters on white face,
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

- A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 10 mm.
- B. Stenciled Legend: In nonfading, waterproof, Black ink or paint. Minimum letter height shall be 25mm.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 5 mm.
 - 2. Tensile Strength: 22.6 kg, minimum.
 - 3. Temperature Range: Minus 40 to plus 85 deg C.
 - 4. Color: Black, except where used for color-coding.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 100 mm wide black stripes on 250-mm centers over orange background that extends full length of raceway or duct and is 300 mm wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 75 mm high black letters on 500 mm centers. Stop stripes at legends. Apply to the following finished surfaces:
 - 1. Floor surface directly above conduits running beneath and within 300 mm of a floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to raceways concealed within wall.
 - 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 50 mm high, with snap-around labels. Repeat legend at 3 m maximum intervals.
- C. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, snap-around, color-coding bands:
 - 1. Fire Alarm System: Red.
 - 2. Fire-Suppression Supervisory and Control System: Red and yellow.
 - 3. Security System: Blue and yellow.
 - 4. Mechanical and Electrical Supervisory System: Green and blue.
 - 5. Telecommunication System: Green and yellow.
 - 6. Control Wiring: Green and red.

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- D. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - Power transfer switches.
 - Controls with external control power connections.
 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
- E. Instruction Signs:
1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 10-mm high letters for emergency instructions at equipment used for power transfer.
- F. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 13-mm high letters on 38 mm high label; where 2 lines of text are required, use labels 50 mm high.
 - Outdoor Equipment: Engraved, laminated acrylic or melamine label 100 mm high.
 - Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 2. Equipment to Be Labeled:
 - Panelboards, electrical cabinets, and enclosures.
 - Access doors and panels for concealed electrical items.
 - Electrical switchgear and switchboards.
 - Transformers.
 - Electrical substations.

- Emergency system boxes and enclosures.
- Motor-control centers.
- Disconnect switches.
- Enclosed circuit breakers.
- Motor starters.
- Push-button stations.
- Power transfer equipment.
- Contactors.
- Remote-controlled switches, dimmer modules, and control devices.
- Battery inverter units.
- Battery racks.
- Power-generating units.
- Voice and data cable terminal equipment.
- Master clock and program equipment.
- Intercommunication and call system master and staff stations.
- Television/audio components, racks, and controls.
- Fire-alarm control panel detectors and sounders.
- Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
- Monitoring and control equipment.
- Uninterruptible power supply equipment.
- Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 15 m maximum intervals in straight runs, and at 7.6 m maximum intervals in congested areas.

- G. Color-Coding for Phase Identification: Power cable cores, which are color-coded red, yellow, blue and black, will in many cases, require no additional designation. On motors where the power connections are designated X, Y, Z (and X1, Y1, Z1 for six wire connected motors), the cable cores shall be labeled with ferrules according to the connection of the core. Connections shall be as follows:

Cable Core	Normal Rotation	Reverse Rotation
RED	R	T
YELLOW	S	S
BLUE	T	R

- H. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 150 mm from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 150 to 200 mm below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 400 mm overall.

END OF SECTION

SECTION 16120 – WIRES AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 SUMMARY:

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

1.3 SUBMITTALS:

- A. Product Data: submit manufacturer's data on electrical wires, cables and connectors.
- B. Field Test Reports: indicating and interpreting test results relative to compliance with performance requirements of testing standards.
- C. Submit detail Voltage drop calculations for the Cables & wires sizes as shown in the drawings & BOQ. Any increase in cable sizes other than the cable sizes which are indicated in the Drawings & BOQ , shall be responsibility of contractor without any additional claims.

1.4 QUALITY ASSURANCE:

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

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Deliver wire and cable properly packaged in factory-fabricated type containers, wound on factory reels.
- B. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.
- C. Handle wire and cable carefully to avoid abrasing, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

PART 2 - PRODUCTS**2.1 MANUFACTURERS:**

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

Liban Cables.
Modern Cable.
Gulf Cables Kuwait

2.2 GENERAL REQUIREMENTS

- In general, all feeders will be installed in conduits laid on cable trays, in trenches or in vertical shafts.
- Life safety and critical feeders shall be of the fire rated type capable of sustaining fire for two hours minimum.
- Cable penetrations through fire separation zones shall be capped off with fire stopping material.
- Cable sizes shall be given in metric units.
- Cables shall have copper conductors stranded for section 4mm² and above, based on IEC 60228 ED 30b Class 2. Signal and control cables are to have solid conductors. Flexible cords are to have finely stranded conductors. Conductors of single core cables 25mm² and above are to be compacted. Multi-core cables 35mm² and above shall be of the sectoral shape.
- Cables buried directly in the ground shall be armored, protected by concrete tiles and warning tapes. When crossing under roads, pipe banks or other services, directly buried cables are to be laid in heavy-duty PVC duct banks. In no case are cables to be directly buried in concrete, in masonry or in floor finish.
- Cables shall be color coded or otherwise identified in accordance with the regulations as applicable to the voltage system. Building wiring insulation shall be as such:
 - Red, Blue, Black for the phases (1, 2, 3)
 - Grey for the neutral
 - Green / Yellow for the earth.
 - Phase conductors for which outer jacket is not color-coded are to have engraved alphanumeric mark (L1, L2, L3) or color-coded heat-shrinkable sleeves.

- Low voltage main feeders and sub-feeders (down to 10mm.sq. section) extending from the transformers to the automatic transfer switches, the main distribution boards and the distribution panels on the floors, shall be copper, XLPE insulated, and PVC sheathed multicore cables.

Cables of cross section equal and smaller than 10mm.sq shall have PVC insulation.

Cables of cross section equal or greater than 16.mm.sq shall have XLPE insulation.

Characteristics of cables shall be:

- **Conductor**

Plain, annealed electrolytic copper or aluminium conductors, solid circular stranded, or sectoral stranded, conforming to the applicable requirements of IEC 60228 ED 30b:2004.

- **Insulation**

PVC based thermoplastic or XLPE thermosetting material, conforming to the applicable requirements of IEC 60502-1.

- **Assembly**

Insulated conductors are laid up, filled where necessary with non-hygroscopic material and covered with an additional layer of extruded thermoplastic material or non-hygroscopic binding tape.

- **Sheath**

PVC based thermoplastic material, conforming to the applicable requirements of IEC 60502-1.

- **Tests**

Conforming to the applicable requirements of IEC 60502-1 either on raw materials or on finished products.

- High temperature cable-type FP200: solid or stranded plain annealed copper conductors to BS 6360 (in sizes up to 4 mm²), extruded silicon rubber insulation to BS 6889 (0.6 mm radial thickness), PVC/PVC laminate and PVC composite sheath with tinned earth continuity conductor / drain wire. Cable is to be rated 300/500 V. capable of accepting voltage surges up to 5KV, to operate continuously at 150 deg. C and for short durations at 200 deg C. It is to be certified to have passed IEC 331 and IEC 332 flame resistance and fire retardant tests. Cable is to be of type FP200 or other equal and approved.

- Multi-Core PVC Insulated control Cables 0.6/1KV rating, solid 1.5mm², 2.5 mm² or stranded 4mm² plain circular copper conductors conforming to IEC60228, with heat resistive PVC/E to IEC 227 (PVC type 5 to BS 6746), rated for 85 degree C, of 7, 12, 19, 24, 30 or 37 cores. Core are to be laid up together and filled with non-hygroscopic material, PVC over-sheathed, to form compact and circular cable for use in switchgear, control gear and generally for control of power and lighting systems. Armored cable is to have extruded PVC bedding which may be an integral part of the filling. Galvanized steel wire armoring, and over-sheath of PVC type ST2 to IEC60501-1, color black. Core identification is to be white printed numbers 1,2, 3 etc. over black insulation.
- Control and signal cables, for use on data systems, are to be generally 300 V rating, polyethylene insulated (PE), color coded, tinned copper conductors (0.6mm diameter) twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075 mm bare copper shielding tape and provided with drain wire and overall PVC sheath.

Characteristics of single core PVC insulated cables shall be:

- **Conductor**

Plain, annealed, electrolytic copper conductors, solid or stranded, complying with the applicable requirements of IEC 228.

- **Insulation**

PVC based thermoplastic material, conforming to the applicable requirements of IEC 227.

Minimum conductor size used shall not be less than 2.5mm².

- Flexible cable for connection to appliances, window fans, pendants etc. is to be 300/500V grade to BS 6500, three or four core, with tinned finely stranded copper wired, EPR insulated, twisted and sheathed with chlorosulphonated polyethylene (CSP) compound and with strengthening cord.

PART 3 – EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 16 Section "Electrical Supports and Seismic Restraints."
- F. Identify and color-code conductors and cables according to Division 16 Section "Electrical Identification."

3.2 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least (300 mm) of slack.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping material.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve rectangle perimeter less than (1270 mm) and no side greater than (400 mm), thickness shall be (1.3 mm).
 - 2. For sleeve rectangle perimeter equal to, or greater than, (1270 mm) and 1 or more sides equal to, or greater than, (400 mm), thickness shall be (3.5 mm).
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

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- F. Cut sleeves to length for mounting flush with both wall surfaces.
 - G. Extend sleeves installed in floors (50 mm) above finished floor level.
 - H. Size pipe sleeves to provide (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 - I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
 - J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 7 Section "Joint Sealants."
 - K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 7 Section "Through-Penetration Firestop Systems."
 - L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
 - M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 7 Section "Through-Penetration Firestop Systems."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections and prepare test reports.
- C. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- D. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 16130 - RACEWAYS AND BOXES

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 raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.
- C. FMC: Flexible metal conduit.
- D. IMC: Intermediate metal conduit.
- E. LFMC: Liquidtight flexible metal conduit.
- F. LFNC: Liquidtight flexible nonmetallic conduit.
- G. NBR: Acrylonitrile-butadiene rubber.
- H. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Custom enclosures and cabinets.
 - 2. For handholes and boxes for underground wiring, including the following:
 - a. Duct entry provisions, including locations and duct sizes.
 - b. Frame and cover design.
 - c. Grounding details.
 - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - e. Joint details.

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

3. Structural members in the paths of conduit groups with common supports.
 4. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
- C. Qualification Data: For professional engineer and testing agency.
- D. Source quality-control test reports.
- E. Locally manufactured conduits in Lebanon are not approved.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 -PRODUCTS

2.1 METAL CONDUIT AND TUBING

- 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 for Rigid Steel, IMC, EMT, LFMC:
1. Wheatland (USA)
 2. Allied Tube (USA)
 3. Barton (UK)
 4. Simplex (UK)
 5. Kopex (UK)
 6. Adaptaflex (UK)
 7. Univolt (Austria).
 8. Maruchi (Japan)
- C. Rigid Steel Conduit: UL 1242, ANSI C80.1 or CEE 23, BS 4568 Part 1 and BS 31 (Class B).

Material shall be heavy gauge drawn and welded steel, threaded at both ends, with class 4 protection for rigid steel conduit, zinc coated inside and outside by hot dip process.

FITTINGS GENERALLY: threaded type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated. Fittings and components are to comply with BS EN 50086-1 and BS 31.

LOCKNUTS for securing conduit to metal enclosure are to be heavy hexagonal or castellated pattern, for fastening.

BUSHINGS for terminating conduits are to be smooth rounded brass rings.

MISCELLANEOUS FITTINGS including reducers, chase, nipples, three piece unions, split couplings and plugs are to be standard fittings designed and manufactured for the particular application.

D. IMC: ANSI C80.6.

Rigid high grade mild strip welded, steel, hot dip galvanized over the entire length including factory made treads, after cutting with organic corrosion resistant polymer inside coating.

IMC FITTINGS GENERALLY: threaded fittings and connectors and terminations with rigid coupling, concrete tight where required, and with red lead coated threads where site cut. Factory made bands are to be provided where site bending is not possible.

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

E. EMT: ANSI C80.3, UL 797.

Welded steel, non threaded type, galvanized externally and protected internally with corrosion resistant enamel.

EMT FITTINGS GENERALLY: threaded pressure type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated. Factory made bends are to be provided where site bending is not possible.

CORROSION RESISTANCE: conduits used in corrosive atmospheres are to be copper silicon alloy, highly resistant to corrosion.

F. LFMC: Flexible steel conduit with PVC jacket.

To have PVC jacket extruded over core. Material shall be steel, cold rolled, and annealed, non threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside, to BS EN 50086-1.

FITTINGS GENERALLY: threadless, hinged clamp type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.

STRAIGHT CONNECTORS: one piece body, female end, having hinged clamp and deep slotted machine screws for securing to conduit, male end having thread and locknut.

ANGLE CONNECTORS of 45 or 90 degree and terminal connectors are to be as specified for straight connectors, except that body is to be two-piece with removable upper section.

- G. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 2. Fittings for EMT: Steel, Die-cast, Steel or die-cast, set-screw, compression, set-screw or compression, type.
 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- H. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- 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 for RNC, LFNC and fittings:
- They shall be embedded in the concrete and block walls and shall be used as conduit above false ceiling.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. MK-Ega (UK)
 2. Decoduct (UAE)
 3. Thomas & Betts Corporation (US)
 4. Hepworth (UK for underground PVC duct)
 5. Al Adasani (Kuwait for underground PVC duct)
- C. RNC: NEMA TC 2, Type EPC-40-PVC or approved European equal (BS EN)
- D. LFNC: UL 1660.
- E. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

G. RNC MATERIAL: rigid unplasticized polyvinyl chloride with high impact and high temperature resistance, flame retardant, non-hygroscopic and non-porous, to CEE 26, BS 4607 and BS EN 50086-1, DIN 49016 or other equal and approved standards conforming to IEC 423, 614-1 and 614-2-2.

H. TECHNICAL PROPERTIES:

Mechanical Properties:

- Percentage of Compression with specified load less than 25%
- Percentage of compression without load less than 10%
- Tensile strength -390, -420Kg. / cm²

Electrical Properties:

- Dielectrical Strength = 36Ky/mm
- Specific resistance = 6.1x10¹⁴ohm cm
- Electric Strength = No breakdown at 2Kv x 50hz. For 15 minutes

Thermal Properties:

- Working Temp. = 70°C
- Burning rate Self: extinguishing
- Flammability = UL94V-0
- Flame Die out Time = less than 30 seconds

RNC FITTINGS GENERALLY: unbreakable, non-inflammable, self extinguishing, heavy moulded plastic. Expansion couplings are to be telescoping double tube type, with at least two inner water-tight neoprene rings.

RNC ASSEMBLY: conduits, boxes and accessories are to be assembled by cementing, using manufacturer's recommended products and appropriate connectors or spouts. Where no spouts are available use smooth bore male PVC bushes and sockets.

LFNC MATERIAL: flame retardant, heat resistant, non-hygroscopic PVC, high resistance to impact, ribbed on circumference for flexibility.

Underground PVC ducts shall have the following specifications:

Nominal size (in)	Wall thickness
2	1.5
3	2.5
4	2.9
5	3.07

- Material: PVC
- Specific gravity : 1.4
- Vicat softening point: 82C to BS 2782
- Inflammability: not to support combustion
- Tensile strength: 6750 PSE at 20C
- Impact strength: 3.5 ft-lb
- Compressive strength: 9,500PSI
- Flexural strength : 13,500PSI

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

- 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:
1. Arco Corporation.
 2. Endot Industries Inc.
 3. IPEX Inc.
 4. Lamson & Sessions; Carlon Electrical Products.
- C. Description: Comply with UL 2024; flexible type, approved for plenum, riser, general-use, installation.

2.4 METAL WIREWAYS / TRUNKING

- 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:
1. Cooper B-Line, Inc.
 2. Hoffman.
 3. Square D; Schneider Electric.
 4. Or Approved Equal.
- C. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, 12, 3R, unless otherwise indicated.
- D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- E. Wireway Covers: Screw-cover type.

- F. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS

- 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:
1. Hoffman (USA)
 2. Lamson & Sessions; Carlon Electrical Products (USA)
 3. MK Ega (UK)
 4. Marghall Tufflex (UK)
 5. Decoduct (UAE)
 6. or approved equal.
- C. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.
- D. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- E. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.6 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (UK).
 - c. Wiremold Company (The); Electrical Sales Division.
 - d. Barton (UK)
 - e. Van Trunk (UK)
 - f. Maruchi (Japan)

2.7 BOXES, ENCLOSURES, AND CABINETS

- 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:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman.
 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 6. O-Z/Gedney; a unit of General Signal.
 7. MK (UK)
 8. Crabtree (UK)
 9. Simplex (UK)
 10. Batron (UK)
 11. Thomas & Betts Corporation.
 12. Walker Systems, Inc.; Wiremold Company (The).
 13. Applebee (UK)
- C. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- D. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, aluminum, Type FD, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- F. Metal Floor Boxes Cast or sheet metal], fully adjustable, rectangular.
- G. Nonmetallic Floor Boxes: Nonadjustable, round.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.
- J. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures: Plastic finished inside with radio-frequency-resistant paint.

K. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.8 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Characteristics

1. Color of Frame and Cover: Gray.
2. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, ELECTRIC, TELEPHONE, BROADBAND TV, as indicated for each service.
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Or Approved Equal.

2.9 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

2.10 SLEEVE SEALS

- 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:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Or approved equal.
- D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.11 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by a independent testing agency.
 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 -EXECUTION**3.1 RACEWAY APPLICATION**

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit Type EPC-40-PVC or RNC type EPC-40, 80-PVC.
 2. Concealed Conduit above false ceiling: EMT Type EPC-40-PVC.
 3. Underground Conduit: RNC, Type EPC-40, 80-PVC, direct buried.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
 6. Application of Handholes and Boxes for Underground Wiring:
 - a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: SCTE 77, Tier 15 structural load rating.
 - b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Ve

B. CONDUITS AND WIREWAYS APPLICATIONS AND INSTALLATION, GENERAL

1. Conduits and wireway installation are to be as described below, unless otherwise shown on the drawings or described in the particular section of the Specifications.
2. Rigid heavy gauge steel conduit is to be used for all exposed installations comprising lighting, power, low current, communication and signal system wiring, including mechanical equipment rooms, electrical equipment rooms, service areas. Use rigid steel conduit in areas classified as hazardous explosive area. Flexible conduit is not acceptable.
3. Electrical Metal Tubing (EMT) is to be used for exposed installations over false ceilings when the false ceiling is used as a return plenum.
4. Electrical Metal Tubing (EMT) is to be used for exposed and above false ceiling wiring installations used in conjunction with exit and escape route lighting, fire alarm and security installations.
5. Electrical Metal Tubing (EMT) is to be used for all installations in elevator machine rooms and shafts, electrical equipment rooms, mechanical rooms.
6. Conduit termination in sheet metal enclosures is to be fastened by lockouts, and terminate with busing. Install locknuts inside and outside enclosure.
7. Rigid heavy gauge PVC conduit is to be used for lighting and power circuits, low current, communication and signal system wiring, where embedded in concrete masonry earth, underfloor, except where otherwise shown on the drawings or described in the particular section of the Specification.
8. Rigid heavy gauge PVC conduit is to be used above false ceilings for lighting and power circuits, low current, communication and signal system wiring, when the false ceiling is not used as return plenum and in furred walls. Use flexible PVC conduits from outlet boxes to fixtures in conjunction with the use of PVC conduits.
9. Flexible conduit of same material as corresponding conduit system is to be used for connection to motors, vibrating and non-rigidly fixed equipment and to fixtures installed in false ceilings.
10. Flexible steel conduit is to be used in movable partitions and from outlet boxes to fixture over false ceilings when used as a return plenum. Conduits are to be liquid tight in damp areas.
11. Liquid-tight flexible steel galvanized conduit PVC conduit is to be used in one or more of the following conditions:
 - a- Exterior location
 - b- Moist or humid atmosphere where condensate can be expected to accumulate
 - c- Corrosive atmosphere
 - d- Subjected to water spray or dripping oil, water or grease.

3.2 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Support raceways as specified in Division 16 Section "Electrical Supports and Seismic Restraints."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
- I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

-
1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
 2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where otherwise required by NFPA 70.
- N. All conduit work and plastering shall be complete before wires are pulled in unless otherwise permitted by the Engineer. Conduit shall be plugged with cork and boxes covered appropriately to avoid filling with plaster.
- O. Conduit runs between outlets shall not contain more than three quarter bends or equivalent. The maximum run between two outlets shall not exceed 25 meters for straight runs and 10 meters for runs with one or more bends. Pull (draw in) boxes shall be provided otherwise whether so indicated on the Drawings or not. Locations of the pull boxes shall be approved by the Engineer.
- P. Conduits shall be installed without causing any damage to the structural members. Horizontal and cross runs in buildings partitions or side walls shall be avoided.
- Q. All bends shall be carefully made to prevent distortion of the circular cross-section. Bends made on site in conduits shall have an inside radius of not less than nine diameter. Where bends of less than nine diameters are necessary, standard factory elbows shall be used; however the conduit size chosen shall be such as to permit a cable-bending radius within the factory elbow of at least eight times the cable diameter.
- R. Conduits in slabs shall be installed as close to the middle of the concrete slabs as practicable without disturbing the reinforcement. Conduits shall be placed between bottom reinforcing steel and top reinforcing steel. The outside diameter shall not exceed one third of the slab thickness, otherwise the Contractor shall use more than one conduit. Conduits shall be placed not closer than three diameters on centers in order to ensure proper conduit bond.

Conduits in slabs shall be placed parallel to the main reinforcement steel in the slab.

Top of any conduit in slabs shall be at least 2 cm below the finishes floor surface, unless otherwise indicated or authorized.

Conduits in slabs running parallel to beam axis shall not run above beams.

Exposed conduits shall be installed parallel or at right angles to walls and ceiling beams. All changes in direction shall be made as far as possible with approved bends, elbows, and pull boxes. The spacing between parallel runs shall be uniform throughout. Unless otherwise indicated conduits shall be held securely in place by standard factory spacer bar saddles, spaced not more than 1.5, 2.0 and 2.4 meters for 20mm, 25mm and 32mm and larger conduit sizes respectively for metallic conduits and at 1 meter for non-metallic conduits.

Unless otherwise indicated, raceways exposed above false ceilings shall be supported from the slab above the ceiling in the same manner as exposed raceways. Raceways shall not be supported from false ceiling supports.

- S. Couplings, expansion couplings, strap saddles, spacer bar saddles, spring clip saddles, conduit clips, adaptors, etc. shall all be standard factory conduit accessories.
- T. Flexible metallic conduits shall be used only for connections to motors, or to other equipment subject to vibration or adjustment or to make connections to lighting fixtures in false ceilings. Each connection shall contain at least one quarter bend so that no vibration can be transmitted behind the flexible connection.
- U. In damp and wet locations all couplings, expansion coupling, strap saddles, spacer bar saddles, spring clip saddles, conduits clips, screws, adaptors shall be corrosion proof, approved for use in damp and wet locations.

In damp and wet locations the entire conduiting system, including boxes, fittings, panelboards etc.. shall be mounted so that there is at least 7mm air space between it and the wall supporting surface.

- V. All conduits shall be carefully cleaned before and after installation. All ends shall be reamed free from burrs, and inside surfaces shall be free from all imperfections likely to injure the cable.

After installations of each complete new conduit run, the run shall be snaked with a band to which shall be attached an approved tube cleaner equipped with an approved cylindrical mandrel of a diameter not less than 85% of the nominal diameter of the conduit. All conduits through which the mandrel will not pass shall be removed and replaced by the Contractor at his own expense.

- W. All field cuts in conduits shall be square, and cut ends shall be filed and shall have burrs removed. An insulating bushing shall be installed on each end of conduit, unless the connector is designed to prevent contact with the cut end. All connections shall be mechanically strong and tight, and made up properly with approved connectors. No running threads shall be permitted.

3.3 INSTALLATION OF BOXES

Boxes of ample capacity shall be provided at every junction of conduit system and as required by the Specifications.

All boxes shall be securely fastened.

Blank plates shall be installed on outlet boxes in which no apparatus is installed, or the apparatus installed does not provide a suitable cover for box.

Device boxes shall be used for all wiring devices.

Non-metallic boxes shall be used only for concealed conwork, and for conduit work above false ceiling.

Exposed boxes for switches, socket outlets and other devices shall be cast metal boxes.

Cast metal boxes shall be installed in such a manner that the conduit connections and the gasketed cover are dust tight. All unused openings shall be closed with pipe plugs and compound.

Boxes for similar equipment shall be mounted at uniform height within the same or similar area. Mounting shall be as shown on the Drawings.

Device box shapes and sizes shall be determined by the type and size of wiring devices for which they serve.

Boxes fixed inside false ceiling shall be provided with mounting brackets for rigid fixing to structure members or other means of support.

A. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
- B. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- C. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
- D. Set metal floor boxes level and flush with finished floor surface.
- E. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.4 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 2 Section "Earthwork" for pipe less than 6 inches (150 mm) in nominal diameter.
 2. Install backfill as specified in Division 2 Section "Earthwork."
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 2 Section "Earthwork."
 4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

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5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
 6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of conduit.

3.5 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.6 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of fire stopping specified in Division 7 Section "Through-Penetration Fire stop Systems."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with fire stop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both surfaces of walls.
- G. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials.
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

- N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.7 INSTALLATION OF DUCTBANKS

Ducts shall be installed with a minimum slope of 0.5% and shall be sloped to manholes or handholes. Ducts shall slope away from buildings where possible.

Spacers shall be installed at intervals of approximately 120cm and staggered between tiers of ducts to not provide legs than 30cm of longitudinal separation. Base spacers shall provide at least 7.5cm between the bottom conduits.

The space shall be completely filled with concrete. Conduits and spacers shall be firmly wired together before the concrete is placed.

Prior to the placing of the concrete, all sand, dirt and any other debris shall be removed from the trench. Steel reinforcement shall be provided for all ductbanks under roadways.

Joints in the conduits shall staggered at 15cm minimum. Couplings clearance of 30cm is left between concrete and parallel pipes, structures, etc. Crossing ducts shall be spaced 15cm as a minimum.

Top of the concrete shall not be less than 50cm below the finished grade or paving except for high tension cables in which case it shall not be less than 80cm.

Power driven vibrators shall not be used for spading of concrete around ducts.

The surface shall be restored to a condition at least equal to that in which it was before work was begun, or as otherwise indicated.

Ducts shall be clean of concrete, dirt and other substances. A flexible mandrel 30 cm long having a diameter approximately 0.5cm less than the conduit inside diameter shall be pulled through each duct. A brush with stiff bristles shall be pulled afterwards to make certain that no particles of earth, sand, or gravel have remained. All duct runs not allowing passage of the mandrel shall be replaced at no extra charges. Spare ducts shall be plugged and sealed after cleaning.

20% spare ducts but not less than one shall be provided in each duct bank.

Cables leaving ducts shall be provided with duct seals.

Where ductbanks are installed below the structural footing level of the building, it shall be the entire responsibility of the Electrical sub-contractor to coordinate with the Civil subcontractor for the laying of the concrete duct bank prior to the installation and erection of the structural footing.

3.8 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.9 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7.

3.10 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.11 HEAVY DUTY IMPACT PROOF PVC WIREWAY

- A. The wireway shall be similar carlon wire safe wireway and wiring trough or approved equal.
- B. The wireway shall be listed and installed per the NEC Article 362-B for nonmetallic wireways.
- C. The wireway shall be manufactured from gray precision extruded Polyvinyl Chloride (PVC) meeting UL94V-0 requirements and shall be suitable for field painting.
- D. The wireway shall include base, cover, fittings, etc.
- E. The wireway shall provide all fittings required to form a complete, integrated surface raceway system. End caps shall be gasketed and shall have a NEMA type 12 rating.

INSTALLATION INSTRUCTIONS:**A. Description:**

Wireway shall be manufactured from extruded PVC. The standard color shall be gray. The wireway consists of a base channel that is formed to receive a “clip-on” cover.

B. Cover Installation and Removal

The cover shall be installed by exerting hand pressure along its front face in such a manner as to engage and clip projections on the side walls of the base channel. The cover shall be removed by inserting a tool (i.e. a screwdriver shaft) into one end of the wireway enclosure and exerting pressure against the underside of the cover which is then “peeled off” from the base.

C. Fittings

Fittings shall enable the wireway to be positioned around corners and enable tees and crosses to be created without detracting from the protective characteristics. Interconnecting pieces can be assembled using couplings and rivets or cement as necessary.

Molded fittings do not require couplings since they fit on the exterior of the wireway. However, primer and solvent cement are needed. See cementing instructions.

Fabricated fittings do require internal or external couplings, and these must be ordered separately. To install fittings, a 9/82” diameter hole should be drilled in the wireway to match the external coupling hole. A push rivet shall be used to connect the two pieces. To connect an internal coupling to the inside of a fitting cement shall be used.

D. Installation:

- Mark the surface upon which the wireway is to be mounted.
- Measure, run, and identify position of fittings.
- Remove cover from wireway, starting at one end, with a peeling action (use of a screwdriver or similar level is recommended).
- Drill mounting holes through base at 60” centers maximum. Two rows of mounting holes should be drilled, adjacent to each wall of the wireway in order to evenly distribute the load.
- The holes in the wireway should be drilled oversize to allow for expansion. Washers should be mounted under the head of the mounting device, which should not be tightened to its full extent.
- Mount the wireway using screws or bolts.
- Affix the wireway cover by aligning it to the wireway base and then pressing it into its engaged position, starting at one end.

- The cover should be made to overlap the base joint in order to improve rigidity of the joint.
- The following wireway dimensions and sectional areas are required.
 $4 \times 4 - 13.694 \text{ in.}^2 (88 \text{ cm}^2)$
 $6 \times 6 - 31.871 \text{ in.}^2 (205 \text{ cm}^2)$

E. Fittings

Internal and external elbow shall be a fitting cover that snaps onto the main base. Flat elbows and flat tees shall be a fitting cover that snaps onto the main base. End caps shall be gasketed and NEMA Type 12 rated.

F. Installation:

Install in accordance with the manufacturer's instructions, NFPA 70 and NECA standard. Install base, cover, fittings, accessories, etc., as necessary for a complete system.

G. Materials

PVC Homopolymer (ASTM F1784)	Minimum cell class 1235B
Specific Gravity (ASTM D792)	1.46
Thermal Conductivity (ASTM C177)	1.3Btu/hr./ft. ² /oF/in.
Heat Deflection Temperature @264 psi (ASTM D648)	700C
Tensile Strength (ASTM D638)	600psi
Flammability (UL 94)	V-0

H. Physical Properties

Size	Crush Strength (lbs.)	Impact Strength ² (ft.-lbs.)
2x2	650	40
3x3	500	30
4x4	500	40
6x6	600	50

END OF SECTION

SECTION 16139 – CABLE TRAYS**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 hot dip galvanized cable trays and accessories.

1.3 SUBMITTALS

- A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
- Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths and fittings.
- C. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
1. Vertical and horizontal offsets and transitions.
 2. Clearances for access above and to side of cable trays.
 3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For cable trays to include in emergency, operation and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
- B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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- C. Comply with NFPA 70 or with BS EN ISO1641

1.5 DELIVERY, STORAGE AND HANDLING

- A. Hot dipped galvanized steel cable tray may be stored outside without cover, but shall be loosely stacked, elevated off the ground, and ventilated to prevent staining during storage.
- B. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

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: Local manufacturers are strictly prohibited subject to compliance with requirements, provide products by one of the following:
1. Wire mold (UK)
 2. Kriey and Zivy (France)
 3. Vergokan (Belgium)
 4. Thomas and Bett (USA)
 5. MP Husky (USA)
 6. Electrolink (Saudi Arabia)
 7. Swifts Legrand (UK – France)

2.2 MATERIALS AND FINISHES

- A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1 or BS EN ISO 1461 and BS EN 10326 and BS EN 10327.
- B. Sizes and Configurations: Refer to the Cable Tray Sizes on Drawings for specific requirements for types, materials, sizes, and configurations.
- C. Minimum thickness= 1.5mm. Cable tray shall be heavy duty type, hot dip galvanized with return flange.
1. Center-hanger supports may be used with approval of Engineer.

2.3 CABLE TRAY ACCESSORIES

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

- B. Covers: Louvered type of same materials and finishes as cable tray.
- C. Barrier Strips: Same materials and finishes as cable tray.
- D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.
- E. Cable trays installed outdoor shall be provided with Sunshade cover

2.4 WARNING SIGNS

- A. Lettering (40mm) high, black letters on yellow background with legend “Warning” NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL”
- B. Materials and fastening are specified in Division 16 Section “Electrical Identification”.

PART 3 – EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Cable trays shall be used for all multicore cables surface mounted.
- B. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees and crosses.
- C. Remove burrs and sharp edges form cable trays.
- D. Fasten cable tray supports to building structure
 - 1. Place supports so that spans do not exceed maximum spans recommended by supplier.
 - 2. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
 - 3. Support bus assembly to prevent twisting from eccentric loading.
 - 4. Manufacture center-hung support if approved and authorized by the Engineer, designed for 60 percent versus 40 percent eccentric loading conditions, with a safety factor of 3.

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5. The cable trays shall be of sufficient width to take all cables without crowding and shall allow for possible future additions to the proportions of the present requirements. Spare capacity shall be 35% minimum. Cables shall be run singly and stacking will not be permitted.
 6. Cable trays fixed to walls or flat ceilings shall be installed with the flange outwards or downwards respectively to suit and shall be fixed with an approved fixing with spacing and washers such that the tray is at least 25mm from the surface of the wall or ceiling. Earth continuity shall be maintained between each section of cable tray and total run of tray shall be effectively bonded to the nearest earth continuity conductor at both ends.
 7. Cable trays installed on roof floor or in any other floor where exposed to sun rays shall be protected with size shade covers (asbestos not approved)
- E. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Supports cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
- F. Install expansion connectors where cable tray crosses buildings expansion joint
- G. Make changes in direction and elevation Not cutting of tray shall be permitted.
- H. Seal penetrations through fire and smoke barriers according to Division 7 Section "Through-Penetration Firestop Systems."
- I. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- J. Workspace: Install cable trays with enough space to permit access for installing cables.
- K. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
- L. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

3.2 CABLE INSTALLATION

- A. Install cables only when cable tray installation has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. On vertical runs, fasten cables to tray every (45mm). Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

- D. In existing construction, remove inactive or dead cables from cable tray.
- E. Install covers after installation of cable is completed.
- F. Wherever the cable trays are exposed to outside conditions, i.e. laid on the roof, these shall be covered with galvanized steel sheet of 20 gauge to protect from heat and rain.

3.3 CONNECTIONS

- A. Install an insulated equipment-earthing conductor with cable tray, in addition to those required by IEC. Earth Continuity shall be maintained between each section of tray and total run of tray shall be effectively bonded to nearest ECC at both ends.

3.4 FIELD QUALITY CONTROL

- A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform in two stages the following field quality-control survey in two stages:

Stage 1: after completion of cable tray installation

Stage 2 after completion of cables installation

1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
 2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
 3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
 4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
 5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorquing in suspect areas.
 6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
- B. Report results in writing.

3.5 PROTECTION:

A. Protect installed cable trays.

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. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION

SECTION 16140
WIRING DEVICES**PART 1- GENERAL****1.1 SUMMARY**

- A. This section includes requirements for the furnishing and installing of concrete recess boxes for wiring devices. The scope of works does not include the wiring devices but the wiring devices are described only in order to ensure the concrete recessed supply and installation of the adequate outlet box matching the requirements of the future wiring devices.
- B. Furnish, install and connect all boxes that are required by wiring devices recessed in concrete as shown on the Contract Drawings and as hereinafter specified and to the approval of the Client Operator.
- C. All devices shall be heavy-duty specification grade conforming to the IEC/EN configurations.
- D. In general all devices shall be one gang wide. Wider devices shall be provided as required for heavier rated loads.
- E. The same manufacturer shall supply all furnished device plates and devices.
- F. All devices shall comply with IEC norm listed below:
- IEC 60083, IEC 60884, IEC 61050, IEC 60309, IEC 60906, IEC 60601, IEC 60730, IEC 61095.
 - Double pole switches shall be in comply with the BS standard BS3676.
- G. It shall be the full responsibility of the Contractor to install the adequate back box of the wiring device outlet during first fix works.

1.2 RELATED WORK

- A. Related Work specified elsewhere includes (but not limited to).
1. SECTION 16010 – BASIC ELECTRICAL MATERIALS AND METHODS
 2. SECTION 16075 – ELECTRICAL IDENTIFICATION.
 3. SECTION 16060 – EARTHING
 4. SECTION 16950 – TESTS AND CERTIFICATES.

1.3 QUALITY ASSURANCE

- A. Devices shall be of IEC/EN configuration and shall bear the label of KEMA or Veritas or LCIE.

B. Products shall be supplied from one manufacturer.

1.4 SUBMITTAL ASSURANCE

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

- Product Data: Data shall be submitted for each product specified in this section, with catalog clippings and manufacturer technical specifications.
- Samples for each device which shall be used and for all relevant accessories (cover, plates).
- Operation and Maintenance Data: Provide operation and maintenance data for materials and products specified in this section.

Manufacturers (or approved equal)

- Vimar
- Legrand
- Ticino
- Niko
- Arnould
- Jung
- Berker
- MK (for DP Switches Only) or any one of the above mentioned manufacturers as per the BS Standard BS367.

Normal plate shall be similar to Jung AS500, Legrand Synergy.

- 1.5 Decorative plate range shall be similar to Legrand Arteur, Jung CD 500 brushed type, or approved equal from other vendors. Non decorative range shall be similar to Legrand Mosaic 45 or approved equal from other vendors. Non decorative water proof devices that are recess mounted in concrete structure shall be similar to Legrand Masaic 45 in normal water protected areas and to Legrand Plexo 55 for devices recess mounted in concrete and water proof type.

PART 2 -PRODUCTS

2.1 DECORATIVE SWITCH

Single pole flush type switch 10A-250V~.The mechanism must contain block-shaped silver contacts (alloy containing 90% silver at least) arranged in the form of a cross, and cage terminals with screws, which cannot be lost. The flush type bridge must have a metal thickness of 1mm and must be bright galvanized on all sides. It must contain lead slots on both the horizontal and vertical spindle for screw-fixing on flush mounting boxes. The mechanism, mounting plate, rocker and cover plate assembly must have protection value IP21.

All parts must be self-extinguishing and halogen-free. Mechanism recess depth: 25mm. Assembly projection height: 8mm on average. CE, CEBEC, KEMA, VDE, ~VE, USE and ESS approved.

2.2 LIGHTING SWITCHES

- A. Switches shall be mounted on the latch side at all hinged doors in suitable outlet boxes in the wall or partitions except where noted on the Contract Drawings.
- B. Switches shall be rated 16 amperes, 220 volts ac.
- C. Switches shall be rocker operated mounted with the operating handle in the upward position when in the “ON” position unless otherwise directed by the Engineer.
- D. Switches shall interrupt the hot wire or hot and neutral simultaneously as applicable.

Switches shall be quick-make, quick-break, with silver alloy contacts, trunnions and spring assembly lubricated for the life of the switch neoprene bumpers.

- E. Switches shall be 250 volt ac only rated with number of gangs, poles and amp ratings as indicated on the Drawings, to VDE.
- F. Switches shall be fully rated for tungsten filament and fluorescent lamp loads, ad up to 80% of rated capacity for motor loads.
- G. Lighting switches in general shall be 16 amp rated as a minimum.
- H. Lighting switches marked on drawings with W, watertight notation shall be weatherproof, IP55, degree of protection, similar to Legrand Plexo range or approved equal.
- I. Timer switches: shall be 16-amp rated, one pole, one throw with switching device and 120 minute dial, recess mounted. Switches shall have 20,000 switching cycles guaranteed life.
- J. Lighting contactors control pushbuttons: pushbutton shall be double contact type with spring return action. Body shall be made of molded plastic with clear baked acrylic protection.
- K. 30-Amp double pole switches shall incorporate a pilot light, and shall have the words “Water Heater” engraved on it when used for that propose.

30-Amp double pole switch shall incorporate the inscription indicating the purpose of its use.

45/50-Amp double pole switches shall incorporate a pilot light, and shall have the word “Cooker” engraved on it when used for that purpose.

- L. Key switch: Key switch shall be cylinder lock operator type control station with three positions: Up-Off-Down. Legend plates shall be incorporated.

- M. Switches in hazardous area in which flammable gases or vapors may occur shall be in accordance with IEC-79 and VDE-0711.
- N. All switches shall have earth connection.

2.3 SOCKETS OUTLETS:

- A. Sockets outlets for general use shall be simplex or duplex, 3 wire, 16ampere, 220 volt.
- B. Socket outlets shall be of the standard, 3-pin, non- switched, single phase, type of molded plastic unless otherwise specified.

In order to distinguish normal sockets from UPS powered sockets, normal sockets shall be white or as approved by the Engineer, and UPS sockets shall be with different color red or as approved by the Engineer.

16-amp sockets with W notation on drawings (watertight) shall be similar to Legrand plexo 90324 or approved equal to the approval of the Engineer.

- C. Dual double pole flush mounting socket-outlet 10A~/16A~ 250V. The socket-outlet must contain contact buses with a large contact area that do not support on the base for clamping the wires and screw clamps with screws which cannot be lost. The pole terminals must contain up to 4x2.5mm² wire. The flush type bridge must have a metal thickness of 1mm and must be bright galvanized on all sides. It must contain lead slots on both the horizontal and vertical spindle for screw-fixing on flush mounting boxes. In addition to this the flush type bridge must contain dovetails which allow an easy horizontal mounting of several socket-outlets. The socket-outlet, central plate and cover plate assembly must have protection value IP21. All parts must be self-extinguishing and halogen-free. Mechanism recess depth: 21mm. Assembly projection height: 8mm on average. CEBEC, KEMA, USE, NF and AENOR approved.

2.4 SWITCH AND SOCKET WALL PLATES:

A. Covers and mounting plates

- a) The mechanism, mounting plate, rocker and cover plate assembly must have a protection level of IP21 to prevent dangerous parts from being touched with the fingers. All parts must be self-extinguishing and halogen-free.
- b) Mounting plate and rocker must be made of impact-resistant, dust-repellent and dimensionally stable polycarbonate. The raw material must be colored in the mass. For common area the rocker must be white or Cream according to the selection of the Engineer that will be made after the mechanism installation and the wall painting.

The possibility of upgrading the shape and colors of the mounting plates and rockers to reinforced fiber covers or elegant metallic covers according to the owner's choice must always be applicable. Dimensions rocker: 70x47mm. Assembly projection height: 8mm on average. CE approved.

For UPS sockets outlets covers shall be with red color or as approved by the Engineer.

- c) For decorative area, the cover plate consists of a top section made from 2mm stainless steel with pearled or brushed finishing and an insulating bottom section made from impact-proof, dust-preventing ABS, which retains its shape. An insulating distance of 3mm must be guaranteed between the metal parts. The upper stainless steel section must have an austere design; it must be leveled, rectangular and slightly over-dimensioned. The combination of the top and bottom section creates a floating effect for the cover plate in relation to the wall.
- d) Plates shall be manufactured by the device manufacturer, and their color shall be selected by the Owner. Selected plate finish is similar to Axend brush plate from Niko or approved equal.
- e) In unfinished areas, plates shall be of the type designed for use with the particular boxes.
- f) In utility room plates shall be provided for weatherproof receptacles. Weatherproof covers shall be of the pad-lockable type.
- g) Weatherproof, gasket covers shall be provided for weatherproof receptacles. Weatherproof covers shall be of the pad-lockable type.
- h) Other plates shall be of material and finish as directed by the Owner.
- i) Provide a single (common) cover plate for triplex or quadriplex sockets.
- j) Provide a single (common) cover plate for multiple (ganged) switches.

2.5 CONTROL STATIONS

Control stations shall be spring type, with silver plated contacts. Contacts shall be 5 amp rated. Plate shall be constructed from aluminum gray baked enamel painted.

ON-OFF maintained contact station shall have two pushbuttons, one green for ON and one red for OFF. A green pilot light shall be incorporated which shall lit when pushbutton ON is depressed. The words ON & OFF shall be engraved on the pushbuttons in white.

START-STOP momentary contact type station shall have two pushbuttons, one green for START and one red for STOP. A green pilot light shall be incorporated which shall lit when pushbutton START is depressed the word START & STOP shall be engraved on all motor control stations.

UP-STOP-DOWN momentary contact type stations shall have three pushbuttons and no pilot lights.

Pushbuttons shall be molded from trac-resistant material, and shall be provided with button shrouding ring.

Key switch shall be a cylinder lock operator type station with three positions UP-OFF-DOWN. These words shall be engraved on the station.

Stations in damp & wet locations shall be enclosed in a Feraloy box and covered with stainless steel plates.

When line voltage is 380-415 and the control is line-to- line connected as described under MOTORS & STARTERS", a warning notice shall be inscribed in the device in a clearly visible manner once the cover is removed.

2.6 FLOOR MOUNTING DEVICES

Floor mounting devices shall accommodate a floor receptacle, a cable outlet or a data outlet as shown on the Drawings. Receptacle shall have a hinged insert constructed from aluminum, with a special locking screw. Edge rings shall have interior adjusting screws.

Telephone outlets shall be split bell nozzle type.

Unused openings shall be covered with floor plate with removable plug insert. Devices shall be coordinated with floor boxes.

Floor mounting devices shall be similar to Steel City floor mounting devices as manufactured by Midland-Ross (USA) or approved equal or as approved by the Engineer.

2.7 BOXES AND FITTINGS

Boxes shall be provided with means for securely terminating conduits.

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

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

2.8 DEVICE PLATES:

Plates shall be rectangular or square in shape to the approval of the Engineer.

Plates shall be designed to match associated devices.

Plates for cord extension shall be provided with cord grip bushings, threaded type, of same material and finish as of plate.

Plates for flush mounting devices shall be constructed of molded material of white in color, unless otherwise approved by the engineer.

Fixing screws shall be chromium plated and polished. Screw heads shall be finished to suit the plates.

2.9 RJ 45 OUTLETS (CAT 6)

Flush mounted faceplates shall accommodate modular telecommunication outlets without any additional mounting hardware.

Telecommunication outlets must be made of high impact plastic.

The connections must be in accordance with standard ISO8877 and ISO 603.7 and category 6, in the form of modular, 8 pin RJ45 outlets. Cabling of the connections must be in accordance with specification EIA / TIA 568A or B.

Telecommunication outlet shall not be responsible for creating resonance on short cable runs (field testing 67 draft 13)

User outlets must have one or two RJ45 connectors, connected apart.

Each telecommunication outlet must have standard dimensions (45 x 45mm) in order to guarantee openness to the market.

2.10 LIGHTING CONTACTORS:

TYPE: Double pole for single phase and neutral circuits, and triple pole for three phase circuits, mechanically held, electrically operated, rated 500V, of current ratings shown on the Drawings, and complying with IEC 60947-4 category 5a for discharge lamps and 5b for incandescent lamps.

CONTACTS: copper alloy, with silver cadmium alloy double break contacts designed for switching inductive ballast loads and switching of tungsten lamp loads.

AUXILIARY CONTACTS: as required to provide shown on the drawings, or required by the Specification, with one N.O. and one N.C. spare contacts.

ENCLOSURE: unless forming part of system housed in sheet steel panel, contactor is to be provided with IP 42 enclosure for indoor use or IP65 enclosure for outdoor use.

CONTROL: each contactor whether part of a system or separately enclosed is to have on/off pilot lights and set of on/off push buttons mounted on cover.

ACCESSORIES:

- Pushbutton: ON/OFF
- Selector Switch: ON/OFF, Automatically.
- Indicating Light: RED, GREEN
- Auxiliary Contacts: One normally open, One normally closed.

2.11 CEILING ROSES

Ceiling roses shall be designed to meet the requirements for the installation of flexible pendent cords for lighting. They shall be molded in a non-track insulating material to BS 1323 and shall comply with BS 67 and IEE Wiring Regulations.

Ceiling rose shall be provided next to each chandelier hook.

Ceiling roses shall incorporate 3 terminals (one of which properly shrouded), loop-in, earth and strain or 4 terminals as directed by the Engineer. The shrouded terminal shall be used for the live un-switched wires.

Ceiling rose shall be similar to MK1161, Crabtree 5860, 5861 or approved equal to the approval of the Engineer.

2.12 HOOK FOR CHANDELIER

Hook shall be suitable for suspension of chandeliers of up to 25kgs, unless otherwise indicated and shall consist of brass plated welded ring loop 10mm.

Each hook for chandelier will have its corresponding ceiling rose.

2.13 DOOR BELL PUSHBUTTONS

Pushbuttons shall be double contact type with spring return action.

Body for driver room shall be made of molded plastic with clear baked acrylic protection.

Body for apartments shall be as selected by I.D

Pushbutton shall have provision for directory of names. Pushbutton shall be lighted type.

2.14 DOOR BELL CHIME

Door bell chime shall be electronic type with 75 dB sound level at 1m. Door bell chime shall have two tones and shall have its own transformer.

2.15 PUSH-BUTTON

Flush type push-button with one make contact (N.O.) 10A-250V~. The push-button must offer the option to be illuminated, a third (additional) terminal must be provided for connection of a pilot lamp. The mechanism must contain block-shaped silver contacts (alloy containing 90% silver at least) must be arranged in the form of a cross, and cage terminals with screws, which cannot be lost. The flush type bridge must have a metal thickness of 1mm and must be bright galvanized on all sides. It must contain lead slots on both the horizontal and vertical spindle for screw-fixing on flush mounting boxes. The mechanism, mounting plate, rocker and cover plate assembly must have protection value IP21. All parts must be self-extinguishing and halogen-free. Mechanism recess depth: 25mm. Assembly projection height: 8mm on average. CE, CEBC, KEMA, VDE, USE, ~VE and ESS approved.

2.16 T.V OUTLETS:

Flush mounting single-coax. TV-FM-SAT socket with female connector. Connection attenuation 1dB, suitable for plugs $\geq 9.5\text{mm}$. The flush type bridge must have a metal thickness of 1mm. It must contain lead slots on both the horizontal and vertical spindle for screw-fixing on flush mounting boxes. The function, central plate and cover plate assembly must have protection value IP21. All parts must be self-extinguishing and halogen-free. Mechanism recess depth: 23mm. Assembly projection height: 8mm on average. CE approved. See specification of outlets in SEC 16780 Central TV System.

2.17 CABLE OUTLET

Cable outlet shall comprise a moulded cover plate with a side groove for 3x10mm² multicore flexible cord, a cable clamp, 3 terminals for 10mm² conductors.

Cable outlet shall be similar to Crabtree 4506, MK 5045 to the approval of the Engineer.

Cable outlet when used for CCTV Camera, power supply shall be covered by the Camera.

PART 3-EXECUTION

3.1 INSTALLATION:

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

Boxes installed in concealed conduit or raceway systems shall be set flush with the finished surfaces. The location of all boxes shall be easily accessible and any interference with mechanical equipment or structural features shall be relocated as directed by the Engineer.

- B. Wiring devices shall be installed in locations indicated on the Contract Drawings, arranged singly or in gangs and at the height indicated. They shall have approved plates and finishes as specified herein. Provide barriers as required per Code.

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- C. Install the devices in strict accordance with the approved shop drawings and the equipment manufacturer's recommendations.
 - D. Adjust the location of devices to accommodate the work in accordance with field conditions encountered as directed by the Construction Manager.
 - E. Provide steel mounting hardware for all wiring device boxes.
 - F. Receptacles on single outlet branch circuits shall be the same rating as the branch circuit over current protection.

Local wall switches near doors, shall be located at strike side of doors as finally hung, whether so indicated on Drawings or not.

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

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

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

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

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

- G. Install wall switches with OFF position down.
- H. Install each convenience receptacle with the grounding pole on bottom when mounted vertically or on the right when mounted horizontally.
- I. Provide plates on all switch and receptacle outlets, and provide blank plates on all unused boxes.
- J. Install devices and plates flush and level.
- K. Each socket and switch shall be side wired. Back wiring is not acceptable. Wrap all terminals with two layers of electrical tape.
- L. Device plates: Device plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Device plates shall be installed vertically with an alignment tolerance of 0.16mm (1/16 inches).

- M. Earthing system shall be installed as required by the drawings, and as specified herein. Neutral conductors of the wiring system shall be earthed at the transformer secondary and at the panel boards, the grounding connections shall be made as indicated on Drawings, and as required by the IEC Code.

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

3.2 PERFORMANCE TESTING

- A. Test the complete wiring device installation to assure proper operation.

3.3 PLUG-IN SOCKETS:

This group includes complementary sockets conforming to Standard CEI 23-16 and plug-in sockets conforming to Standard CEI 23-5.

3.4 FIRE RESISTANCE TESTS:

Product	Parts which hold in position parts which carry current or parts of the earth circuit	Parts which do not hold in position parts which carry current
Control devices and bells	Incandescent wire 850°C- Standard CEI 23-9	Incandescent wire 650°C – Standard CEI 23-9
Sockets	Incandescent wire 850°C- Standard CEI 23-5 and 23- 16	Incandescent wire 650°C – Standard CEI 23-9 and 23-16
Frames and cover plates		Incandescent wire 650°C – Standard CEI 23-9
Flush-mounted device holder boxes.		Incandescent wire 650°C – Standard CEI 23-9 Publication IEC 670 II edition
Wall-mounted device holder boxes.		Incandescent wire 550°C – Standard CEI 64-8 Incandescent wire 650°C – Publication IEC 670 II edition.
Protected flush-mounted device holder boxes.		Incandescent wire 650°C – Standard CEI 23-9 Publication IEC 670 II edition
Protected wall mounted device holder boxes.	Incandescent wire 850°C- Standard CEI 64-8 Publication IEC 670 II edition.	Incandescent wire 550°C – Standard CEI 64-8 Incandescent wire 650°C – Publication IEC 670 II edition.
Flush-mounted junction boxes		Incandescent wire 650°C – Standard CEI 64-8 Incandescent wire 650°C – Publication IEC 670 II edition.

Protected flush-mounted junction boxes.		Incandescent wire 650°C – Standard CEI 23 Publication IEC 670 II edition
Protected wall-mounted junction boxes.		Incandescent wire 650°C – Standard CEI 23 Publication IEC 670 II edition

3.5 FIELD QUALITY CONTROL

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

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

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

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

Test wiring devised for proper polarity and ground continuity.

Replace damage or defective components.

Control Device Test Conditions:

Test Voltage: 200V, 60Hz gradual for one minute.

Insulation resistance tested at 500V: $> 5M\Omega$.

Breaking power: 200 changes of position at 1.25 in 275V a.c. $\cos \phi$ 0.3.

Prolonged operation test: 50,000 changes of position at 250V a.c. $\cos \phi$ 0.6 with rated current.

END OF SECTION

SECTION 16231 – PRIME ENGINE GENERATOR SET**PART 1- GENERAL****1.01 GENERAL:**

The emergency power generators and controls system will consist of engine generators with their individual set mounted digital control units, one master digital control unit mounted alone or inside the totalizer board and required local command units mounted on each set. The units shall be designed to properly interface with the number of remotely located load connection contactors and automatic transfer switches in number as shown on drawings. All equipment supplied shall be new and unused, and designed to meet all applicable NEMA, ANSI, IEEE and NFPA-76A, BSS standards.

Ratings of generator set smaller than rating shown on drawings are strictly prohibited.

1.02 RELATED DOCUMENTS:

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

1.03 SUMMARY:

- A. This section includes packaged engine-generator sets for emergency power supply with the following features:
1. Diesel engine with Alternator.
 2. Unit-mounted cooling system.
 3. Unit-mounted control and monitoring.
 4. Performance requirements for sensitive loads.
 5. Load banks.
- B. Related Sections include the following:
1. Division 16 section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and stopping signals for engine-generator sets.

1.04 DEFINITION:

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.05 SUBMITTALS:

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

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1. Thermal damage curve for generator.
 2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases. The Engineer shall be from the DG set manufacturer or from Authorized agent.
 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Details fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 4. Wiring Diagrams: Power, signal and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified".
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For installer, manufacturer and testing agency.
- E. Source quality-control test reports.
1. Certified summary of prototype-unit test report.

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2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Certified Summary of performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 5. Report of sound generation.
 6. Report of exhaust emissions showing compliance with applicable regulations.
 7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. List of tools and replacement item recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- H. Warranty: Special warranty specified in this Section.

1.06 QUALITY ASSURANCE:

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project. The DG set Engine, Alternator and the synchro (locally mounted on units and the master panel) Control Panel shall be the standard product of one single manufacturer with single source warranty.
1. Maintenance Proximity: Not more than four-hour's normal travel time from installer's place of business to Project site.
 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 30Km of project site, a service center capable of providing training, parts and emergency maintenance repairs.

- C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the Association of the officially approved Bureau de Controle operating in Lebanon Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use. Comply with ASME B15.1.
- E. Comply with NFPA 37.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110 requirements for Level (2) emergency power supply system.
- I. Comply with UL 2200.
- J. Engine Exhaust Emissions: Comply with applicable Lebanese government requirements.
- K. Noise Emission: Comply with local governmental and solidere BCD requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.07 PROJECT CONDITIONS:

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: (50 deg C).
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 0m.
- B. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:
 - 1. High salt-dust content in the air due to sea-spray evaporation.

1.08 COORDINATION:

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Structural Specification.

- B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Structural Specification.

1.09 WARRANTY:

- A. Special Warranty: Manufacturer's standard for in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years from date of Substantial completion.

1.10 MAINTENANCE SERVICE / LOCAL REPRESENTATIVE:

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.11 LOCAL REPRESENTATIVES:

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

1.12 MAINTENANCE CONTRACT:

Obtain an undertaking by the equipment manufacturer and his authorized local representative to provide an annual maintenance contract, available after substantial completion of the work, covering routine service and emergency service by trained employees, and to ensure supply of necessary standard spare parts.

The supplier to provide the original catalogues of the O&M with the generator before starting installation of the gensets.

1.13 EXTRA MATERIALS:

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

1.14 EQUIPMENT DATA:

Submit full technical data of equipment for approval including, but not limited to, the following:

General description and characteristics of engine- generating sets, standards with which components comply, site rating and overload capability, overall efficiency, and fuel and lubricant consumption at 100%, 75%, 50% and 25% of rated load

Description and operating criteria of engine; type, model, manufacturer, fuel and lubricating oil types and specific consumption, starting conditions and starting periods from cold to full-load pick-up, governor and response characteristics due to sudden load changes, super-charger, fuel injection system, cooling system and radiator, air filters, fuel filters, oil filters and pumps

Description and operating criteria of generator, exciter and voltage regulator, with loading response and short-circuit characteristics, insulation, cooling and accessories dimensions, weights and forces, mounting methods, vibration protection etc.

Battery type, make, charge/discharge characteristics, capacity and constructional features

Battery charger, method of charging, equalizing and trickle charging

Fuel tanks, pipes and accessories; materials and construction

Exhaust system and silencers; materials and construction

Control instruments, protection, alarms, cut-outs, indicating lamps, indicating instruments and all other devices or components

Automatic transfer switch and control gear

Synchronization system where two or more sets are in parallel, including technical data, instruments, governor and voltage regulation, with characteristic curves etc.

Calculated noise levels in dBA at typical points within engine room and at various locations inside and outside.

1.15 SHOP AND CONSTRUCTION DRAWINGS

Submit drawings for approval including, but not limited to, the following:

Certified manufacturers' dimensional drawings, templates and installation instructions for equipment and accessories, showing weights and distribution of forces, location and size of cabling (power and control), piping connections to equipment, and other pertinent data

Plans and elevations of all equipment

Separate unit wiring diagrams, schematics and interconnecting wiring diagrams

Constructional details of bulk fuel storage tanks and daily service fuel tank, including outline drawings showing piping arrangements, connections and dimensions

Complete execution drawings of associated auxiliaries.

1.16 COMPLIANCE REVIEW:

Bidding Manufacturer shall provide a Compliance Review of generator room and installation plans and specifications. The first section of the Compliance Review shall be a review of the plans. The second section shall be a paragraph-by-paragraph review of the specifications with the following information, "C", "D" or "E" marked in the margin of the original specification and any subsequent addendums.

- a. "C": Comply with no exceptions.
- b. "D": Comply with deviations. For each and every deviation, provide a numbered note with reasons for the proposed deviation and how the intent of the specification can be satisfied.
- c. "E": Exception, do not comply. For each and every exception, provide a numbered note with reasons and possible alternatives.

Unless a deviation or exception is specifically noted in the Compliance Review, it is assumed that the manufacturer is in compliance with the plans and specifications. Deviations or exceptions taken in cover letters, subsidiary documents or by omission or by contradiction do not release the manufacturer from being in compliance unless the exception or deviation has also been specifically noted in the Compliance Review.

1.17 SPARE PARTS:

Provide manufacturer's recommended spare parts for 1000 hours operation of the standby plant and shall be submitted for approval with the supplier's offer. Provide list of manufacturer's spare parts for 2000 hours operation together with current prices.

1.18 TOOLS AND INSTRUMENTS:

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

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:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide (the product indicated on Drawings) a comparable product by one of the following:
 - 1. Caterpillar: Engine Div.
 - 2. Wilson
 - 3. Cummins Generation, Industrial Business Group.
 - 4. SDMO.
 - 5. Kohler
 - 6. Perkins

2.2 GENERAL:

Diesel Engine-Generator Set: 4 cycle, 1500 rpm, diesel engine generator set (Each unit shall be prime rated with 10% overload capability for one hour every twelve hours) as shown on drawings. Generator set ratings: as shown on drawings at 0.8 PF, rating based on site conditions noted below. System voltage of: 380 volts AC, Three phase, Four-wire, 50 hertz. Site Conditions: ambient temperatures up to 40 degrees C.

Two-cycle engine are not approved.

The generator set shall include inherent over current, short circuit and overload protection, digital and analog AC metering equipment, sensor failure detection, and remote monitoring and control capability. No exceptions or deviations to these requirements will be permitted.

All necessary interface units and contacts to be provided with BMS-for status indication only -.

MINIMUM TIME INTERVAL BETWEEN TWO SUCCESSIVE OVERHAUL PERIOD SHALL BE CERTIFIED TO BE NOT LESS THAN 15000 HOURS.

LOCALLY ASSEMBLED GENERATOR SETS ARE STRICTLY PROHIBITED.

ALL SYNCHRO / CONTROL PANELS SHALL BE MANUFACTURED BY SAME MAUFACTURED BY SAME MANUFACTURER OF GENERATOR. SYRNCRO PANELS FROM ANY OTHER SUPPLIER, INLCUDING APPROVED SWITCHBOARD LOCAL PANEL MAKERS ARE STRICTLY PROHIBITED.

BIDDER SHALL BE FULLY RESPONSIBLE TO PROVIDE AT NO EXTRA COST ALL NECESSARY EXTRA FANS – OTHER THAN THE ONES INCLUDED IN THE MECHANICAL WORKS -, BIDDER SHALL BE RESPNOSBILE TO INCLUDE IN HIS PRIC, ALL THE. NECESSARY PROPER VENTILATION OF THE ROOM AFTER VERIFYING DESIGN CONDITIONS OF ROOM.

VENTILATION (AT NO EXTRA COST) SHALL ENSURE A MAXIMUM RADIATOR COOLANT TEMPERATURE OF 90 DEG C.

The installation of the outdoor type generators at ground level shall be closely coordinated during construction stage and shall consider the archeological site conditions of the Museum. Contractor shall secure at no extra cost dismantling of generator set (installing radiator separately) in coordination with generator vendor.

All breakers, contactors, controls used in this package shall strictly abide with the specifications of those same in other sections of this book of specifications.

The generator package shall also include all necessary interface cards, RS485 connection with a dedicated PC, which allows remote measurement and status indication of all the parameters and variables that can be read on the generator engine local panels. The PC shall be part of this Contract's package.

A 2 KVA UPS shall be provided (2 UPS's in parallel or hot standby combination with 2 hours battery autonomy) for supplying power to the dampers and all necessary controls in the generator room.

Generator bidder shall submit separate qotation part of this contract for a complete dust particle and fume cleaning system similar either to Cyclone or DCL.

The horsepower of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Engine accessories and features shall include:

An electronic governor system shall provide automatic isochronous frequency regulation. The engine governing system shall not utilize any exposed operating linkage.

Skid-mounted radiator and cooling system shall be provided and be rated for full load operation in 40 degrees C ambient as measured at the generator air inlet. Radiator shall be provided with a duct adaptor flange. The cooling system shall be filled with 50/50 ethylene glycol/water mixture by the equipment supplier. Rotating parts shall be guarded against accidental.

The following elements shall be provided:

- An electric starter capable of three complete cranking cycles without overheating.

- Positive displacement, mechanical, full pressure, lubrication oil pump. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
- An engine driven, mechanical, positive displacement fuel pump. Fuel filter with replaceable spin-on canister element.
- Replaceable dry element air cleaner with restriction indicator.
- Flexible supply and return fuel lines.

Engine mounted, thermostatically controlled, water jacket heater(s) for each engine. The heater(s) shall be sized as recommended by the generator set manufacturer. Heater voltage shall be as shown on the project drawings.

2.3 ENGINE GENERATOR SET:

- A. Factory-assembled and tested, engine generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation, and have lifting attachments.
 - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated (Prime rating).
 - 2. Output Connections: Three-phase, (three)(four) wire.
 - 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
 - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 - 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 - Voltage regulation: $\pm 0.5\%$ from no load to full load.
 - Voltage drift: $\pm 0.5\%$ for 60° F (33° C) change in ambient over eight (8) hours with temperature stabilization at each point.
 - Random voltage variation: For constant loads from no load to full load will not exceed $\pm 0.5\%$ if its mean value.

3. Steady-State Frequency Operation Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no loads harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3 phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.
9. The diesel engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
10. Motor starting capability shall be a minimum of twice the KVA rating of the generator. The generator set shall be capable of sustaining a minimum of 70% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.

E. Generator-Set Performance for Sensitive Loads:

1. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain with the steady-state operating band within 0.5 second.
3. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operations band and not hunting or surging of speed.

5. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain with the steady-state operating band within three seconds.
6. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
8. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
9. Start Time: Comply with NFPA 110, Type 10, system requirements

2.4 PROTOTYPE TESTS AND EVALUATION:

Prototype tests shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.

A witnessed test shall be performed on gensets in factory of origin and shall be attended by two engineers selected by Client or Consultant. Testing shall include all the paralleling and load sharing + load shedding functions with dummy loads similar to project load. Bidder who do not include this factory witnessed testing will not be considered.

2.5 GENERATOR:

AC Generator: The AC generator shall be; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc.

All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 125 degrees Centigrade.

The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.

Any other exaltation method different from PMG shall be rejected.

2.6 GENERATOR, EXCITER, AND VOLTAGE REGULATOR:

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- C. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- D. Construction shall prevent mechanical, electrical and thermal damage due to vibration, over speed up to 125percent of rating, and heat during operation at 110 percent of rated capacity.
- E. Enclosure: Drip proof.
- F. Instrument Transformers: Mounted within generator enclosure.
- G. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.7 ENGINE-GENERATOR SET CONTROL:

The generator set shall be provided with a microprocessor-based control system, which is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote control as described in this specification. The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered. The control shall be UL508 labeled, and meet IEC8528 part 4. All switches, lamps and meters shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts. The controls shall meet or exceed the requirements of IEC Std 801.2, 801.3., and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.

The entire control shall be tested and meet the requirements of IEEE587 for voltage surge resistance. The generator set mounted control shall include the following features and functions:

Three position control switch labeled RUN/OFF/AUTO.

In the RUN position the generator set shall automatically start, and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

Red "mushroom-head" push-button EMERGENCY STOP switch.

Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

Push-button RESET switch.

The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

Push-button PANEL LAMP switch.

Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

2.8 GENERATOR OVER CURRENT AND FAULT PROTECTION:

- A. Generator Circuit Breaker: Molded-case, electronic-trip type, 100 percent rated; complying with UL489.
 - 1. Tripping characteristics: Adjustable long-time and short-time delay and instantaneous.
 - 2. Trip settings: Selected to coordinate with generator thermal damage curve.
 - 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 - 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:

1. Initiates a generator overload alarm when generator has operated at on overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 3. As over current heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 4. Senses clearing of a fault by other over current devices and controls recovery of rated voltage to avoid overshoot.
- C. Ground-Fault Indication: Comply with NFPA 70, “Emergency System” signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.9 GENERATOR SET AC OUTPUT METERING:

The generator set shall be provided with a metering set with the following features and functions:

2.5-inch, 90 degree scale analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. These meters shall be provided with a phase select switch and an indicating lamp for upper and lower scale on the meters. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0-90% of generator set prime rating: green; readings from 90-100% of prime rating: amber; readings in excess of 100%: red.

Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.

2.10 GENERATOR SET ALARM AND STATUS MESSAGE DISPLAY:

The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing alarm and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel:

- Low oil pressure (alarm)
- Low oil pressure (shutdown)
- Oil pressure sender failure (alarm)
- Low coolant temperature (alarm)
- High coolant temperature (alarm)

High coolant temperature (shutdown)
Engine temperature sender failure (alarm)
Low coolant level (alarm or shutdown-selectable)
Fail to crank (shutdown)
Overcrank (shutdown)
Overspeed (shutdown)
Low DC voltage (alarm)
High DC voltage (alarm)
Weak battery (alarm)
Low fuel-day tank (alarm)
high AC voltage (shutdown)
Low AC voltage (shutdown)
Under frequency (shutdown)
Over current (warning)
Over current (shutdown)
Short circuit (shutdown)

Ground fault (alarm)
Over load (alarm)
Emergency stop (shutdown)

In addition, provisions shall be made for indication of two customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

2.11 ENGINE STATUS MONITORING:

The following information shall be available from a digital status panel on the generator set control:

Engine oil pressure (psi or kPA)

Engine coolant temperature (degrees F or C; Both left and right bank temperature shall be indicated on V-block engines.)

Engine oil temperature (degrees F or C)

Engine speed (rpm)

Number of hours of operation (hours)

Number of start attempts

Battery voltage (DC volts)

2.12 CRANKING AND GOVERNOR:

The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and No. of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.

The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position. In this mode, the alternator excitation system shall be disabled.

The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.

The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

2.13 ALTERNATOR CONTROL AND VOLTAGE REGULATION FUNCTIONS:

The generator set shall include an automatic voltage regulation system which is matched and prototype tested with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [48-49] HZ. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alpha-numeric LED readout to indicate setting level.

The voltage regulation system shall include provisions for reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

Controls shall be provided to monitor the output current of the generator set and initiate an alarm when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator.

Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition when total load on the generator set exceeds the generator set rating for in excess of 5 seconds.

Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded .

An AC over/under voltage monitoring system which responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine starting, the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.

The control system shall include a ground fault monitoring relay. The relay shall be adjustable from 100-1200 amps, and include adjustable time delay of 0-1.0 seconds. The relay shall be for indication only, and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set, and provide relay which will function correctly in system as installed.

2.14 INTERFACES FOR REMOTE MONITORING:

All control and interconnection points from the generator set to remote components shall be brought to a separate connection box. No field connections shall be made in the control enclosure or in the AC power output enclosure. Provide the following features in the control system:

Form "C" dry common alarm contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.

One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.

A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

A fused 20 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

The control shall be provided with provisions for connection of remote monitoring equipment as described herein or shown on the drawings.

2.15 BASE:

The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.

Vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer.

Base frame shall have for lifting points.

The generator set shall be vibrationally isolated from structure on spring type antivibration mountings. There shall be no rigid connections between the generator set and the structure.

The spring type vibration isolators shall preferably be constructed from suitably treated and finished steel or steel alloys. They shall be manufactured with elastomeric acoustic pads to prevent transmission of high frequencies.

Spring type isolators shall have auxiliary dampers or adjustable snubber type restraints to prevent excessive movements as the machine speed passes through resonant frequency of the mounting system.

2.16 VIBRATION ISOLATION DEVICES:

Characteristics of Elastomeric pads and spring isolators shall be:

- A. Elastomeric Isolator Pads: Oil -and water- resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel base plates of sufficient stiffness for uniform loading over pad areas, and factory cut to sizes that match requirements of supported equipment.
 - 1. Material: Standard neoprene
 - 2. Durometer Rating: 50
 - 3. Number of Layers: Four
- B. Restrained Spring Isolators: Freestanding steel, open-spring isolators with seismic restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled base plate bonded to ¼-inch-(6mm) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.17 BATTERIES AND CHARGERS:

Starting and Control Batteries: Starting battery bank, lead calcium type, 24 volt DC, sized as recommended by the generator set manufacturer, shall be supplied for each generator set with battery cables and connectors.

Battery Charger: A UL listed/CSA certified 10 amp voltage regulated battery charger shall be provided for each engine-generator set. The charger may be located in an automatic transfer switch, or may be wall mounted, at the discretion of the installer. Input AC voltage and DC output voltage shall be as required. Chargers shall be equipped with float, taper and equalize charge settings. Operational monitors shall provide visual output along with individual form C contacts rated at 4 amps, 120 VAC, 30VDC for remote indication of:

Loss of AC power - red light
Low battery voltage - red light
High battery voltage - red light
Power ON - green light (no relay contact)

Analog DC voltmeter and ammeter, 12 hour equalize charge timer, AC and DC fuses shall also be provided on the charger.

Batteries Technical Characteristics:

1. Components: Sized so they will not be damaged during a full-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: (as required by NFPA 110 for system level specified).
4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature. Include accessories required to support and fastener batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

Charger Technical Characteristics:

1. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 50 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, type 1, wall-mounted cabinet.

2.18 COUPLING SYSTEM:

The coupling system shall be of unit construction which forms the engine and generator into one unit of exceptional strength and ensures perfect alignment.

The alternator end shield and the engine flywheel housing faces shall be fully machined with spigots concentric to their shafts. The machined flanges mounted on the alternator shall be connected to the flywheel housing flange by steel bolts.

A flexible rubber block coupling shall be fitted between the engine and alternator to provide the drive and absorb the transmission of shock loads. The torsional flexibility shall be designed to match the torsional characteristics of the system to prevent resonant conditions.

2.19 REMOTE ANNUNCIATOR:

Provide and install a 20-light LED remote alarm annunciator with horn, located as shown on the drawings or in a location which can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems; and in addition shall provide indications for high battery voltage, low battery voltage, loss of normal power to the charger. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 3-5.6.2.

2.20 EXHAUST MUFFLER(S) & COMBINED SOOT FILTER CATALYTIC CONVERTER

Shall be provided for each engine, size and type as recommended by the generator set manufacturer. The mufflers shall be residential grade. Exhaust system shall be installed according to the generator set manufacturers recommendations and applicable codes and standards. Exhaust pipe shall have sufficient size to ensure that exhaust back pressure does not exceed the maximum limitations set by supplier the muffler and indoor exhaust piping shall be lagged to maintain a surface temperature not to exceed GSC. The insulation shall be installed so that it does not interface with the functioning of flexible exhaust fitting.

Flexible gastight connection pieces shall be provided in the exhaust pipe line to allow for thermal expansion and to prevent vibration being transmitted to the engine.

A clearance hole shall be allowed where exhaust pipe passes through a wall to avoid over heating.

2.21 STAINLESS STEEL DOUBLE SKIN EXHAUST PIPES:

Furnish and install where indicated on the drawings a factory-built Underwriters Laboratories, Inc. listed chimney and breaching.

The chimney shall be listed by UL as a "1400" Fahrenheit Chimney" for continuous operation at 1400 °F and intermittent operation at 1800 °F and also as a "Building Heating Appliance Chimney" (UL103) for continuous operation at 1000 °F and intermittent operation at 1400 °F. The chimney manufacturer shall furnish all items which form a part of the assembly including straight sections, tee sections, elbows, cleanouts, drains, expansion joints, boiler adapter kits, guybands, flashing, counter flashing and insulated thimble where required.

Installation shall be made in accordance with the Manufacturer's recommendation and in compliance with the Underwriters Laboratory, Inc. listing. Product shall be listed for 4" clearance to combustibles. All chimney sections shall be of double wall construction with 4" insulation between the liner and the shell.

The liner shall be 20 gage 304 stainless steel and the shell shall be of 24 gage aluminized steel for all sizes up to and including 36" I.D. for sizes 38" I.D. and above liner shall be 18 gage 304 stainless steel and the shell shall be 20 gage aluminized steel. (Type 316 stainless steel is also available for liners and shells).

All section shall be joined with a Vee band sealed with silicone sealant around the inner liner and a drawband around the outer shell. Silicone sealant shall also be used on the outer drawband for exterior installations. High temperature joint cement shall be used instead of silicone sealant on the Vee band for operating temperatures exceeding 600 °F. Diameter and total stack height shall be as indicated on drawings. Chimney to terminate three feet above the roof.

Free-standing chimney specifications

The Chimney shall be a metal jacketed refractory lined factory-built sectional type chimney. The sections shall be up to 40 feet in length and cylindrical in shape. It shall be freestanding, self-supporting and shall be designed to resist wind and earthquake loads. Drawings shall be prepared showing all features of the work including thickness of steel shell and refractory, overall height and diameter, and the design of the anchor system and foundation if required. The stack shall be mounted on a concrete foundation, which includes a drain, and is installed by a general contractor. Detailed design calculations for tension, compression, cantilever, vibration ovaling, dynamic stability and seismic forces shall be furnished. Wind forces are to be calculated as directed by the Engineer.. Deflection shall in no case exceed a ratio of 1 to 200 in reference to stack height.

The cast insulating acid resistant refractory shall be suitable for continuous operation at 1800 °F and for intermittent operation at 2000 °F as proven by Underwriter's Laboratories Standard #959. Each factory-built refractory section shall be up to 40'0" in length with internal angle-shelves to prevent ovaling. Assembly in the field shall be made by joining sections with high temperature, acid resistant joint cement prior to welding the sections. All field welding shall be done by certified welders.

All exterior surfaces of the chimney shall be thoroughly cleaned of all rust, scale, dirt, grease, oil and other foreign matter in accordance with the latest revision of the Steel Structures Painting Council Surface Preparation Specification. Commercial Sandblast Cleaning using a compressed air blast nozzle and dry sand of maximum particle size no larger than that passing through a 16 mesh screen U.S. SIC-C series. All blast cleaned surfaces shall be painted the same day they are cleaned. No blast cleaned surface shall remain unpainted overnight. Shop painting shall consist of a prime coat of high temperature primer suitable for the application.

The chimney shall be secured to the foundation with plumbness not to exceed 1 – per 50 feet. Grouting of the chimney base plate shall be by the chimney erector or the general contractor.

Shop drawings will contain details as to thickness of outer shell and complete information on all chimney accessories. Calculations shall account for all stresses characteristic to that stack installation.

The engineer's review shall not constitute checking or approval and shall in no way relieve the stack manufacturer of his full responsibility for the accuracy of the calculations and the ultimate safety and structural integrity of the stack. The stack and breaching shall fully conform to overall dimensions and characteristics as shown on the drawings.

Accessories

Ail pollution control test ports, gas sampling platforms, ladders, lightning protection, painters trolley shall be shown on shop drawings. Lightning protection will be designed to meet the standards contained in and published by the National Fire Protection Association. Grounding shall be accomplished by providing pads at the stack base for attachment of grounding cables (Per NFPA 780(1977) 3-11.8 "Chimneys" and 5-11 "Metal Stacks") Grounding system to be installed under the electrical section of this specifications.

A base anchorage system shall be provided at the base of the chimney to transmit the forces in the shell to the foundation either directly or through the anchor bolts, without inducing local stresses of appreciable magnitude in the shell or exceeding the allowable bearing stress of the concrete.

General

The outer steel jacket of the chimney shall be designed to resist the stresses resulting from the weight of the chimney, the effect of wind and earthquake, and to resist corrosion from the weather. The inner liner of refractory is designed to resist corrosion and temperature associated with the flue gases and absorb and dampen the effects of aerodynamic wind forces.

All surfaces to be welded shall be smooth, uniform, free of laminations, scale, grease, or other material which might adversely affect the welding. Precautions shall be taken to minimize distortion and stresses due to heat build-up. The stack manufacturer shall have developed weld-procedures which, in conjunction with the overall fabrication methods, will produce a stack that meets the quality requirements of these specifications. The detailed design shall take into consideration shipping procedures and adequately provide for any stresses which might normally develop there from. The allowable unit stresses for structural shapes shall be as given in the American Institute of Steel Construction Specification for Design, Fabrication and Erection of Structural Steel of Buildings.

Anchor bolts shall be set by a wood or metal template and plumbed in two directions true and level to the foundation by the contractor.

The chimney erector shall use special care in unloading and handling all materials from truck and/or cars. The erector shall handle all materials in such a way as to minimize damage and to avoid scarring or damaging the outer jacket or the refractory liner. If temporary erection clips or braces are employed, care should be used to prevent unsightliness upon removal. Tack welds should be ground smooth and holes shall be filled with weld metal and ground smooth. All finish welds are to be clean, showing good fusion and 100% penetration with extensive visual inspection.

If finish painting is required and after all exterior surfaces of the chimney are cleaned and free of all rust, dirt, grease, oil and other foreign matter. It shall be finish painted with two coats of finish paint. This finish painting shall be performed by the chimney erector.

Approved Manufacturers

- Selkirk
- Van Packer
- Flux Tubi

or approved equal

2.22 ACOUSTIC PANELS:

Factory fabricated acoustic panel, double skin 0.5mm thick galvanized outer and inner sheets, a “Penta Post” supporting frame. Panels and frames are to be secured using internally bolted fixings so that welding minimized and integrity of the galvanized finish is maintained. Panels are to be provided with 25 mm thick fiberglass filter and to be designed to withstand an internal positive pressure of 250 mm water gauge in the outlet section and an internal negative pressure of 75 mm water gauge in the fan inlet section. Casing to be fitted with rails for mounting the unit components and all sections requiring servicing are to be fitted with quick release doors. All panels are to be screwed on external side to permit removal of components through either side of unit. Casing to be self supporting on 3m horizontal span or 3.6m vertical span.

2.23 GENERATOR MOUNTED POWER COMMAND FOR SYNCHRONIZING:

The digital power command shall consist of a control panel mounted on the generator set with built-in microprocessor and shall also consist of:

Digital governing, voltage regulation, synchronization and load sharing controls, including export/ impact controls for paralleling with a mains bus.

Protection for alternator. (over current types).

Analog and digital AC output metering.

Battery monitoring system to sense and warn against a weak battery condition.

Digital alarm and status message display.

Display status of all critical engine and alternator generator set functions.

Smart starting control system with integrated fuel ramping to limit black smoke and frequency overshoot in addition to cold weather starting.

Network capability.

Dust, water + oil resistant enclosure

Semi automatic paralleling facilities including single check synchronizer, auto-close attachment for circuit breaker, common busbar and synchroscope to adjust speed of incoming generating set(s).

2.24 TECHNICAL CHARACTERISTICS OF SYNCHRONIZING SYSTEM:

Governing Performance:

- Frequency regulation: Isochronous under varying loads from no load to full load.
- Frequency drift: $\pm 0.5\%$ drift for a 60° F (33° C) change in ambient over eight (8) hours with temperature stabilization at each points.

Isochronous Real Load Sharing:

- Real load sharing controls allow generator sets to share load to within as low as 1% of equal. Load sharing controls operate directly on the engine governor actuator, to provide zero droop in frequency for loads from zero to 100% of rated generator set capacity.
- Kilowatt import and export control, to allow the generator set to share load with an infinite bus. The controls allow setting of ramping rate, and steady state operation level. Steady state KW level, or on a signal from a remote control device which allows loading of the generator set as a function of the load provided by the utility (mains) service.
- Load demand ramping controls cause the generator set to ramp down to a low load condition prior to switching off on a load demand signal. On removing the load demand signal, the generator set will automatically start, synchronize to the system bus, and close at no load. The generator set then ramps up to its proportional share of the total on the system.

Isochronous Reactive Load Sharing:

- Reactive load sharing controls allow generator sets to share load to within as low as 1% of equal. Load sharing controls operate directly on the excitation system, to provide zero droop in voltage for loads from zero to 100% of rated generator set capacity.
- Reactive load sharing controls allow generator set to share reactive load with an infinite bus. The control system allows a technician to adjust the operating reactive load level on the generator set.

Synchronizer:

- Range: The synchronizer can drive generator set frequency and voltage to a bus value which is -40% to +10% of selected voltage and frequency. Ramp speed for matching is 4% second.
- Frequency differential: Controls generator set to match bus frequency.
- Voltage differential: Electronically controls generator set voltage to within 1% of system bus voltage, and checks for correct phase rotation to bus.
- Permissive protection: Adjustable for a phase difference of 5-20 degrees, with phase difference decreasing. Time delay is adjustable from 0.5 to 5 seconds.
- Control system: Automatically resets bus frequency and voltage to preset values after the paralleling breaker closes.
- Includes "Dead Bus" sensor: Allows closure of the generator set to an inactive system bus.

The front panel of the control panel shall be formed by a single membrane that covers the entire control surface. The control face shall be easy to clean and impervious to water spray, dust and oil/exhaust residue. Electronic control switches for many functions shall be integral to the front panel. The control door shall be dual/ moisture and RFI/EMI gasket to protect internal components from airborne contaminants. The control shall perform properly over a wide range of environmental conditions and is vibration, RFI/EMI, and surge tested.

- Operating temperature: -40° C to +70° C.
- Storage temperature: -40° C to +85° C.
- Humidity: up to 95% relative, non-condensing.
- Altitude: up to 3048 M (10,000 feet) without derating.

2.25 CONTROLS AND ADJUSTMENTS SWITCHES:

An oil tight, three position switch shall start and stop the generator set locally or shall enable start/stop control from a remote location. It shall provide the following functions:

- The "OFF" position de-energized all primary DC circuits. When the switch is in this position, the non-automatic indicator will flash continuously.
- The "RUN" position energized the control and initiates generator set starting operation.
- The breaker control switches are enabled only in the "RUN" position. The non-automatic indicator will flash when the switch is in the "RUN" position, indicating that the paralleling breaker will not automatically close.

- The “AUTO” position enables the control to receive a start signal from a remote location, such as an automatic transfer switch or master control panel.

A two position safety “mushroom” head switch shall provide an easy and obvious means to immediately shut down the generator set in the event of an emergency condition.

2.26 ALARM AND STATUS INDICATING PANEL:

Control arrows on the screen shall lead the operator to information. The system control switches shall provide the operator with a positive indication that the switch is operated. The switches shall be totally sealed and designed to provide reliable service for the life of the generator set control.

Alarm and status indicating panel to indicate the following conditions (alarm horn shall be located on master control) :

<u>Function</u>	<u>Lamp</u> <u>Color</u>	<u>Alarm</u> <u>Horn</u>	<u>Shutdown</u> <u>Unit</u>
Low DC Voltage	Amber	*	
High DC Voltage	Amber	*	
Weak Battery	Amber	*	
Fail to Sync	Amber	*	
Low Oil Pressure Alarm	Amber	*	
Low Fuel - day tank	Amber	*	
High Engine Temp	Amber	*	
Alarm			
Spare (2)	Amber	*	
Ground Fault	Amber	*	
(when required)			
Overcurrent Alarm	Amber	*	
Breaker Failure	Red	*	*
Not in Auto	Red	*	*
High Engine Temp	Red	*	*
Low Oil Pressure	Red	*	*
Overcurrent	Red	*	*
Short Circuit	Red	*	*
Loss of Excitation	Red	*	*
Reverse Power	Red	*	*
Overcrank	Red	*	*
Overspeed	Red	*	*
Under Frequency	Red	*	
Under Voltage	Red	*	*
Over Voltage	Red	*	*
Phase Rotation	Red	*	*
Low Coolant Level	Red	*	*
Automatic	Green		
Generator Running	Green		
Breaker Open	Green		
Breaker Closed	Green		

Demande Mode Standby
Timing for Start
Timing for Shutdown

Provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for reliable system operation, as described herein under "SYSTEM OPERATION".

2.27 MASTER DIGITAL CONTROL PANEL:

Provide a master control panel to monitor and control the operation of the entire paralleling system. The master control panel shall contain the components described in this section, and all meters, controls and status of the generators shown in the previous sections. Master digital command panel shall be located in generator room or in totalizer board, as per system vendor recommendation and as close as possible from alternator panel.

The digital master control shall be microprocessor based paralleling system component, designed to directly interface with local power command paralleling.

Power command paralleling systems shall utilize a true distributed logic design. Each major component in the system shall include sufficient controls and logic to operate completely autonomously in the event of failure of other system components.

Reliability shall also be improved by extensive use of microprocessor based components and elimination of common nuisance failure points in the system, such as incandescent lamps.

A touch screen shall be quoted as an alternative extra and if approved shall eliminate the need for switches and rotary potentiometers which are open to the environment, and subject to failure due to contamination or degradation of contact assemblies.

The use of a common set of hardware for almost all applications allows complete, standardized documentation to the system. Since the same core software, control and monitoring components are used in most applications, system reliability is not compromised by use of untested components or one-of-kind software.

The control system, including touch screen and the LED annunciator panel shall be designed for operation under the following conditions:

Operating temperature: 0 to + 60 degrees C.

Storage temperature: -30 to + 70 degrees C.

Humidity: up to 95% relative, non-condensing.

The control system shall be housed in a rigid, free-standing, metal enclosed structure designed to require front access only. Framework of the equipment is constructed of minimum 12 gauge (2.5 mm) steel sheet metal.

The framework and all other sheet metal components of the system are primed with a rust-inhibiting primer and finished with satin finish ANSI 61 gray or black enamel.

Control components shall be totally isolated from power-carrying components by metal or insulating barriers. All components and surfaces operating at more than 50 volts are shielded to prevent inadvertent contact.

All control wiring is UL type 105 degree C, 600 volt rated and sized as required. Each wire, device and functional component shall be defined by silk-screen or similar permanent identification.

Fuses shall be installed in DIN-rail mounted safety-type fuse holders with integral “fuse blown” indicating lamps.

Terminal blocks for all field connections shall be DIN-rail mounted devices with removable plugs for connection of section-to-section breaks.

RMS AC metering transducers shall provide input via a serial link to the system PLC, so that AC metering data can be displayed on the system Touch screen.

The transducers shall operate with a metering accuracy of plus or minus 0.25% for amps, volts, power and energy; and 0.01 hertz for frequency.

The transducers shall meet IEEE/ANSI C 37.50 SWX ring wave test requirements and have a voltage breakdown level of in excess of 2500 volts.

Master Control Front Panel

The front panel of the master control shall contain the following instruments and devices.

- a) 1% accuracy True RMS digital instruments to monitor total output of bus: Ammeter, Voltmeter, Frequency Meter, Wattmeter, Varmeter, Power Factor Meter, kW-Hour Meter, kW demand, kVAR hours, kVA hours. Selector switches to allow viewing of voltage and amperes for each phase shall be provided. For 3-phase/4-wire systems the voltmeter shall indicate line to line and line to neutral conditions.
- b) Operator Interface Panel. An operator interface panel shall be provided which allows the operator to monitor and control the following functions:

General System Status: A graphic status panel shall be provided which indicates Generator set and bus configuration; genset designation and KW rating; generator set and bus energized/de-energized indication; generator set mode (auto/not in auto/run); generator set alarm status (normal/warning/shutdown); paralleling breaker designation and status (open/closed/tripped); utility main and feeder breaker status for breakers controlled by this system (see contract drawings for details of equipment required).

Load Demand On/Off control switch and indicating lights. The system shall also include provisions for field adjustment of load demand pickup/drop out set points, load demand shut down time delay, and load demand shut down sequence.

Load Shed On/Off control switch and indicating lights. (One set for each load shed level.)

Load Add control switches and indicating lights. (One set for each load shed level.)

Test On/Off control switch and indicating lights.

System Auto/Manual switch and indicating lights.

Individual generator set manual paralleling provisions (one set per generator set in the system), including: generator set start/stop switches which are operable only in the manual system mode (control switch on the generator paralleling control panel must be in the “auto” position); generator set synchronized indication; synchroscope; manual breaker control switches (open/closed).

Individual generator set fault reset (all but emergency stop).

Under Frequency/Over Load reset. The system shall include provisions for field adjustment of load shed time delay.

Help screens for each display screen, to describe the functions which can be performed and the meaning of the terms on each screen.

Emergency messages shall be provided to highlight operational problems in the system to the operator, and provide specific direction to the operator describing how to respond to the problem.

Solid State System Status Panel. The system status panel shall have the following features and functions:

Alarm Silence Push-button Switch

Alarm horn

Indicating lamps to indicate the following conditions:

<u>Function</u>	<u>Color</u>	<u>Alarm Horn</u>
Load Demand Mode	green	
Priority “n” Load On (1 lamp/level)	green	
Load Shed Level “n” (1 lamp/level)	red	*
System Test	green	
Remote System Start	red	
Check Generator Set (1 per generator set)	red	*
Bus Overload	red	*
Non-Automatic	red (flashing)	*

Internal Control Components

The following internal controls shall be provided within the master control section:

- a) Programmable controller for interface with touch screen, and to provide load demand, load pick-up, and load shed functions.
- b) Load pick-up output contacts, rated 10 A at 600 VAC (3 contacts per level). There shall be a minimum of one level of output contacts for each generator set in the system.
- c) Load shed output contacts, rated 10 A at 600 VAC (3 contacts per level). There shall be a minimum of one level of output contacts for each generator set in the system.

Provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for reliable system operation.

2.28 SYSTEM OPERATION:

Automatic Operation:

The normal mode of system operation shall provide for unattended automatic emergency paralleling of all engine generator sets, transfer of load, and load control for the entire emergency power system. Emergency power shall be supplied to the system emergency loads within 10 seconds after interruption of the normal service or in case of overvoltage or under voltage of the normal service. Upon receiving a signal of failure of normal power, the system control unit will signal all engine generators to start. Each engine generator will automatically start, and the first generator to achieve 90% of rated voltage and frequency will automatically connect to the emergency bus, via the generator circuit breaker and connexed step-up transformer. Generators with improper voltage or frequency shall not be permitted to connect to the bus until the abnormality is corrected.

As the remaining generators achieve proper operating conditions, the automatic synchronizer of each generator control unit will rapidly force them into synchronism with the bus, by sending correction signals to the electronic governor of each engine generator. After proper synchronism is attained, each engine generator will be automatically shared between all generators connected to the bus.

The transfer of load from normal to emergency bus shall be controlled by the system controls and shall occur in accordance with an established load control program thru independent controller or combined with the centralized monitoring and control system i.e. Building Management System (preference is for second alternative, and Contractor to deploy necessary action to ensure coordination and compatibility of hardwares for a perfect operation of the system as intended the BMS interfaces with all the motorized breakers of power distribution and contactors for load shedding shall be included in this part of contract). The program shall assign priority level to each load. The highest priority load shall be the first to transfer to the emergency bus, regardless of the number of load contractors experiencing the failure. The first load transfer shall occur only after adequate generating capacity is connected to the bus. As additional capacity is connected to the bus, subsequent load transfers will occur in order of their assigned priority levels, as established by the load control program. The number of load priority levels will never exceed the number of engine generator sets.

The load control shall, as required, automatically dump loads connected to the emergency bus, by controlling distribution circuit breakers within the distribution units. If a sustained bus under frequency occurs, or an engine generator has experienced a fault while all load transfer contactors are in the emergency position. The load control shall activate and exercise control over blocks of emergency fault, a block of load equal to the capacity of one generator shall be dumped. After the engine generator's fault condition has been corrected and manually reclosed to the emergency bus, the load can be reinstated.

In the event of a sustained bus under frequency, a block of load will be dumped approximately every 10 seconds (adjustable) until the bus regains proper frequency. Loads dumped in this manner shall be manually reinstated. Loads will be dumped and reinstated in accordance with their assigned priority level as established by the load control program. The lowest priority load will be dumped first and the highest priority load dumped last. It shall be possible to selectively disable the dump circuitry of the highest priority loads, to prevent dumping regardless of system conditions.

Once normal power has returned and been determined stable, the transfer switch loads connection contactors or breakers and load shedding contactors will signal a return to the normal source. After all loads have transferred load back to the normal source, the engine generators will run unloaded for a short cool down period (adjustable 0-15 minutes) and then shut down. The emergency power system circuitry shall then automatically reset and remain in readiness for the next failure of normal power.

Manual Operation:

The emergency power system shall have the capability of being manually operated. Each generator set may be individually started by engine control switches located on the respective engine generator control units. Once started and stable, the generator may be manually connected to the emergency as through individual generator circuit breakers. After the emergency bus is energized by the first generator, each remaining generator may be connected to the bus by utilizing permissive paralleling circuitry. Each generator control unit will be equipped with a synchronizing switch, generator breaker control switch, engine speed adjusting potentiometer and a generator voltage adjust rheostat to facilitate manual paralleling. The master control unit shall include an integral synchronizing “swing” panel equipped with bus and on coming generator instrumentation, along with synchronizing lights to enable manual paralleling. During manual operation, all load dump circuitry shall be disabled by a load dump disable switch and individual distribution breaker control switches shall provide the means of controlling system loads.

A key operated system mode switch shall be provided to manually test the emergency power system. The switch shall have three positions: “full load test”, “normal”, “no load test”, with the key removable in the “normal” position only. In the “normal” position the system shall be in readiness for fully automatic operation. The “no load test” position shall automatically start and parallel all generators sets to the emergency bus, however, load will not be transferred as long as normal power remains available. The “full load test” position shall automatically start and parallel all generator sets and transfer load to the emergency bus.

Electrical Components:

To include all required meters, transformers, fuses, control relays, control wirings, timers, indicating lamps, switches etc.

2.29 FUEL OIL STORAGE:

- A. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
1. Tank level indicator.
 2. Capacity: Fuel for eight hour’s continuous operation at 100 percent rated power output.
 3. Vandal-resistant fill cap.
 4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

B. Above Ground Storage (Vertical Mounting)

- Tank shall be constructed of not less than 6 mm. thick welded black steel sheet metal to the capacities indicated on Drawings, and in accordance with UL standard for steel above ground tanks for flammable and combustible liquids .UL. 142-1972.
- Tank shall be tested for leaks before installation and shall be painted with two coats of red lead oxide or approved equal, and two coats black bituminous paint , and finished with Silver or White enamel paint.
- Tank shall be mounted on a concrete pad and shall be equipped with the following:
 - Manhole and manhole cover 600 x 600 mm.
 - Protected oil level indicator fixed to the tank. (level gauge Cat and Mouse).
 - Fill and vent pipes.
 - Two gate valves one in fuel supply line and one in drain line.
 - Overflow, drain and supply lines.
 - One external and one internal caged ladders.
 - Earthing connection.

2.30 MISCELLANEOUS CONTROLS:**a) Under frequency Relay**

A solid state under frequency relay shall be provided to monitor the frequency of the emergency bus for alarm and load dump.

b) Mode Switch

A key operated system mode switch shall be provided to enable testing the emergency power system. The switch shall have three positions, No load test, normal, and full load test, with the key removable only in the normal position.

c) Load Dump Disable Switch

Shall be provided to enable all load dump circuits to be disabled simultaneously. The switch shall be key operated having two positions. Normal and Disable, with the key removable only in the normal position.

d) Best Battery Selector

Solid state circuitry shall be supplied in the system control unit to automatically select the best set of engine starting batteries as the system control DC sou. The selected DC source shall supply all DC control logic within the system controls. If the selected source deteriorates the next best set of engine starting batteries shall automatically become the system control DC source.

e) **System Alarm Horn**

Of the solid state DC type shall be provided to audibly annunciate system abnormalities of bus under frequency and load dumps.

f) **Status and Fault Lamps**

A group of these lamps shall be provided for each distribution feeder circuit and the emergency system control. Lamps shall be provided as follows:

System status and/or fault lamps shall be provided, and shall illuminate to indicate the following conditions.

- Full load test
- No load test
- Load dump disabled

Distribution feeder circuit status lamps shall illuminate to indicate the status of each transfer switch associated emergency distribution circuit breakers as follows:

- Transfer switch and loads connection gears in normal.
- Transfer switch and loads connection gears in emergency, load dumped.

g) **Alarm Silence Push Button**

And circuitry shall be provided to silence the system alarm horn prior to resetting a fault or to acknowledge a condition.

h) **Transformers**

Potential transformers shall be provided as required for bus metering and synchronizing circuits. Control transformers shall be provided as required to supply power to the distribution circuit breaker closing circuits.

i) **Pilot Lights**

Are to indicate which L.V. breaker is on.

j) **Instruments**

Are to include voltmeter and ammeter with selector switches.

k) **Circuit Breakers**

Used instead of contractors are to provide same functions as a minimum requirement and are to be electrically and manually operated non-automatic type.

l) **Wiring**

Moisture and heat resistant silicon rubber insulated stranded copper conductors, modularly and neatly arranged on master terminal blocks, with suitable numbering strips and appropriate cartridge type fuses where required. Flexible wiring is to be used on all hinged/draw-out components.

m) **Connections**

Are to be made at a front terminal block with no live metal exposed. Power cables are to terminate on fixed insulated copper connectors suitably sized to receive specified cables. Cable glands and gland plates are to be provided.

n) **Metal Cases**

Of instruments control switches, relays etc. are to be connected by flexible protective conductors, of not less than 2.5 mm² section, to nearest earthing bar or terminal.

o) **Earthing**

Earthing bar is to be provided for connection of protective earthing co, using set-screw or bolted anti-turn pressure terminations.

p) **Ferrules**

Wire ends are to be fitted with numbered ferrules of approved type at each termination.

If the bus does not return to proper frequency within a predetermined period of time, additional load shed signals will be generated.

SYSTEM TESTING:

Test Mode: Operation of the test switch on the paralleling control system master control panel shall simulate a power failure in the system, and the system shall function as described in "Loss of Normal Power" above.

The paralleling equipment shall be tested with the generator sets for this project at the factory, at rated load and power factor. At least 2 gensets at a time shall be tested with dummy loads. System testing shall include tests to demonstrate all functions of the system, and system cold start test, parallel unit load sharing, and transient loading of the system, at loads up to and including full block loading of the generator sets. These tests may be witnessed by the engineer. Provide certified factory test report documenting factory system testing. See generator set testing requirements for other test requirements.

2.31 DISTRIBUTED CONTROL AND MONITORING NETWORK:

- i) On-site power system equipment shall be interconnected by a serial communications network for distributed control and monitoring of the complete system. All of the data listed in this section shall be accessible from the network. The network shall be capable of initiating testing the generator set(s) and transfer switch(es) and reporting alarms and status information.
- ii) The network application devices shall be specifically designed for control and monitoring of generator sets, transfer switches, and accessory equipment of the power system as installed. The network application devices (hardware) and programming (software) shall be designed, manufactured, and supported by the same manufacturer.
- a) Network Protocol: The network protocol shall be Echelon Lonworks. The network protocol shall be peer-to-peer such that any network application device has access to the network at any time. Access to the network shall be managed effectively, including error detection, priority access for critical messages, and a collision resolution and avoidance scheme. Network devices shall be addressable such that the network is configurable using software, initially and for future modifications. Messages shall be capable of end-to-end acknowledgement. Token ring or master/slave protocols will not be accepted at submittal.
- b) Network Media: The network media shall be a minimum 78 kbps transformer-coupled twisted pair with a range of 2000 meters. The digital signal shall be Manchester encoded or alternate means to achieve wiring polarity insensitivity. The transformer coupled-twisted pair cable shall be unshielded meeting UL Level IV or EIA Cat 4 transmission characteristics as recommended by the manufacturer. The cable shall include as a minimum, one 22 AWG pair for data communications, and a second (spare) 22 AWG pair.
- c) Topology: The network topology shall be a multi-drop bus with end terminations as required. Drops, or stubs, shall be permitted at any point along the bus, each drop with a ten foot maximum distance from the bus.
- d) Network Power: The network shall function normally whether or not AC power is available in the facility.
- e) Network Monitor: The distributed control and monitoring network shall be capable of being monitored by an IBM-compatible personal computer, 486 minimum, running Microsoft Windows 3.1 or higher. The personal computer and its peripheral equipment is not included in the contract for the on-site network

Generator Set Monitoring: The network shall monitor real-time generator set operating data, alarms and status information. Alarm and status information to be date and time stamped, and automatically entered in the Events Log or Alarms Log as appropriate shall include the following:

Table: Generator Set Real Time Operating Data, Alarms, and Status Indications

Start	Low Coolant Temperature	Frequency
Run	Customer Selected Faults (2)	Power Factor
Oil Pressure	Common Alarm	Kilowatts
Low Oil Pressure Pre-Alarm	AC Volts L1-N	Reactive Power - kVAR
Low Oil Pressure Shutdown	AC Volts L2-N	Energy, mW-hrs.
Coolant Temperature	AC Volts L3-N	Low Fuel
High Coolant Temp Pre-Alarm	Current L1	Low DC Voltage Warning
High Coolant Temp Shutdown	Current L2	High DC Voltage Warning
Overcrank Shutdown	Current L3	AC Failure to Charger
Overspeed Shutdown		
Switch OFF (Not-in Auto)		

Logs: User Activity Log, Event Log, and Alarms Acknowledgement Log for automatic record-keeping. All user keyboard commands, events, and alarms/alarm acknowledgements shall be stored in separate logs file for subsequent use and tracking. These logs shall be viewable on the monitor.

Trend Charting and Reports: All available real-time network data shall be individually selectable for trend charting and analysis by the user, with up to six parameters included. Three standard report formats shall be available; one for Engine Data, one for Generator Data, (See Table.), and one report on the active status of each input/output of the digital I/O modules.

The software shall be upgradeable to include the capability for user-defined report formats.

Auxiliary Equipment Control and Annunciation: Provide as necessary digital I/O modules each with sixteen Form C (5A at 250VAC) relay outputs and four digital inputs to be controlled and read from the network.

Remote Communications: Provide devices and equipment for remote telecommunications from the network to an assigned remote control station personal computer and pager. Include gateway(s), modems and UPS for modems as required. The alarms as individually specified in this section shall be programmed for automatic “dial-out” requested by client to the remote control station.

The manufacturer shall have a service and support network capable of fully supporting the entire system provided. The service and support network shall include a local service organization, with factory trained service and support technicians, and locally available spare parts for all components provided in the system.

2.32 GENERATOR EARTHING (GROUNDING):

Generator frame shall be connected to the equipment earthing system through a separate equipment earth conductor. In addition a local electrode might be required if generator is appreciably remote from the main electrical room. Neutral and frame of generator shall not be bonded except in the case of local neutral earthing as mentioned above.

PART 3- EXECUTION:**3.01 EXAMINATION:**

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting package engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

- A. Comply with packaged engine-generator set manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install engine generator set with restrained spring isolators having a minimum deflection of 25mm on 100mm high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 16 Section "Electrical Supports and Seismic Restraints".

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

BUILT-IN ITEMS: ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases or building structure are provided as and when required and that they are properly installed.

TOOLS: use only tools recommended by equipment manufacturers for installations, particularly in making connections and adjustments.

SUPERVISION: carry out equipment installation under the direct supervision of a qualified technician, licensed by and trained at the factory. Final adjustments and putting into satisfactory operation are to be made by a specialist delegated by the factory.

GENERATING SET: install to maintain alignment and minimize engine and generator stresses. Protect instrumentation and control equipment including engine mounted instruments from machine vibration. Mountings and method of mounting are to be as recommended by the manufacturer and approved by the Engineer.

ENGINE EXHAUST PIPING is to be slightly sloped away from engine to avoid condensation returning to engine and is to have drain plugs or clean-out at lower end as required.

ENGINE HOT-AIR EXHAUST DUCT: install approved canvas duct with metal frames between radiator and louvered opening in wall for radiator exhaust air.

TANK VENT PIPE: extend to nearest outside wall of building and carry up to at least 2 m above ground level with end at least 1 m away from any building opening. Slope vent pipe back to tank without traps and support securely. Provide replaceable dust filter and gooseneck bend or approved weatherproof vent cap at top of pipe.

PIPE HANGERS AND SUPPORTS: fasten securely to building structure with approved masonry expansion bolts, minimum 20 mm diameter and install in accordance with manufacturers' instructions.

EARTHING: install earthing system in accordance with SUB-SECTION 16450 of the Specification.

- D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are as specified in Division 15 Section "Hydronic Piping".
1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping".
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 CONNECTION:

- A. Piping installation requirements are specified in Division 15 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to engine generator to allow service and maintenance.
- C. Connect engine exhaust pipe to engine with flexible connector.
- D. Connector fuel piping to engines with a gate valve and union and flexible connector.
1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems outside the building are specified in Division 2 Section "Fuel Oil Distribution".

2. Diesel fuel piping, valves, and specialties inside the building are specified in Division 15 Section “Fuel Oil Piping”.
- E. Ground equipment according to Division 16 Section “Grounding and Bonding”.
- F. Connect wiring according to Division 16 Section “Conductors and Cables”.

3.04 IDENTIFICATION:

- A. Identify system components according to Division 15 Section “Mechanical Identification” and Division 16 Section “Electrical Identification”.

3.5 FIELD QUALITY CONTROL:

- A. Testing Agency: (Owner will engage) a qualified agency to perform tests and inspection and prepare test reports.
- B. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Test and Inspections:
 1. Perform test recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for “AC Generators and for Emergency Systems” specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 3. Battery Tests: Equalize charging of battery cells according to manufacturer’s written instructions. Record individual cell voltage.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge
 - d. Verify that measurements are within manufacturer’s specifications.

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4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Exhaust-system Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120kPa). Connect to exhaust line close to engine exhaust manifold. Verify that backpressure at full-rated load is within manufacturer's written allowable limits for the engine.
 7. Exhaust Emissions Test: Comply with applicable government test criteria.
 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 to 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at (four) (insert number) locations (on the property line) Insert location for measurement, and compare measured levels with required values.
- E. Coordinate tests with tests for transfer switches and run them concurrently.
- F. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- J. Remove and replace malfunctioning units and (retest) (reinspect) as specified above.
- K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

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- L. Report results of tests and inspection in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- M. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 DEMONSTRATION:

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain packaged engine generators. Refer to Division 1 Section "Demonstration and Training".

3.07 VISUAL INSPECTION:

All equipment which form part of the diesel generating plant shall be visually inspected for damage and checked against the manufacturer catalogues/drawings and schedule, for the following:

1. Type of generating set
2. Serial number
3. Engine details
4. Alternator, exciter and AVR details
5. Rated speed
6. Rated voltage
7. Number of phases
8. Rated frequency
9. Rated KVA at continuous rating
10. Rated KW at continuous rating
11. Rated KVA at service rating
12. Rated KW at service rating
13. Ancillary equipment

3.08 PRELIMINARY INSPECTION CHECK:

Preliminary inspection check shall include the following:

1. Alignment of engine/alternator assembly on bed plate.
2. Installation of vibration isolators

3.09 PRELIMINARY RUNNING TEST:

Preliminary running test to check the following:

1. Engine start and stop control
2. Engine oil pressure
3. Generator voltage and frequency including phase sequence
4. Control and protection devices
5. Leaks in oil, water and exhaust
6. Excessive vibration
7. Adjustments of meters and potentiometer related to generated output parameters

3.10 LOAD TESTS (IN FACTORY)

The set shall be run continuously for 8 hours at rated load followed by 110 percent of rated load for a period of one hour.

Every 15 minutes for the first hour and every hour thereafter, the following parameters shall be recorded:-

1. All electrical output parameters associated with main alternator.
2. Parameters of charging alternator
3. Measurements of all engine parameters
4. Lubricating oil consumption
5. Cooling air medium flow
6. Alternator cooling air inlet and outlet temperatures.

Load test shall be secured along with ATS and synchronizing panel at 90%, 100% and 110% loads by arranging external load banks for the performance of the DG set installations.

3.11 TRANSIENT LOAD SWITCHING:

Resistive load shall be applied and switched "ON" and "OFF" in STEPS, with the diesel generator running at rated speed and generating rated voltage.

Transient recordings of maximum, minimum and nominal voltage and frequency levels together with the response times shall be obtained.

3.12 INSULATION TEST:

1. Remove all external wiring between the plant and load bank/ test panels.
2. Isolate sensitive electronic equipment in alternator and control panel as per manufacturers recommendation.
3. Open any neutral earthing links.
4. Using 1000V megger check the insulation resistance :-
 - a) Between the load terminals and plant structure
 - b) Between the generator terminals and plant structure
5. Reconnect electronic equipment and neutral earth links.

3.13 FUNCTIONAL TEST:

The operation of interlocks and interconnections with all external equipment and controls to be connected on site, shall be simulated as part of these tests.

The generating set shall be tested on Site for manual and automatic operation, for regulation, for sudden load pick-up and for withstanding long lasting load.

3.14 ROUTINE TESTS:

Fully assembled plant or equipment is to be tested at the factory and witnessed by two engineers from Consultant Client side, before shipping. Complete performance tests are to be carried out under site simulated conditions, in accordance with the Standards and as described in the Specification.

Inspection and tests on site

EQUIPMENT: inspect equipment upon delivery to Site and report any loss or damage to the Engineer.

EARTHING RESISTANCE TESTS if any are to be carried out to verify specified requirements.

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

TESTS are to include:

- 1- Full load test for 8 hours continuous, immediately followed by 10% overload test, without interruption
- 2- Insulation measurement
- 3- Functional tests for voltage sensing, automatic start and synchronization, transfer of load and load-sharing as applicable
- 4- Operation of engine shut-down and alarm signaling and indication, under simulated fault conditions
- 5- Measurement of vibration transmission to building structure

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

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

END OF SECTION

SECTION 16264 – STATIC UNINTERRUPTIBLE POWER SUPPLY**PART 1 – GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes three-phase, double-conversion, static-type, UPS installations complete with transient voltage surge suppression, input harmonics reduction, rectifier – charger, battery, battery disconnect device, inverter, static bypass transfer switch, external maintenance bypass/isolation switch, output isolation transformer, remote UPS monitoring provisions, remote battery monitoring.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. LCD: Liquid-crystal display.
- C. LED: Light-emitting diode.
- D. THD: Total harmonic distortion.
- E. UPS: Uninterruptible power supply.

1.4 SUBMITTALS

- A. Product Data: Include data on features, components, ratings, and performance for each UPS component indicated.
- B. Shop Drawings: Detail assemblies of equipment indicating dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
 - 1. Wiring Diagrams: Power, signal and control wiring.
- D. Qualification Data: For Installer, manufacturer and testing agency.
- E. Manufacturer Certificates: For each product signed by manufacturers.
- F. Factory Test Reports: Comply with specified requirements.
- G. Field Quality-Control and Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.
- H. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals. Include the following:
 - 1. Lists of spare parts and replacement components recommended being stored at Project site for ready access.

2. Detailed operating instructions covering operation under both normal and abnormal conditions.

I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for both installation and maintenance of units required for this Project.
- B. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, experienced in performance testing UPS installations and in performing power quality surveys.
- C. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 30km of Project site, a service center capable of providing training, parts, and emergency maintenance repairs with two hours maximum response time.
- D. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the Lebanese certified Bureau de Cotnrole.
 1. Obtain the UPS and associated components specified in this Section from a single manufacturer with responsibility for entire UPS installation.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70. Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. UL Compliance: Listed and labeled under UL 1778.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.
- B. Store equipment in spaces with environments controlled within manufacturer's ambient temperature and umidity tolerances for non-operating equipment.

1.7 WARRANTY:

- A. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Valve-Regulated, Lead-Acid Batteries: Equal to or greater than that represented by manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle life
8hours	8 hours	1.67	6 cycles
30minutes	30minutes	1.67	20cycles
15minutes	45seconds	1.67	120cycles

- B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: Three years from date of Substantial Completion.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner,
 1. Fuses: One for every 10 of each type and rating, but no fewer than 1 of each.
 2. Cabinet Ventilation Filters: One complete set.

1.9 STANDARD MANUFACTURERS

UPS

- Merlin Gerin
- Liebert
- Socomec
- APC

BATTERIES

- Oldham
- Exide
- Yuasa

PART – 2 PRODUCTS**2.01 OPERATING PRINCIPLE**

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

A. Normal Operation:

(Normal AC source available)

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

B. Operation by Battery Power:

(Normal AC source not available or outside tolerances)

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

C. Battery Recharge:

(Normal AC source restored)

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

D. Static Bypass Operation (Static Switch):

In the event of an overload exceeding system capabilities (short-circuits, heavy inrush currents, etc.) or inverter shutdown (user-initiated for maintenance or automatic for internal faults), the static bypass switch shall instantaneously transfer the load to the bypass AC source without interruption, on the condition that bypass power is available and within tolerances.

To that end, synchronization of the inverter in phase and frequency with the bypass source shall be automatic. Transfer back to the inverter output (synchronized with bypass power) shall be automatic or manual and without interruption or disturbance of power to the load.

E. Operation of the Manual Maintenance Bypass:

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

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

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

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

F. Battery Maintenance:

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

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

2.02 SIZING AND GENERAL CHARACTERISTICS

A. Technology:

The UPS shall be based on IGBT technology and a free-frequency chopping mode. It shall be 100% potentiometer free.

B. Power Rating:

The UPS shall be sized to continuously supply a load in kVA, at a power factor (pf) of 0.8, as detailed in the BOQ.

C. Battery Backup Time:

The battery backup time in the event of a normal AC source outage shall be 20 minutes as mentioned in the BOQ at full rated load with a pf of 0.8. Battery service life shall be equal to at least 5 years. The battery shall be selected and sized accordingly.

D. Types of Loads Accepted:

If all the connected loads are non-linear (100% non-linear loads), the UPS shall accept high crest factors (3:1) without derating of output.

For both linear and non-linear loads, the total harmonic voltage distortion at UPS output (THDU downstream) shall respect the following limits:

- THDU downstream ph/N ≤ 5%;
- THDU downstream ph/ph ≤ 3%.

E. Efficiency:

Overall efficiency shall be greater than or equal to:

- 92% at full rated load (I_n);
- 90% at half rated load ($I_n/2$).

For non-parallel UPS, an optional operating mode as described in the "static bypass" section shall be available to increase the efficiency up to a value of 97%. This function shall be user enabled or disabled.

2.03 AC SOURCES

The UPS shall be designed to receive power from the following sources:

A. Normal AC Source:

(Rectifier/charger input)

The normal AC source supplying the UPS shall, under normal operating conditions, have the following characteristics:

- Voltage: 380 volts, $\pm 15\%$;
- Number of phases: 3 + earth; or on 220 V $\pm 10\%$, 1 phase + neutral + earth.
- Frequency: 50Hz, $\pm 10\%$.

B. Bypass AC Source:

(Bypass input)

The bypass power supplying the UPS in the event of an inverter shutdown (maintenance, failure) or an overload (short-circuit, heavy inrush currents, etc.) shall have the following characteristics:

- Voltage: 380 volts, $\pm 10\%$.
- Number of phases: 3 + N + earth; or on 220 V $\pm 10\%$, 1 phase + neutral + earth.
- Frequency: 50Hz $\pm 5\%$.

2.04 ELECTRICAL CHARACTERISTICS

A. Rectifier/ Charger:

Power

The rectifier/charger shall be supplied via the normal AC input (see "AC sources").

Inrush Current

A walk-in circuit shall eliminate overcurrents during starting by imposing a gradual increase of the rectifier/charger input current until nominal conditions are reached. This walk-in period shall last approximately 10 seconds.

Current Limiting

For long battery life, an electronic device shall automatically limit the charging current to the maximum value specified by the battery supplier (0.1x C10 for a sealed lead-acid battery). A second device shall limit the total current drawn by the rectifier/charger to avoid overloading the power supply line.

Operating Modes And DC-Voltage Levels

To substantially extend battery life without lowering its performance, the rectifier/charger shall provide a float charging mode. In this mode; the battery-charger output voltage shall be set to the value specified by the battery supplier, i.e. 2.25 volts/cell.

Input Power Factor

The rectifier/charger shall present an input power factor greater than or equal to 0.8 for the normal AC source rated voltage and frequency and the inverter operating at full rated load.

Voltage Regulation

Rectifier/charger regulation shall ensure DC output voltage fluctuations of less than 0.5% irrespective of load and AC input voltage variations (within the limits specified in the "normal AC source" section).

B. Battery:

The battery shall be of the sealed lead-acid type, integrated within cabinet mounted next to UPS with a service life of 5 years. A DC circuit breaker inside an enclosure shall be provided and installed inside the battery cabinet.

The battery shall be sized to ensure continuity in the supply of power to the inverter for at least the time specified in the BOQ, in the event of a normal AC source failure, with the system operating at full rated load at a power factor $pf = 0.8$.

Sizing calculations shall assume an ambient temperature between 15° C and 25° C. The battery shall be protected against deep discharge.

C. Inverter:

The inverter shall be sized to supply a rated load as mentioned in the BOQ at 0.8 pf and shall satisfy the specifications listed below.

Output Voltage

- 220 V rms, adjustable to $\pm 3\%$ or 380 V rms adjustable to $\pm 3\%$.
- Number of phases: 1 phases + neutral + earth, or 3 phase + neutral + earth.
- Steady-state conditions

The variation in the rated voltage shall be limited to $\pm 1\%$ for a balanced load between 0 and 100% of the rated power, irrespective of normal AC input and DC voltage levels, within the limits specified in the “normal AC source” section and the “rectifier/charger - operating modes and DC-voltage levels” section.

- Voltage transients (transient conditions)

Output voltage transients shall not exceed $\pm 5\%$ of rated voltage for 0 to 100% or 100 to 0% step loads.

In all cases, the voltage shall return to within steady-state tolerances in less than 20 milliseconds.

- Unbalanced load conditions

For a 30 % unbalanced load, the voltage unbalance, calculated using the following formulas:

- Percent load unbalance:

$$100 \times \frac{I_{\max} - I_{\min}}{I_n}$$

- Percent voltage unbalance:

$$100 \times \frac{U_{\max} - U_{\min}}{U_{\text{average}}}$$

Shall be less than 2% for the phase-to-neutral amplitude and 3 degrees for the phase angle deviation.

- Phase-to-phase harmonic distortion (voltage wave form)

The UPS shall be provided with a system limiting total harmonic distortion of the phase-to-phase output voltage to 3% and individual harmonic distortion to 1.5%, irrespective of the type of load, as indicated in the "sizing - types of loads accepted" section.

Output Frequency

- Rated frequency: 50 Hz.
- Variation: ± 0.5 Hz, adjustable up to ± 2 Hz.

Synchronization With Bypass Power

- When bypass power is within tolerances

To enable transfer to bypass power (see conditions below in the "static bypass" section), the inverter output voltage shall be synchronized with the bypass source voltage whenever possible. To that end, during normal operation, a synchronization system shall automatically limit the phase deviation between the voltages to 3 degrees, if the bypass source frequency is sufficiently stable (within ± 0.5 Hz of its rated value).

If the bypass source is a generator set, the synchronization tolerances shall be approximately ± 2 Hz (adjustable).

- Autonomous operation following loss of synchronization with bypass power

When the bypass source frequency deviates beyond these limits, the inverter shall switch over to free-running mode with internal synchronization, regulating its own frequency to within $\pm 0.04\%$.

When bypass power returns to within tolerances, the inverter shall automatically resynchronize.

- Variation in frequency per unit time

During the switch to free-running mode and the switch back to synchronized mode, frequency variations per unit time (dF/dt) shall be limited to 1 Hz/s.

Overload Capacity

The UPS shall be able to supply 125% full rated load for at least 10 minutes and 150% full rated load for at least 1 minute.

If necessary, the UPS shall operate as a generator (current limiting) with a peak capacity of 233% for 1 second, to allow highly disturbed transient operating states (high overloads, very high crest factors, etc.) without transferring the load to the bypass.

D. Static Bypass:**Static Bypass Function**

Instantaneous transfer of the load from the inverter to bypass power and back shall take place without a break or disturbance in the supply of power to the load, on the condition that the bypass source voltage and frequency are within the tolerances specified in the "bypass AC source" section and that the inverter is synchronized.

Transfer shall take place automatically in the event of a major overload or an internal inverter fault. Manually initiated transfer shall also be possible.

If the bypass power is outside the specified tolerances or is not synchronized with the inverter, automatic transfer of the load from the inverter to bypass power shall be inhibited or shall take place after a calibrated interruption of 500 to 800 milliseconds.

Manual initiation of this transfer as well as transfer back to the inverter shall also be possible.

Efficiency Optimization Option

(Non-parallel UPS)

The static switch associated with a microprocessor controlling the bypass shall provide an operating mode that increases the efficiency of the UPS up to 97% during periods when the bypass source is stable and within tolerances. It shall be possible for the operator to enable or disable this operating mode at any time.

The time required to transfer the load to and from the bypass shall not exceed 15 ms.

E. Discrimination

If the bypass power is within the tolerances specified in the "bypass AC source" section, the presence of the static switch shall make it possible to use the short-circuit power of the bypass source to trip the downstream protection devices of the inverter.

To ensure tripping in a selective manner, the available power shall be sufficient to trip protection devices with high ratings (circuit breaker rated $I_n/2$ or UR fuses rated $I_n/4$, where I_n is the rated inverter current).

If the bypass source is outside the specified tolerances, the inverter on its own shall, for the same discrimination requirements, be capable of tripping circuit breakers rated $I_n/2$ or UR fuses rated $I_n/4$, irrespective of the type of short-circuit.

2.05 MECHANICAL CHARACTERISTICS**A. MODULARITY:**

The UPS shall be of modular design so as to allow the installed power to be easily increased on site by connection of additional UPS units, either to meet new load requirements or to enhance system reliability by introducing redundancy.

It shall be possible to adapt a single UPS unit for connection with parallel UPS units directly on site, without returning the equipment to the factory and without causing excessive system downtime.

Similarly, the UPS output frequency shall be readily adaptable on site from 50 to 60 Hz or vice-versa to meet possible changes in load requirements.

B. MECHANICAL STRUCTURE

The mechanical structure of the UPS shall be sufficiently strong and rigid to withstand handling and installation operations without risk. Access to UPS subassemblies shall be through front doors equipped with locking facilities. Rear panels shall be removable. The sheet-metal elements in the structure shall be protected against corrosion by a suitable treatment, such as zinc electroplating, bichromating, epoxy paint or an equivalent.

C. DIMENSIONS

The UPS shall require as little floor space as possible.

To facilitate installation, UPS height shall not exceed 1900 mm and passage through an 800 mm wide door shall be possible (with panels and/or doors removed, as necessary).

To save considerable space, it shall be possible to install the UPS with its back right against a wall.

D. CONNECTIONS AND BUSBARS

Entry of upstream and downstream power cables, as well as any auxiliary cables, shall be possible at the bottom of the UPS (or at the top as an option), or through the bottom for a false floor.

Installation shall be facilitated by clear marking of connection terminals. Connections shall be made through the front of the UPS cabinets.

All connections shall be directly accessible, without undoing any other connections.

The UPS shall be equipped with an earth-circuit connector, in compliance with the standards listed in the "standards and tests" section.

Any busbars shall be made of rectangular cross-section electrolytic copper or aluminum bars.

Cables shall comply with the standards listed in the "safety" section.

The neutral conductor shall be oversized for any third-order harmonic currents and their multiples. The cross-sectional area of the neutral shall be 1.5 times that of a phase.

E. VENTILATION

The UPS shall be provided with forced-air cooling.

To avoid UPS shutdown in the event of a fan failure, redundant fans shall be provided on the UPS and fan failure shall initiate an alarm.

F. SAFETY

The equipment shall meet the requirements of degree of protection index IP21, in compliance with standard IEC 60529.

For the safety of maintenance personnel, the cabinet shall be provided with a manually operated mechanical bypass designed to isolate the rectifier/charger, inverter and static switch while continuing to supply the load from the bypass AC source. Control circuits shall be galvanically isolated from power circuits.

Live parts that could be touched during normal operation or maintenance shall be protected by insulated barriers.

2.06 ENVIRONMENT CONDITIONS**A. UPS (not including battery)**

The UPS, not including the battery, shall be capable of operating under the following environmental conditions without loss of performance:

- Ambient temperature:
0° C to + 40° C
- Recommended temperature range: + 15° C to + 25° C
- Maximum average temperature:
35°C for 24 hours
- Maximum temperature:
40°C for 8 hours
- Maximum relative humidity:
95% at 25° C
- Maximum altitude: 1 000 meters.

The UPS, not including the battery, shall be designed for storage under the following conditions:

- Ambient temperature:
- 20° C to + 70° C
- Maximum relative humidity:
95% at 25° C
- Maximum altitude: 1 500 m.

B. BATTERY

The battery shall be capable of operating under the following environmental conditions without loss of performance:

- Ambient temperature:
 - 15° C to + 40° C
- Recommended temperature range: + 15° C to + 25° C
- Maximum relative humidity: 95%
- Maximum altitude: 1 000 meters.

The battery shall be designed for storage under the following conditions:

- Ambient temperature:
 - 20° C to + 45° C
- Maximum relative humidity: 95%.

2.07 PROTECTION**A. UPS**

The UPS shall include protection against AC source overvoltages (as per standard IEC 60146, previously IEC 146), excessive external or internal temperature rise and vibrations and impacts during transport.

B. RECTIFIER / CHARGER

The rectifier/charger shall be equipped to receive an external order to automatically shut down under the following circumstances:

- Emergency off; in this case, the shutdown will be accompanied by opening of the battery circuit breaker.
- Battery room ventilation fault.

The rectifier and the charger shall automatically shut down if the DC voltage reaches the maximum value specified by the battery manufacturer.

C. INVERTER

The load shall be protected against any overvoltages that could result from voltage regulation failure at the inverter output.

The inverter (and the rectifier/charger) shall automatically shut down if the DC voltage reaches the minimum value specified by the battery manufacturer.

The inverter shall be equipped with an automatic shutdown system to protect its power circuits against overloads exceeding its overload capacity when bypass power is not available.

In particular, a short-circuit on the load shall initiate a static shutdown of the inverter, without blowing a fuse.

D. BATTERY

A safety device shall limit the discharge time to three times the backup time at full rated load to avoid excessive discharge at less than the rated output.

A second device shall avoid self-discharge of the battery into the inverter control circuits during an extended shutdown of the UPS (over two hours).

It shall be possible to disable this device as necessary.

2.08 BATTERY MANAGEMENT

As the life of a battery is very sensitive to operating conditions, the battery shall be managed in an optimum manner.

In addition to the devices indicated in "protection -battery" above, battery management features shall include the following:

A. SELF TESTS

System initiated in two manners:

- As necessary by a manual command,
- Automatically at user-defined intervals.

This self-test system shall update the battery parameters and detect any abnormal deterioration to facilitate preventive maintenance.

B. TEMPERATURE CORRECTION

The battery management system shall automatically adapt the battery voltage to the ambient temperature in order to optimize battery service life.

C. MEASUREMENT OF ACTUAL BACKUP TIME

The battery function shall be combined with a system that continuously monitors the actual backup time available (AC source present) or remaining (AC source absent), according to the actual load on the UPS, the battery temperature and the age of the battery.

2.09 USER INTERFACE AND COMMUNICATION**A. USE INTERFACE****Operating and Startup Assistance**

The UPS shall be equipped with an operating and start-up assistance a system providing start-up and operating assistance including:

Display of installation parameters, configuration, operating status and alarms and indication of operator instructions for switching operations (e.g. bypass);

Times-tamped logging and automatic or manually initiated recall of all important status changes, faults and malfunctions, complete with an analysis and display of troubleshooting procedures;

Controls

Two push buttons on the front panel of the UPS shall control UPS ON/OFF status.
A keypad shall be provided to carry out the following operations:

- Forced transfer or forced shutdown of inverter when the bypass AC source is outside specified load tolerances;
- Equipment self-test and battery charge cycle.

Indications

The following status information shall be monitored by indicating lights on the UPS front panel:

- Rectifier/charger on,
- Load on inverter,
- Load on bypass,
- General alarm.

A buzzer shall warn the user of faults, malfunctions or operation on battery power. This system shall be equipped with an alarm reset button.

Display of Parameters

A display unit shall indicate at least the following parameters in the English language:

- Remaining battery backup time,
- Internal fan fault,
- Low battery warning,
- Position of switching devices,
- Bypass AC source outside tolerances,
- Battery temperature.

Additional information shall be provided in view of accelerating servicing of the system, as specified in the “maintenance” section.

Measurements

The display unit shall also indicate the following measurements:

- Inverter output phase to neutral voltages,
- Inverter output currents,
- Inverter output frequency,
- Voltage across battery terminals,
- Battery charge or discharge current,
- Rectifier/charger input phase to phase voltages,
- Rectifier/charger input currents,
- Crest factor,
- Active and apparent power,
- Power factor of the load.

Teleservicing

The UPS shall have the possibilities to be connected to a teleservicing center. This center shall be available in Lebanon and already operational. A demonstration shall be done to the satisfaction of the Engineer at the submittals stage

PART 3 – EXECUTION**3.1 INSTALLATION**

- A. Install system components on 4-inch- (100mm) high concrete bases. Concrete base construction requirements are specified in Division 16 Section "Electrical Supports and Seismic Restraints."
- B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.

3.2 EARTHING

- A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to earthing electrodes and for bonding to metallic piping near isolation transformer.

3.3 IDENTIFICATION

- A. Identify components and wiring according to Division 16 Section "Electrical Identification."
 - 1. Identify each battery cell individually.

3.4 BATTERY EQUALIZATION

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

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect [test, and adjust] equipment installation including connections [and to assist in field testing]. Report results in writing.
- B. Electrical Tests and Inspections: Perform tests and inspections according to manufacturer's written instructions and as listed below to demonstrate condition and performance of each UPS component:
 - 1. Inspect interiors of enclosures, including the following:
 - a. Integrity of mechanical and electrical connections.
 - b. Component type and labeling verification.
 - c. Ratings of installed components.

-
2. Test manual and automatic operational features and system protective and alarm functions.
 3. Test communication of status and alarms to remote monitoring equipment.
- C. Electrical Tests and Inspections: Perform tests and inspections by an independent testing agency meeting the qualifications specified in Part 1 "Quality Assurance" Article according to manufacturer's written instructions and as listed below to demonstrate condition and performance of each UPS component:
1. Inspect interiors of enclosures, including the following:
 - a. Integrity of mechanical and electrical connections.
 - b. Component type and labeling verification.
 - c. Ratings of installed components.

Load the system using a variable-load bank to simulate kilo volt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated, within the previous [six months].

 - a. Simulate malfunctions to verify protective device operation.
 - b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
 - c. Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
 - d. Test output voltage under specified transient-load conditions.
 - e. Test efficiency at 50, 75, and 100 percent of rated loads.
 - f. Test remote status and alarm panel functions.
 - g. Test battery-monitoring system functions.
- D. Seismic-restraint tests and inspections shall include the following:
1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
- E. Retest: Correct deficiencies and retest until specified requirements are met.
- F. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

3.7 PERFORMANCE TESTING

- A. Engage the services of a qualified power quality specialist to perform tests and activities indicated below.
- B. Monitoring and Testing Schedule: Perform monitoring and testing in [four 3-day periods, each in a different season of the year]
 - 1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
 - 2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.
- C. Monitoring and Testing Instruments: Three-phase, recording power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:
 - 1. Current: Each phase and neutral and grounding conductors.
 - 2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
 - 3. Frequency transients.
 - 4. Voltage swells and sags.
 - 5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
 - 6. High-frequency noise.
 - 7. Radio-frequency interference.
 - 8. THD of the above currents and voltages.
 - 9. Harmonic content of currents and voltages above.
- D. Monitoring and Testing Procedure: [For each test period, as follows:]
 - 1. Exploratory Period: For approximately the first [two days] <Insert tune>, [of the first scheduled monitoring and testing period,]make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these preliminary measurements with the objective of identifying optimum UPS. power system, load, and instrumentation set-up conditions for subsequent test and monitoring operations.
 - 2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

-
- a. Set thresholds and sampling intervals for recording data at values selected to optimize dataon performance of the UPS with respect to values specified in Part 2, and to highlight any need to adjust, repair, or modify the UPS or any distribution system or load component that may influence its performance or that may require better power quality.
 - b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.
 - c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design,
 - d. Create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients [that can be performed using loads and devices available as part of the facility's installed systems and equipment] [and a temporarily connected portable generator set]. Maintain normal operating loads in operation on system to maximum extent possible during tests.
 - e. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.
- E. Correlation with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in tins Section that are simultaneously recorded with portable instruments in this Article.
1. Provide the temporary use of an appropriate personal computer and printer equipped with required connections and software for recording and printing if such units are not available on-site.
 2. Correlate printouts with recordings for monitoring performed according to this Article, and resolve and report any anomalies in and discrepancies between the two sets of records.
- F. Monitoring and Testing Assistance by Contractor:
1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
 2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.

- Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
3. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
 4. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.
- G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.
- H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in final report:
1. Description of corrective actions performed during monitoring and survey work and their results.
 2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
 3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
 4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
 5. Recommendations for operating, adjusting, or revising UPS controls.
 6. Recommendation for alterations to the UPS installation.
 7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
 8. Recommendations for power distribution system revisions.
 9. Recommendations for adjusting or revising electrical loads, their connections, or controls.
- H. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

END OF SECTION

SECTION 16280 - 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 automatic power factor correction equipment rated 600 V and less
- B. Complete Capacitor Bank in order to increase P.F. to 0.95 with control equipment for automatic multistage.
- C. The capacitor bank comprises the additional outgoing branch protective device with the shedding contactor, located in the main distribution switchboard.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include data on features, ratings, and performance.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, method of field assembly, components, and location and size of each field connection. Show access and workspace requirements and required clearances.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For equipment to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 include the following:
 - 1. Lists of spare parts and replacement components recommended for storage at Project site.
 - 2. Detailed instructions covering operation under both normal and abnormal conditions.

1.4 QUALITY ASSURANCE

- A. Comply with IEEE 18 and NEMA CP 1.
- B. Comply with NFPA 70
- C. Comply with IEC 70
- D. Comply with NFC 54-100
- E. Comply with VDE 0560
- F. Comply with BS 1650.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace capacitor-bank components that fails in materials or workmanship within specified warranty period.
 - 1. Special Warranty Period for Capacitor Cells: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products, but are not limited to, the following:
 - 1. Automatic Power Factor Correction Units:
 - ABB Control, Inc.
 - Merlin Gerin (France).
 - Or approved equal.

2.2 CAPACITORS, GENERAL

- A. Construction: Multiple capacitor cells or elements, factory wired in three-phase groups and mounted in metal enclosures.
- B. Capacitor Cells: Dry, metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside plastic container.
- C. Cell Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

- D. Capacitor-Bank Fuses: Current-limiting, noninterchangeable type; factory installed in each phase and located within the equipment enclosure. Features include the following:
 - 1. Interrupting Capacity: 200,000 A, minimum.
 - 2. Fuse Ratings and Characteristics: As recommended by capacitor manufacturer.
- E. Discharge Resistors: Factory installed and wired
- F. Enclosure: NEMA 250, steel or aluminum, arranged to contain the fluid leakage from capacitor cells; factory equipped with mounting brackets suitable for type of mounting indicated.
 - 1. Indoor Enclosures: The capacitor banks shall be equipped with dust-tight, boxes, to IP50 or as indicated.

2.3 AUTOMATIC POWER FACTOR CORRECTION UNITS

- A. Comply with NEMA ICS 2.
- B. Description: Capacitor banks, contactors, controls, and accessories factory installed in motor-control center, with a connection to motor-control center bus. Units include a separately mounted current transformer to sense current in the power circuit being corrected and to provide input to unit controls.
- C. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contractor 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. Control Equipment
 - 1. All capacitor bank shall be equipped with main disconnect and main contactor.
 - 2. The equipment for the connection and disconnection of reactive power in several stages shall consist of two devices housed in the same case: a) an electronic sensing device to measure the reactive load and a synchronous motor with a switching drum which switches the capacitors in and out in accordance with pulses from the load-measuring section.
 - 3. The electronic measuring system shall be connected to a current transformer with a 5 amp secondary winding.

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4. The regulator shall have the following controls:
 - "Hand-Auto" changeover switch.
 - Knob for manual control, which shall also indicate the number of steps connected when the system is on automatic.
 - Two knobs for separate setting of the switch-in and dropout values. One knob to set phase shift.
 5. The regulator shall be flush mounted in the cubicle door. Above it shall be the indicator lamps to show the number of steps in circuit.
 6. Main contactor of capacitor bank shall be automatically de-energized during generator standby power operation.
- E. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the capacitor application.
- F. Buses: Plated copper.
- G. Fuses for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.
- H. Mechanical Bracing for Current-Carrying Parts: Adequate to withstand the maximum fault current to which they may be exposed.
- I. Identification of Energized Capacitor Banks: LED indicating lamps on front panel.
- J. Local Display: LED or liquid-crystal digital type, mounted in door of enclosure, indicating the following:
1. Target and actual power factors accurate to plus or minus 1 percent of reading.
 2. Steps energized.
 3. Step reconnection delay.
 4. Real and reactive currents.
 5. Voltage THD.
 6. Alarm codes.
- K. System Alarms: Alarm relay and local display indication of the following conditions:
1. Low power factor.
 2. Leading power factor.
 3. Frequency not detected.
 4. Overcurrent.
 5. Overvoltage.
 6. Overtemperature.
 7. Excessive voltage THD.
 8. Capacitor overload.
 9. Loss of capacitance.
- L. Current Transformer: Type, configuration, and ratio to suit sensing and mounting conditions.

- M. The capacitor banks shall comprise one cubicle for protection and control equipment and one or two steel racks for the capacitor units.
- N. Main Circuit Breaker: Operable from outside the enclosure to disconnect the unit.
 - 1. Operating handle can be padlocked.
- O. Remote Monitoring Components: Sensors, associated communication modules, and network interface units, matched to and compatible with electrical power monitoring and control network. Communication module shall have capability to transmit the following data to remote monitoring devices:
 - 1. System in alarm.
 - 2. Power factor set-point.
 - 3. Corrected power factor.
 - 4. Number of capacitor steps activated.

2.4 FACTORY FINISH

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

2.5 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 free standing equipment on concrete bases. Cast-in-place concrete is specified in Division 3.
- B. Comply with mounting and anchoring requirements.
- C. Maintain minimum workspace according to manufacturer's written instructions.
- D. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.
- E. The capacitor bank shall be automatically disconnected during emergency generator operation

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

3.2 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each power factor correction capacitor element, bus, and component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS, "Capacitors and Reactors - Capacitors." Certify compliance with test parameters.
- C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.3 ADJUSTING

- A. Adjust for optimum automatic power factor correction.

3.4 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean components internally, on completion of installation, according to manufacturer's written instructions.

END OF SECTION

SECTION 16410– ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- 1. Nonfusible switches.
- 2. Enclosures.
 - All switches shall be ON LOAD metal clad type

1.3 DEFINITIONS

- A. GD: General duty.
- B. GFCI: Ground-fault circuit interrupter.
- C. HD: Heavy duty.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw

1.4 SUBMITTALS

- A. Product Data: for each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings.
 - 4. UL listing for series rating of installed devices.
 - 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Shop Drawings: Diagram power, signal and control wiring.
- C. Field quality-control test reports including the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed test and corrective action taken to achieve test results that comply with requirements.
- D. Manufacturer's filed service report.

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- E. Operation and Maintenance Data: for enclosed switches and circuit breakers to include emergency, operation and maintenance manuals. In addition to items specified in Division 1 Section (Operation and Maintenance Data) include the following:

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.5 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
1. Ambient Temperature: minus 5 deg 0 and not exceeding (40degC).

1.6 COORDINATION

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

PART 2-PRODUCTS

2.1 TECHNICAL SPECIFICATIONS:

- A. Fusible and non fusible switches are 100% load break and load make rated.
- B. The continuous load current of fusible switches is not to exceed 80% of the rating of fuses employed in other than motor circuits. Non-fusible switches are 100% fully rated.
- C. Visible double break rotary blade mechanism. Two points of contact shall provide a positive open and close easier operation and shall also help prevent contact burning for longer contact life.
- D. Interlocking mechanism. Door cannot be opened when the handle is in the ON position. Built-in defeater mechanism shall provide for user access when necessary.
- E. De-ionizing arch chutes. Arc chutes shall confine and suppress the arcs produced by contacts under load.
- F. All disconnect switches used with elevators shall have a shunt trip disconnect.

2.2 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.3 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products. (USA)
 2. General Electric Co.; Electrical Distribution & Control Division. (USA)
 3. Siemens (Germany)
 4. Square D/Group Schneider. (UK)
 5. ABB Europe (Germany)
 6. MEM (UK)
- B. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminium ground conductors.
 2. Neutral Kit: Internally mounted, insulated capable of being grounded and bonded and labeled for copper and aluminium neutral conductors.
 3. Auxiliary contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.4 ENCLOSURES

1. Outdoor Locations: IP55.
2. Kitchen Areas: IP55
3. Other Wet or Damp Indoor Locations: IP 55
4. Indoor Ares Indicated on Drawings: IP50

PART 3- EXECUTION**3.1 EXAMINATION**

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

3.3 INSTALLATION

- A. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- B. Comply with mounting and anchoring requirements specified in Division 16 Section "Electrical Supports and Seismic Restraints".
- C. Temporary Lifting provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification".
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplates as specified in Division 16 Section "Electrical Identification".

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test and adjust field-assembled components and equipment installation, including connection and to assist in field testing report results in writing.
- B. Prepare for acceptance testing as follows:
 - 1. Inspect mechanical and electrical connections.
 - 2. Verify switch and relay type and labeling verification.
 - 3. Verify rating of installed fuses.
 - 4. Inspect proper installation of type, size, quantity and arrangement of mounting or anchorage devices complying with manufacturer's certification.
- C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspection and prepare test reports.

END OF SECTION

SECTION 16415 - AUTOMATIC TRANSFER SWITCHES (BASIC SPECIFICATIONS):**PART 1 – GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This section includes transfer switches rated 600 V and under. It includes the following items:
 - 1. Automatic transfer switch (ATS) consisting either:
 - a- Of two contactors AC3 rated electromechanically interlocked (up to 600 A).
 - b- Or of two air circuit breakers above 600Amp (10000 A operations electrical endurance) as specified under breakers and switchboards.
 - c- Installation of automatic transfer switches within distribution switchboard on panelboard shall comply with same testing requirement TTA as specified for switchboard or distribution panelboard.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections
- B. Product data for each transfer switch including dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and materials lists.
- C. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring.
- D. Single line diagram of the unit showing connections between the automatic transfer switch, the power source and the load, plus interlocking provisions.
- E. Operation and maintenance data for products, for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 16 Section “Basic Electrical Requirements”. Operating and maintenance data shall cover each type of product, including all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions. Provide spare parts data.

- F. Manuals: Four sets operators and spare parts manuals shall be provided for all system equipment. The manuals shall include outline, interconnection, wiring, and control drawings accurately describing the equipment provided. Provide ladder logic for all programmable logic controllers in the system.
- G. Manufacturer's certificate of compliance to the referenced standards and manufacturer's certification of tested short circuit closing and withstand ratings.
- H. All conditions and stipulated for switchboards manufacturers shall apply to Automatic Transfer Switch local assemblies (refer to Section 16441 Parag. 1.4.1 and 2.04)

1.4 QUALITY ASSURANCE

- A. Electrical component standard: comply with:

IEC/EN500 81-1, IEC/EN500 82-2
IEC/EN61010-1, IEC/EN600 68-2-6
IEC/EN60068-2-27, IEC/EN60429
IEC/EN61000-4-11, EN50011.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Telemecanique.
 - 2. Siemens.
 - 3. ABB Europe
 - 4. Lovato.
 - 5. Socotec (France)
- B. Enclosures: IP50 except as otherwise indicated.
- C. Factory Wiring: Train and bundle wiring and identify consistently with shop drawings, either by color code or by numbered or lettered wire and cable tape makers at all terminations. Provide designated terminal blocks for field wiring, and arrange power terminal and field wiring space to be suitable for top, side, or bottom entrance of feeder conductors as indicated. Provide pressure-type terminals suitable for copper or aluminium conductors of sizes indicated.
- D. Switch Contacts: Heavy duty silver composition for switching load current with separate arcing contacts where rated 400 amperes and above.

2.2 MAINS FAILURE AUTOMATIC TRANSFER SWITCHES (ATS):

- A. TYPE: wall or floor mounted, or integrated within switchboard as per IEC EN 60439, with same protection form as specified for corresponding switchboard galvanized sheet steel cubicle of equal construction to control cubicle, comprising two main contactors AC3 rated with one manual by-pass switches or motorized mccbs acting as b-pass switch on generator side with similar specifications as under breakers and controls necessary for automatic transfer of power supply from normal source to standby source, voltage sensing control relay and time delay relays to signal generators start and stop, auxiliary switches and indicating lights, etc. as necessary for the required operation of the system. Contactors, and by-pass switches ratings are specified on drawings. Finished shall be RAL 7032.

ATS integrated within enclosure of apartment panelboards shall be built-in assembly and shall comply with corresponding enclosure corresponding quality assurance.

- B. OPERATION: when voltage and/or frequency of any phase drops below an adjustable setting (85-100%) of normal supply for an adjustable period of 1-300 seconds, power failure relay is to actuate engine starting control, whilst normal mains contactor or breaker is to open. After an adjustable period of 0-10 seconds from sensing stabilized rated voltage and frequency of generators at the ATS, voltage pick-up adjustable from 85% to 100% nominal, frequency pick-up adjustable 90% to 100% nominal, the emergency contactor is to close. Upon restoration of normal mains supply to above the present limits, adjustable between 90% and 100% of rated voltage and/ or frequency contactor is to open and after a presentable pause 0.5 to 30 seconds minimum, normal mains contactor is to close, time delay is to be effective in both directions.
- C. ENGINE SHUTDOWN: is to be initiated of the load normal source (Refer to generator set controls upon shut-down).
- D. MECHANICAL AND ELECTRICAL INTERLOCKS: are to prevent contactors/ circuit breakers from being closed simultaneously at any time. Transfer mechanism is to be powered from the source to which the load is being transferred.
- E. SELECTOR SWITCHES: are to be provided as follows:
- F. Operating selector switch to include the following:

Normal: Generator set is set for automatic operation and the generator set starts of a power outage occurs, as described above.

Test: Shuts down the generating set and prevents it from starting. This is used when servicing the generator.

Another selector switch is to be provided for two positions, “with load”, and “without load” for testing or exercising:

“With load” the generating set is to carry the load during testing or exercising periods.
“Without load” generating set is to start but not assume the load.

- G. PILOT LIGHTS: are to indicate which contactor is on and availability of code alternator.
- H. INSTRUMENTS: are to include voltmeter and ammeter with selector switches and necessary HRC fuses.
- I. CONTACTORS: are to comply with and UL standard 1008, and be 3-phase, 4-pole, magnetic type, 600 V rating, capable of interrupting at least ten times rated current inductive or non-inductive loads under normal service conditions and are to have replaceable main arcing contacts and arc quenching devices. Contactors are to withstand, without welding or burning of contacts, a inrush current of 20 times normal rating for 4 seconds upon closing and are to be capable of closing on the heaviest short-circuit of the system and withstand the short circuit for period required by upstream short circuit protective device to operate. Three N.O. and three N.C. Spare contacts are to be provided in each contactor.
- J. **CONTROL SYSTEM:**
 - 1. Control shall be solid-state and designed for a high level of immunity to power line surges and transients, demonstrated by a test approved by Engineer. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs, and relays on all outputs.
 - 2. Solid-state under voltage sensors shall simultaneously monitor all phases of both sources. Pick-up and drop-out settings shall be adjustable. Voltage sensors shall allow for adjustment to sense partial loss of voltage on any phase. Voltage sensors shall have field calibration of actual supply to nominal system voltage.
 - 3. The switch shall transfer when the emergency source reaches the set point voltage and frequency. Provide a solid-state time delay on transfer, adjustable from 0.5 to 120 seconds. Factory set at 1 second.
 - 4. Controls shall signal the engine-generator set to stop after a time delay, adjustable from 0 to 10 minutes, beginning on return to the normal source. Factory set at 5 minutes.
 - 5. Power for transfer operation shall be from the source to which the load is being transferred.
 - 6. All necessary contacts and relays shall be provided for BMS connection.

K. Accessories:

1. Close differential voltage sensing on each phase of normal source. Pickup voltage shall be adjustable from 85 percent to 100 percent of nominal, and dropout shall be adjustable from 75 percent to 98 percent of the pick up value. Factory set for pick-up at 90 percent and dropout at 85 percent.
2. Time-delay override of normal source voltage sensing shall delay all transfer and engine start signals. Adjustable 0 to 6 seconds, and factory set at 1 second.
3. Voltage/ frequency lockout relay and sensing of the emergency source shall be provided to prevent premature transfer. Voltage pick-up shall be adjustable from 85 to 100 percent of nominal. Factory set to pick-up at 90 percent of nominal. Pick-up frequency shall be adjustable from 90 percent to 100 percent of nominal. Factory set to pick-up at 95 percent.
4. System test switch, momentary type.
5. Retransfer time delay to normal or preferred power source: adjustable from 0 to 30 minutes and factory set at 30 minutes. Provide automatic defeat of the delay upon loss of voltage or sustained under voltage of the emergency source, provided the normal supply has been restored. Factory set at 15 minutes.
6. LED pilot lights to indicate source to which the load is connected.
7. Unassigned auxiliary contacts: two normally open SPDT contacts for each switch position.
 - a- Rating: 10 amperes at 240 VAC.
8. Source available indicating lights: A green LED indicating light to supervise the normal power source with a nameplate engraved "NORMAL SOURCE AVAILABLE", and a red LED indicating light to supervise the emergency power source with a nameplate engraved "EMERGENCY SOURCE AVAILABLE". Supervision of sources shall be via the transfer switch normal and emergency source sensing circuits, respectively.
9. Transfer override switch: to override automatic retransfer control so the ATS will remain connected to the emergency power source regardless of the condition of the normal source. Provide a pilot light to indicate the override status.
10. Remote Control Features:
 - a- Engine exerciser contact for switches connected to generators.
 - b- Transfer test contact.

11. Front Panel Items:

- a- Key operated switch with standby and normal positions to manually switch between the standby and normal source.
- b- Transfer switch position and source LED lamps.
- c- Test switch – simulates normal power loss to control for generator testing. Control shall provide for test with or without load transfer.
- d- Retransfer – Momentary position to override retransfer time delay and cause immediate return to normal source, if available.
- e- Digital display to indicate voltage levels of two sources, and maintain history of switch operations.
- f- Control that can interface with a LON compliant environment.

L. Wiring:

- A. Hard – wired connections: Conform to division 16 section “Wires and Cables” for conductors between transfer switches and remote annunciator panels.

M. Finishes:

- A. Clean ferrous surfaces to be painted free of oil, grease, welding slag, and spatter, mill scale, corrosion, and dirt.
- B. Paint with rust – inhibiting and finish enamel. Apply primer to clean, dry surface immediately after cleaning. Use manufacturer’s standard material and procedure except as required to produce a total dry film thickness not less than 2.5 mils. Use finish coat of manufacturer’s approved standard color. Provide a finish free from runs, sags, peeling, and other defects.

N. There shall be two modes of operation:

- 1. **MANUAL CHANGEOVER:** This mode consents to the manual changeover from one source to another and vice versa.
- 2. **AUTOMATIC CHANGEOVER:** This mode automatically enables the switching of two lines within a time period, adjustable between 0.5 and 120 seconds.

The control of the two line contactors of circuit breakers shall be achieved in a safe and reliable manner by means of a safety system with internal electromechanical interlock of the unit.

O. Main Features:

- 24 VDC or 220 VAC auxiliary supply.
- Galvanic isolation between control network and internal circuits.
- True RMS control of supply voltage.
- Microprocessor supervision of functions.

- Membrane keypad and 3-digit display.
- 11 signaling LEDs.
- Adjustable tripping limits and time.
- AUT-MAN-TEST-OFF operating mode.
- Diagnostics.
- 1 “Main” L-L voltage measurement input.
- 1 “Secondary” L-L voltage measurement input.
- 100-400 VAC rated voltage control.
- 70-500 VAC L-L voltage range.
- 50 Hz rated frequency.
- Full scale measurement accuracy: $\pm 1\% \pm 1$ digit.
- 2 output relays (16 A lth changeover contact) for “Main” and “Secondary” contactor or circuit breaker control.
- 1 alarm output relay (8 A lth changeover contact).
- 144 x 144 mm housing of self-extinguishing insulated material.
- IP41 on front, IP54 with sealable cover (order separately).
- IP20 at rear.

P. Set Up:

A. The set up contemplates the following setting parameters:

- Max voltage limit for “Main” and “Secondary” lines.
- Min voltage limit for “Main” and “Secondary” lines.
- Min-Max limit tripping delay for “Main” and “Secondary” lines.
- Min-Max limit delay at voltage return of “Main” and “Secondary” lines.
- Changeover/ interlock control time for circuit breakers control of “Main” and “Secondary” lines.

Q. Operational Characteristics:

A. 230 VAC auxiliary power supply:

- Rated supply voltage: 230 VAC.
- AC voltage range: 0.8-1.2% Us.
- Maximum current consumption: 45 mA.
- Rated current: 35 mA.
- Connection time: 100%.
- Power loss ride through (MPU circuit): ≥ 300 ms.

B. Input Voltage Control:

- Rated voltage U_e adjustable: 230 V - 380 VAC.
- Maximum voltage limit adjustable: $1.02 - 1.2 U_e$.
- Minimum voltage limit adjustable: $0.7 \div 0.98 U_e$.
- Operating frequency: 50/60Hz configured at setup.
- Reset hysteresis fixed: 3%.
- Power consumption: 0.5 VA.

C. Line 1 – Line 2 control output contacts:

- Contact type: 1 changeover.
- Rated operational voltage: 250 VAC.
- Maximum operational voltage: 380 VAC.
- Rated current life: 100,000 operations.
- Mechanical life: 50,000,000 operations.

D. Alarm Output Contact:

- Contact type: 1 changeover.
- Rated operational voltage: 250 VAC.
- Maximum operational voltage: 380 VAC.
- Rated current lth: 8A.
- Rated capacity DC13 o DC14: 5A 24 VDC.
- Electrical life: 100,000 operations.
- Mechanical life: 30,000,000 operations.

PART 3 – EXECUTION**3.1 INSTALLATION**

- A. Floor mounting of transfer switches: level and anchor the unit to the floor.
- B. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.
- C. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
- D. Equipment shall be initially started and operated by representatives of the manufacturer.
- E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to final testing of the system.
- F. Identify components in accordance with division 16 section "Electrical Identification".

3.2 CONNECTIONS

- A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with lightening torques specified in UL 486A and UL 486 B.

3.3 GROUNDING

- A. Provide equipment grounding connections for transfer switch units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified to assure permanent and effective grounding.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a factory service representative to assist with demonstrations and field tests.
- B. Transfer equipment factory tests: Each transfer switch supplied shall be factory tested before shipment. Factory tests shall include a complete functional test of the transfer switch controls, including calibration of the voltage sensors.
- C. Field Tests: Energize transfer switches and demonstrate functioning of all devices, components, and sequences. Give seven calendar days advance notice of the tests, and perform tests in presence of Owner's representative.
- D. Tests for Transfer Switches: Demonstrate each sequence and operational function at least five times.
- E. Tests for ATSS: include the following:
 - 1. Simulate power failure of normal source.
 - 2. Simulate power failure of emergency source with normal sources available.
 - 3. Simulate low phase to ground voltage for each phase of normal source.
- F. Checking, measuring, and optimizing all adjustable time delays.
- G. Test failures: correct deficiencies identified by tests and make ready for retest.

END OF SECTION

SECTION 16441 - SWITCH BOARDS:**PART 1- GENERAL:****1.1 RELATED DOCUMENTS:**

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

1.2 SUMMARY

- A. This Section includes service and distribution switchboards rated 600V and less.

1.3 SUBMITTALS

- A. Product Data: For each type of switchboard, over current protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of switchboards and over current protective devices.
 - d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - e. Utility company's metering provisions with indication of approval by utility company.
 - f. Mimic-bus diagram.
 - g. UL or IEC listing for series rating of installed devices.
 - h. Features, characteristics, ratings, and factory settings of individual over current protective devices and auxiliary components.
 2. Wiring Diagrams: Power, signal and control wiring.
- C. Samples: Representative portion of mimic bus with specified finish, for color selection.
- D. Field quality –control test reports including the following:
1. Test procedures used.

2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- E. Operation and Maintenance Data: for switchboards and components to include in emergency, operation, and maintenance manuals include the following:
1. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting over current protective devices.
 3. Time-current curves, including selectable ranges for each type of over current protective device.
 4. Full detailed calculation sheets for heat dissipation.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of Lebanese Bureau de Controle or is a nationally recognized testing laboratory (LIBNOR), and that is acceptable to authorities having jurisdiction.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory.
- C. Main and emergency switchboards, ATS, MCCs, totalizing boards, synchronizing panels shall be totally type tested. All assemblies shall conform for minimum 7 type tests as defined in IEC-60439-1.
- D. Source Limitations: Obtain switchboards through one source from a single manufacturer. Local manufacturer who do not have official license issued by international panel maker who are fully certified as manufacturers of Type tested switchboards, shall be disqualified.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- F. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, or corresponding IEC standards by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in sections or lengths that can be moved past obstructions in delivery path.
- B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards; install electric heating (250 W per section) to prevent condensation.

1.6 PROJECT CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated.
 - 1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
- C. All necessary ventilation to be integrated within enclosure to avoid any derating of breakers and busses, otherwise larger rating of breakers to be used at not extra cost.
- D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated.
 - 1. Notify Owner no fewer than Seven days in advance of proposed interruption of electric service.
 - 2. Indicate method of providing temporary electric service.
 - 3. Do not proceed with interruption of electric service without (Owners) written permission. 1.8
- E. Coordinate layout and installation of switchgear and components with other construction including I conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
- F. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

- G. Only switchboard / panel maker having an official license to work in Lebanon for assembly of switchboard for the past three years and not only for this project as approved.

Licenses of following manufacturers are approved:

- Schneider
- Holec
- Cubic
- Logstrup
- Legrand

1.7 EXTRA MATERIALS

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

1. Potential Transformer Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 2 of each size and type.
2. Control-Power Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 2 of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
4. fuses for Fused Switches: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
6. Indicating Lights: Equal to 10 percent of amount installed for each size and type, but no fewer than 1 of each size and type.

PART 2 – PRODUCTS:

2.1 GENERAL

These specifications cover the main synchronizing and totalizing switchboard of the 3 generators.

This specification relates to Type Tested Assemblies (TTA) and Partially Type Tested Assemblies (PTTA). In accordance with IEC 60 439-1 Standard.

The switchboard shall be suitable for operating on 3 phase, 4 wire, 380 volts, 50 Hz supply.

The symmetrical fault rating shall be 50 KA for 1 second. The switchboard shall be ASTA tested at the fault; copies of the test certificates shall be submitted for Engineer's approval.

The switchboard shall be compartmentalized and manufactured to IEC 439-1, Form **2b**, rated, as described hereafter. All the internal separation must be metallic type electrozinc plated.

The height of the switchboard shall be limited to 2300 mm unless otherwise specified.

The equipment shall be suitably constructed for safe, proper and reliable operation without undue wear, corrosion, heating or other operating trouble.

All breakers and controls shall be manufactured exclusively in Western Europe or in Northern America.

The design and arrangement of the equipment shall be subject to the approval of the Engineer.

The Engineer shall have the full discretion any authority to reject part or total assembly work of local representative of approved switchboard manufacturer makes and to insist for switchboard to be manufactured in country of origin.

The main breakers shall be Air circuit breaker withdrawable, electric operated motorized spring charge type with electronic trip unit, 3 poles with the following features:

ICW = 50kA for **1** seconds
Safety shutter
4 auxiliary contacts - ON/OFF signaling status
2 Alarm auxiliary contacts

The main breaker shall also include one overcurrent relay Solid state type, with in the following feature:

LT, ST, INST

It shall monitor voltage, current, frequency, power factor, kVA, kW.... And be equipped to communicate with external hardware and software for the purpose of monitoring and measurement.

The overcurrent relay shall be similar to STR68U from Merlin Gerin, DIGITRIP 11 50i from Cutler-Hammer or approved equal.

All the branch circuit breakers shall be Molded Case type, fixed, motor operated and with number of poles as indicated on the drawings, with the following features:

ICS = 50kA.
2 auxiliary contacts - ON/OFF signaling status

1 Alarm auxiliary contacts

Overcurrent relay solid state type LT, ST, INST similar to STR23SE from Merlin Gerin, DIGITRIP 310 from Cutler-Hammer or approved equal.

3 C.T. to be connected to BMS

KWH reading with impulse to be connected to BMS (only in MDSB type switchboard connected directly to transformer).

The arrangement of the equipment within the assemblies shall be individually mounting type in a modular arrangement and shall be such as to afford maximum accessibility to all parts, incoming and outgoing wires and cables.

The main distribution switchboard shall be factory built assembly, metal clad, totally enclosed box type, type tested at the factory, complying with B.S. 5486/IEC 439-1 Form 2b **unless otherwise noted**

Distribution switchboard indicated on drawings as DS, or EDS shall comply with IEC 439-1 Form 3a.

All the circuit breakers of the distribution switchboards type DS or EDS including branches and main shall be MCCB, fixed type.

All plastic parts shall be self-extinguishing at 460 deg. C as per IEC 695-21 and NFC 20, 455 class VD (UL 94).

Over voltage protection shall be provided at incoming feeder entry point and shall be coordinated with over voltage protection located down stream at entry point of feeder of panel fed directly from main switchboard.

Approved nameplates, permanently mounted for identification of all major and control equipment shall be provided as described under "GENERAL".

Main steel work should be electrozinc plated and passivated followed by stoved powder, finish colour shall be RAL 7032.

The switchboard shall comply with the latest versions of : IEC 439-1, EN 60 439-1, BS EN 60 439-1, VDE 0660 part 500, DIN EN60 439-1 Part 1, Salt mist test of IEC 68.2.30.

Switchboard supplier shall provide all necessary calculation sheets in order to verify that maximum heat dissipated inside end-enclosure does not exceed the maximum allowable temperature T of the circuit breaker without derating the circuit breaker.

If during after execution stage the temperature inside the end-enclosure exceeds that value T, the breaker will be replaced at no cost by a larger breaker.

Compartment of circuit breakers, switch fuses shall be finished in white. Fasteners shall be zinc plated and bronze passivated.

Structural steel base shall be provided for securing entire assembly to floor.

In general, manufacturer's standardized construction is desired.

Switchboards shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation and bolted directly to the floor without the use of floor sills.

The Contractor must at an early stage provide the Engineer with all the necessary manufacturer's details and shop drawings concerning the assembly to allow him to check the design of the concrete structure, particularly concerning the loads, the overall dimensions and the cable grouting holes.

Main distribution switchboard that is directly fed from transformer of the local Electrical Authorities shall comply with all the requirements of these authorities. The Contractor shall modify the specified switchboard to meet these requirements at no extra cost.

Terminal identification and marking shall be in accordance with IEC 9471 and IEC 60445.

Switchboards shall be manufactured by Cutler Hammer (USA), Holec (France), Schneider (France), Square D (UK), Siemens (Germany), ABB Europe, Moeller (Germany) or approved equal.

All above listed suppliers shall be approved only if product is manufactured in country indicated between brackets. All products from other countries of manufacturing shall be automatically rejected.

2.2 SWITCHBOARD ELECTRICAL TESTS:

The following electrical tests must be carried to all switchboards, sub-switchboards, main distribution boards and motor starter panels.

A. Full type tests

- 1) Full type tests shall be carried out in accordance with IEC60439-1, IEC60947-1, and IEC60947-6-1. Certificates issued by approved independent testing laboratories shall be submitted to the employer's representative.

The type tests shall include the following:

- a) Verification of temperature-rise limits
- b) Verification of the dielectric properties
- c) Verification of the short-circuit withstand strength
- d) Verification of the effectiveness of the prospective circuit
- e) Verification of the clearances and creepage distances

- f) Verification of mechanical operations
- g) Verification of the degree of protection

B. Routine tests

Before the product leaves the works, the manufacturer shall carry out the relevant routine tests in accordance with IEC60439-1 on the total assembly, and the IEC60947-1 and IEC60947-6-1 parts thereof when delivered with time intervals, and the results shall be recorded in a test report.

C. Special tests:

Carry out the special tests recommended in IEC1641 guide for testing under conditions of arcing due to internal fault, the result shall be recorded in a test report.

D. Acceptance tests and manufacturer's work:

- a) Acceptance tests shall be carried out on the completely assembled switchboards and motor starter panels. Transportable units can be wired together for the purpose of the tests instead of completing the busbar joints.
- b) The tests and checks shall include, but not limited to, the following:
- c) All the switchboards and motor starter panels shall be visually inspected for technical execution and conformity with the latest issue of approved drawings and the latest issue of the relevant standards. Spot checks shall be made to verify the following:
 - 1) Dimensions
 - 2) The degree of protection of enclosures
 - 3) The degree of protection within compartments
 - 4) The effectiveness and reliability of safety shutters, partitions and shrouds
 - 5) The effectiveness and reliability of operating mechanisms, locks and interlock systems
 - 6) The insulation of the busbar system
 - 7) The creepage distances and clearances
 - 8) The proper mounting of components
 - 9) The internal wiring and cabling system
 - 10) The correct wiring of main and auxiliary circuits
 - 11) The suitability of clamping, earthing and terminating arrangements
 - 12) The correct labeling of functional units
 - 13) The completeness of the data on the nameplate
 - 14) The availability of the earthing system throughout the switchgears
 - 15) The interchangeability of electrically identical components
- d) Dielectric tests shall be carried out in accordance with IEC60439-
 - 1. The test voltage shall be at least:
 - 1) For main circuits, 2500Vac for 1 minute
 - 2) For control and auxiliary circuits, $2 \times U_n + 1000\text{Vac}$, with a minimum of 1500 Vac for 1 second

- e) Testing of the mechanical and electrical operation of a number of functional units on random basis, including their control and protective devices
- f) CT polarity, magnetization, ratio and burden measurements
- g) Secondary injection tests
- h) Primary injection tests
- i) Painting and finishing tests
 - 1) Measurement of paint thickness
 - 2) Humidity (cyclic condensation) tests to BS3900 Pt.F2. painted panel shall withstand 1000hours under test with no blistering of film and corrosion of base metal
 - 3) Adhesion test to ASTM D3350-02. Test tape shall not expose more than one 3mm.sq of bare metal or underlying coating.
 - 4) Impact resistance test to BS3900 Pt. E7. Paint shall not chip off.
- j) The manufacturer test shall be verified and witnessed by the employer's representative or his representatives

E. Site Tests

At the completion of the installation at site, each switch board and motor starter panels shall be field tested by a representative of the manufacturer. A report recording each item of the tests shall be certified by the manufacturer and submitted to the Employer's representative

- a) Visual inspection
 - 1) Correctness of location and mounting
 - 2) Labeling, nameplates and markings
 - 3) Verification of torque for all nuts and bolts on busway.
 - 4) Observation of cable bracing, both incoming and outgoing, certifying that it is in accordance with the manufacturer's recommendations
 - 5) Safety shutters, partitions and shrouds
 - 6) Functional units, operating mechanisms, locks and interlock systems
 - 7) Mounting of components
 - 8) Internal wiring and cabling system
 - 9) Clamping, earthing and terminating arrangement
 - 10) Earthing system
- b) Dielectric tests shall be carried out in accordance with IEC60439
 - 1. The test voltages shall be at least:
 - a) For main circuits, 2500Vac for 1 minute
 - b) For control and auxiliary circuits, $2 \times U_n + 1000\text{Vac}$ with a minimum of 1500V for 1 second
 - c) Power frequency withstand voltage test.
 - d) CT polarity, magnetization, ratio and burden measurements
 - e) Secondary injection test
 - f) Primary injection test

- g) Functional / sequence test
 - I. Operation of each disconnecting means under load
 - II. Operation of each automatic transfer switch
 - III. Operation of all alarm devices
- h) Mechanical operation test
 - i) Operation of each auto transfer switch
 - j) Operation of all interlocks
- i) Calibration and setting of protection devices

2.3 MANUFACTURER

Subject to compliance with the following requirements, switchboard shall be the product, manufacturer and assembly of a manufacturer who is certified ISO 9000, 9001 or 9002.

The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of seven (7) years. Local manufacturers shall be approved only if they can meet the presented specifications, and if they are guaranteed by an international company. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this equipment.

The manufacturer shall thoroughly test the assembled switchboard for proper functioning with the following specifications. Submit certification to the Engineer that this testing has been completed and that the function and compliance conform to the specification.

The following test certificate must be submitted with the bids.

- Busbars short circuit certificate, as above mentioned, from international recognized testing institute,
- Manufacturer certificate of ISO 9000, 9001 or 9002,
- Manufacturer certificate of compliance with international standards issued by an international company.
- If switchboards are assembled locally, all components of main distribution switchboard shall be imperatively approved by the foreign firm who has issued the license
- Local panel makers who are granted a single project license from an approved foreign manufacturer shall be automatically rejected
- The panel maker shall be manufacturing similar switchboards type tested under license of approved foreign manufacturer for the last 7 years as a minimum with a minimum of 3 similar project panel makers that are awarded a license on a single project basis are rejected.

2.4 CONSTRUCTION OF THE ASSEMBLY

The assembly shall be of the indoor gasketed type of size, rating and arrangement as indicated on the Drawings. The complete assembly shall be ground mounting type with matching cases to form continuous internal structures.

The assembly shall consist of a completely enclosed self supporting metal structure, containing circuit protective devices and all other associated equipments as indicated on the Drawings and/or specified under other Clauses.

The assembly shall consist of the required number of formed and welded electrozincated sheet steel enclosures required to mount circuit protective devices and other equipments.

The metal sheets that are in close proximity of high currents shall be made of aluminum.

Bolted frames shall be provided at the rear to support and house copper busbars, cables and other accessories.

Front, side and top plates shall be steel, removable and not less than 2 mm thickness.

All fastenings between structural members shall be bolted, not welded to provide flexibility during installation.

Removable panels shall be provided at the front of each vertical section. The arrangement shall permit cables to enter bottom and top of the enclosure and connect to their respective terminals without interference.

The assembly shall be provided with cable racks and bolting down holes.

A modular individual mounting arrangement shall be used to permit interchanging different sized device cover plates without additional drilling of structure.

Structure and buses shall be arranged to permit future sections to be added to the left and right sides. Suitable cover plate must be provided for temporary protection. The assembly shall be vermin and rodent proof. Protection shall be to IP 41, as Standard to IEC 529 as a minimum requirement.

Paint finish shall be color light grey RAL 7035 semi glass.

Paint depth shall be 60 microns

Paint process shall be 4 stage process of chemical spray degreasing, iron phosphate coating, automatic electro-static epoxy polyester film application and curing in a high temperature controlled oven.

The complete switchboard, after assembly shall be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment.

The main circuits shall be given a dielectric test of 2500 volts one minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute between live parts and ground.

Racking in or racking out of the withdrawable feeder drawers shall allow safe, quick intervention with the installation still energized.

Possibility of modifying the current rating or type of drawer, with no down time shall be provided.

Total withdrawability of the upstream or downstream power and control circuits shall be possible with 3 or 4 power connection terminals (400 A) and a separate control output block (maximum 26).

Padlocking latch shall be used to lock the drawer in the racked out position.

2.5 BUSBARS

Main horizontal busbar ratings as shown on the Drawings shall be provided across the top of each structure. Each structure shall also be complete with vertical copper buses to distribute incoming power to each outgoing protective device in the structure.

All bus connections shall be bolted and clamp type terminals provided for cables.

All bus work and connections shall be accessible for inspection and maintenance purposes.

Neutral shall be full size, unless otherwise indicated.

The short time with stand current shall be 80 KA rms for 1 sec..

The busbars shall have sufficient number of insulating brackets in order to withstand the electrodynamic stress caused by the flow of 220 KA peak asymmetrical short circuit current.

Earth bus and lug shall be firmly secured to each vertical section structure and shall extend the entire length of the switchboard. A breaking strip shall be used for insulation measurement and shall be removed by using a tool.

Earthing bus shall be sized not less than 500mm² in cross- section earthing bus shall extend through the entire length of the assembly.

Main Distribution Switchboard that is fed directly from the transformer shall have the following additional features:

- a) Neutral busbar shall be provided with a removable solid bar link for testing purposes.
- b) A separate bonding strap shall be connected from the neutral bus to the switchboard frame. This bonding strap shall be located on the line side of the removable neutral link maintaining a service ground to the switchboard frame when the test link is removed.
- c) Any additional feature as per the Electrical Authorities requirements.

All buses and connections of the switchboard shall consist of high conductivity copper bars mounted on heavy duty glass polyester supports to BS 159.

Busbars insulating supports shall withstand fire and excessive heat as per IEC 695-2.1.

The bus shall be electrolytic copper of the CU ETP type (ISO 1337) and of sufficient cross-sectional area to continuously conduct rated current with a maximum average temperature rise of 20° C above an ambient temperature of 50° C.

All section (vertical) and through (horizontal) busbars shall be isolated phase from phase and phase from grounded dead metal through the use of insulating material properly applied in a complete insulation/isolation system. This system shall be in addition to the minimum UL clearances established in the basic bus design. It shall be totally independent of the bus support system so that it may be removed or replaced for inspection and maintenance without effecting the structural rigidity of the assembly.

2.6 PROTECTION AND SAFETY

The LV switchboards shall ensure the safety of people and equipment as well as a high level of continuity of service.

Switching safety shall be procured by a mechanical system that prevents on-load disconnection.

Operating safety shall be ensured by individual form 4 partitions.

Isolation shall be of the "visible break" or "positive contact indication" type in accordance with the IEC 947-3.

In order to reduce the risks of electric shocks.

The power circuit and the control circuit shall be separated and fully isolated.

The auxiliary circuits shall be of the ELV type.

The LV switchboards shall have two types of mechanical interlocking compatible with the different positions of the drawer. The system shall be on the fixed part and of the "3 padlock" type.

2.7 CONTROL AND MONITORING SYSTEM

switchboard must be equipped with a monitoring system that includes:

- Power meter module (PM) at the incoming and at each outgoing (Breaker or ATS). The (PM) shall monitor voltage, currents, frequency, Cosphi, kVA, kW, etc...and must include a port RS 485 for communication.
- Internal bus; all modules will be connected in parallel to a terminal block. The bus RS485 will be connected to the main BMS of the project through a central unit CU (Interface or integrator). The CU will be supplied by the BMS contractor in order to ensure the transmission of all collected data by the modules inside the switchboard. The BMS will record the data on current and voltage to be used for inspection in case of failure; in addition all the collected data will be available on the BMS screen for regular supervision.

The switchboard CU shall ensure:

- The collection and organization of data.
- The communication with the installation supervisor.

The power monitoring modules shall be designed to:

- Control all types of outgoing or incoming feeders.
- Be remotely addressed.
- Be equipped with disconnectable connections.
- The PM will be similar to PM300 from M.G. or D96FM-4 from FRER or approved equal from IME, Circutor or Socomec.

2.8 FORMS FOR PANEL

The basic four forms according to IEC 439-1 for the assembly of switchboards and internal separation of assemblies or partitions into sub-compartment is as follow:

Form 1	No separation between busbars, functional units and terminals for external conductors.
Form 2A	Separation of the busbars from the functional units. The terminals for external conductors do not need to be separated from the busbars.

Form 2B	Separation of the busbars from the functional units. The terminals for external conductors are also separated from the busbars.
Form 3A	Separation of busbars from the functional units and separation of all functional units but not their terminals for external conductors, from one another. The terminal for external conductors need not to be separated from the busbars.
Form 3B	Separation of busbars from the functional units and separation of all functional units from one another. Separation of terminal for external conductors from the functional units and from the busbars but not from one another.
Form 4a	Separation of busbars from the functional units and separation of all functional units including their terminals for external conductors, from one another. The cables shall be glanded off on gland plates within the functional unit compartment.

Note: In for 3A, 3B & 4a, the main breaker and outgoings larger than 600A frame size shall be located in a their own column, completely segregated from all others parts of the switchboard.

2.9 INSTRUMENTS AND METERS (Microprocessor Based)

The Contractor shall provide instruments, instrument transformers and selector switches as shown on the Drawings. The Contractor shall otherwise provide three ammeters with current transformers and one voltmeter with 7 position selector switch for the main, and one maximum demand meter.

Instruments shall be digital type, similar to cutler Hammer catalog number IQ data plus II HV.

Instrument transformers shall be rated for 600 volt service with adequate thermal capacity and mechanical strength to match the short circuit of the switchboard. Potential transformers primaries and secondaries shall be protected by fuses. Primary fuses shall be current limiting.

Selector switches for use in instrument shall be of the rotary type with a rectangular escutcheon. The operating handle shall be of the round knurled or no type for voltage and current.

2.10 CIRCUIT BREAKER

LV AIR CIRCUIT BREAKER

The circuit breakers shall comply with IEC947.2 or corresponding standards in member countries (VDE 0660: BS 4752: UTE C63120); optional version may comply with UL/ANSI/JIS standard.

The breaking capacity performance certificates shall be available for category B to the above-mentioned standards. The test shall be carried out with a breaking performance during operation (Ics) equal to the ultimate breaking capacity (Icu).

All circuit breakers can be reverse fed without reduction in performance.

All breakers shall be with drawable and motorized.

All circuit breakers shall have a rated operational voltage of 690V AC (50/60Hz).

The rated insulation voltage shall be 1000 V AC (50/60 Hz).

All circuit breakers shall fully tropicalized (T2) as standard.

The circuit breaker shall comply with the isolating function requirements of IEC 947-2 section 7.1.2.

All breakers shall be equipped with necessary contacts and control devices for connection and monitoring through Building Management System.

Minimum electrical endurance: 10000 operations

Approved suppliers:

ABB (Italy)
Merlin Gerin (France)
Siemens (Germany)
Cutler Hammer (USA)
Klockner Moeller (Germany)

CONSTRUCTION

They shall be available in fixed or drawout models and in 3-poles or 4-poles versions as indicated on drawing.

The required safety clearance around the air circuit breaker may be canceled by adding protective covers. Type tests shall be achieved with the minimum safety clearance.

All air circuit breakers shall be designed to be maintained; in order to reduce maintenance, electrical endurance characteristics shall be very high. Up to 2000A, the circuit breaker shall offer an electrical endurance without servicing nor maintenance (CO at Un = 690V) equal to the mechanical endurance.

On 4-pole version, the neutral pole shall have the same current rating as the other poles from 800 up to 4000A and N/2 from 5000 up to 6300A.

All air circuit breakers main contact shall be encased in a reinforced polyester casing and offer double insulation from the operators on the breaker front face. The circuit breaker also shall offer total insulation of the control part with respect to the power part.

Operating Mechanism

The operating mechanism shall be of the O.C.O stored energy spring type with a closing time of less than or equal to 80 ms.

There shall be 2 types of spring charging, either:

- Hand charged spring where the springs are wound only by hand or:
- Motor charged spring, where the springs are automatically charged by an electric motor. The maximum time to charge the springs shall not exceed 4 seconds. It shall also be possible to charge the springs manually.

Arc Chutes

Arc chutes shall be common on the whole range and removable on site to allow inspection of arc chutes and main contact.

Drawout Mechanism

General

The drawout operation shall be possible through a closed door.

Three positions of the moving part shall be possible:

- 1- Connected position - all auxiliary and main circuits engaged.
- 2- Test position - all auxiliary circuits engaged all main circuits disconnected.
- 3- Isolated position - all circuits disconnected.

Safety Requirements

A door interlock shall be provided so that it shall not be possible to open the door until the air circuit breaker moving part is in the disconnected position.

Insulated safety shutters shall be provided over the incoming and outgoing main circuits and over the auxiliary circuits. An interlocking shall be provided to prevent insertion of a circuit breaker having a rating higher than the current range the fixed part, into that fixed part.

The racking handle shall be stowed on the air circuit breaker in such a manner as to be accessible without defeating the door interlocking.

The safety perimeter shall be reduced to zero for the drawout version above and to the sides of the A.C.B.

Electrical Auxiliaries

All electrical auxiliaries including the motor spring charging mechanism shall be field adaptable without adjustment or the necessary for any tool (except a screwdriver). They shall be fitted into a compartment which under normally loaded conditions has no metalwork energized from the main poles exposed with it. Any adaptation carried out thus shall not increase the breaker volume.

It shall be possible connect all auxiliary wiring from the front face of the air circuit breaker, this wiring shall be taken through a set of disconnecting contact, so that all auxiliary wiring is automatically disconnected in the isolated position.

Mechanical Indicators

Mechanical indication on the front of the air circuit breaker shall be provided to indicate the following:

- 1- Main contacts closed "ON".
- 2- Main contacts open "OFF".
- 3- Springs charged.
- 4- Springs discharged.
- 5- Circuit breaker in "connected" position (drawout only).
- 6- Circuit breaker in "test" position (drawout only).
- 7- Circuit breaker in "disconnected" position (drawout only).

All indicators must be clearly visible.

General Requirements

The overcurrent relay shall be a **solid state type**

It shall be microprocessor based and use digital programming techniques for highest protection accuracy.

And be **integrated as part of the circuit breaker**

- The sensors and the wiring shall be integrated within the case.
- The overcurrent relay shall be self powered.
- The current sensors shall be located within the case of the circuit breaker.

The overcurrent relay shall have a wide adjustment range to allow flexibility of setting on site. The trip unit shall measure the true RMS value of any waveform of current.

The control unit shall be equipped with a push to reset mechanical indicator, for anti-pumping function.

The control unit may communicate with other equipment on a communication BUS.

Characteristics

Long time protection (LT).

- Adjustable (in steps of 4%) from 0,4 to 1 of the sensor rating.
- Time delay adjustable from 15 to 480 seconds (at 1.5 times the long time setting)

Short time protection (ST)

- Adjustable (in steps of 4%) from 0,4 to 1 of the sensor rating.
- Time delay adjustable from instantaneous to 0.4 seconds.
- Time inverse characteristics (12t) may be switched in to improve discrimination.

Instantaneous (INST)

- N and H types, adjustable from 2 times up to:

At least 20 times the rated current for sensor rating u to 2000A

At least 10 times the rated current for sensor rating above 2000A

- L type, adjustable from 2 times up to at least 6 times the rated current.

Control functions

In order to optimize the operation, maintenance and monitoring of the breaker in complete safety the following control items shall be supplied as standard as an integral part of the control unit:

- Local overcurrent LED indication with 2 levels - LED steady or flashing - on the front face and one volt free out contact shall indicate as a pre trim alarm.
- Two NO and two NC output contacts plus one CO fault trip contact (SDE) shall be available.
- Thermal memory:

The control unit shall optimize the protection of the equipment or the circuit conductors in the event of repeated overloads or faults by using thermal integration to memorize temperature rises.

Safety:

Internal overheating of the control unit shall be signaled by a self monitoring alarm.

Options

Without increasing the volume it shall be possible to combine the following functions into the circuit breaker control unit.

Load monitoring and control

Two adjustable settings with output contacts shall be available. These settings to be related to the long time protection setting.

Zone selective interlocking for the short time and earth fault protection

Earth fault protection

Remote indication of one particular fault as selected by a switch on front face.

Fault trip indication- indicating the element (long time, short time/instantaneous, earth fault protection of supplied) that has caused the circuit breaker to trip, indicated locally by a LED.

Measurement:

- A digital display ammeter shall indicate the RMS value of the circuit breaker phase currents with a switch on the front face for selection.
- A bar graph shall display the load indication of each phase.
- The highest value of phase current shall be stored and displayed on demand.

Communication:

The data or action needed for the control and indication functions shall be available on a BUS via a specific modular system i.e.:

- Circuit breaker state.
- Control unit settings.
- Cause of circuit breaker trip.
- Circuit breaker operation.

General Requirements

The overcurrent relay shall be a solid state type

It shall be microprocessor based and use digital programming techniques for highest protection accuracy.

And be integrated as part of the circuit breaker

- The sensors and the wiring shall be integrated within the case.
- The overcurrent relay shall be self powered.
- The current sensors shall be located within the case of the circuit breaker; they shall be air core type to ensure:
- Accurate measurement from 200 A up to 75 kA.
- The highest discrimination up to the circuit breaker electro-dynamical withstand even for the instantaneous protection

The overcurrent relay shall have a wide adjustment range to allow flexibility of setting on site. The trip unit shall measure the true RMS value of any waveform of current.

The control unit shall be equipped with a push to reset mechanical indicator, for anti-pumping function.

The control unit may communicate with other equipment on a communication BUS.

Characteristics

Long time protection (LT).

- Adjustable (in steps of 2%) from 0,4 to 1 of the sensor rating.
- Time delay adjustable from 15 to 480 seconds (at 1.5 times the long time setting)

Short time protection (ST)

- Adjustable (in steps of 4%) from 0,4 to 1 of the sensor rating.
- Time delay adjustable from instantaneous to 0.4 seconds.
- Time inverse characteristics (12t) may be switched in to improve discrimination.

Instantaneous (INST)

- Adjustable from 2 times the rated current up to the circuit breaker electro-dynamical withstand.

Control functions

In order to optimize the operation, maintenance and monitoring of the breaker in complete safety the following control items shall be supplied as standard as an integral part of the control unit:

Operation, maintenance

- All settings shall be made on the front face by keyboard with direct reading the adjustment value (A) displayed on a digital ammeter.
- The phase currents and interrupted current values shall be displayable on the ammeter. LED's on the front face shall indicate the type of fault (LT, ST/INST, T).
- A maintenance indicator shall give an indication of main contact wear according the number of operations and the values of the switched currents (the true parameters for maintenance)

Monitoring

- Thermal memory:

The control unit shall optimize the protection of the equipment or the circuit conductors in the event of repeated overloads or faults by using thermal integration to memorize temperature rises; this function can be inhibited if required.

Safety:

The protection and load monitoring curves and the local and remote indicators shall be checked by a test circuit incorporated in the control unit.

- Internal overheating of the control unit shall be signaled by a self monitoring alarm.

Options

Without increasing the volume it shall be possible to combine the following functions into the circuit breaker control unit.

Load monitoring and control to adjustable settings with output contacts shall be available.

These settings to be related to the long time protection setting.

Zone selective interlocking for the short time and earth fault protection

Earth fault protection

Remote indication of cause of trip.

Energy Measurement

In order to optimize the network energy management, the parameters:

Voltage, frequency, active and reactive power and energy and power factor shall be displayable on a digital display on the front face. The voltage measurement shall be achieved without external transformers.

All of this data shall be available on a BUS.

Data Transmission:

The data needed for the control and indication functions shall be available on a BUS.

- Circuit breaker state.
- Control unit settings value.
- Cause of circuit breaker trip and current interrupted.
- Phase current values, voltage value, power value.
- Thermal memory status, self monitoring output status.
- Circuit breaker operation.

HIGH RATING MOLDED CASE CIRCUIT BREAKERS (FROM 1250A UP TO 1600A)**A. General**

The high rating MCCB shall comply with IEC 947-2 or corresponding standards in member countries (VDE 0660; BS EN 60947; UTE C63120); they may as an alternative comply with UL/JIS standards.

The breaking capacity performance certificates shall be available for the category B to the above-mentioned standards. The test shall be carried out under the breaking performance during operation (Ics) and under the admissible short time withstand (Icw) equal to 50% of the ultimate breaking capacity (Icu).

All breakers shall be equipped with necessary auxiliary contacts and controls for connection and monitoring through Building Management System.

The MCCB shall have a rated operational voltage of 690V AC (50 Hz).

The rated insulation voltage shall be 750V AC (50 Hz).

The MCCB shall be designed for horizontal or vertical mounting without any adverse effect on electrical performance.

It shall be possible to reverse feed the breaker without reduction in performance up to 500V AC.

The breaker shall be maintenance free and fully tropicalized (T2).

It shall either be 3 poles or 4 poles (switched neutral).

The MCCB shall be of circuit breaker disconnect type.

Otherwise MCCB shall have a minimum rms symmetrical interrupting capacity of 35 KA rms.

B. Construction

The operating mechanism of the circuit breaker shall be of the trip free type, quick make and quick break design. All mechanical components of the breaker shall be enclosed in an insulated casing.

The trip unit shall be of the solid state type energized by internally mounted/current transformers. It shall not require any external power supply to operate the tripping mechanism. The trip unit shall be interchangeable.

C Characteristics

The solid state protection unit shall have as required.

Long time protection adjustable from 0.5 to 1 times sensor rating

Short time protection.

Adjustable from 3 to 6 times the setting made on the long time protection

Time delay (when required) adjustable from instantaneous to 0.225s.

Instantaneous

Threshold set at 35 kA.

Earth fault protection (when required).

Adjustable from 0.2 to 0.5 times the setting made on the long time protection

Time delay from instantaneous to 0.3s.

The standard operating mechanism shall be constructed so that the handle of the circuit breaker indicates the true position of the contacts to ensure a positive break indication.

Where required, motor operated mechanism, shunt trip, undervoltage release, auxiliary switches up to four changeover contacts and a tripped signal contact shall be provided. Each of these units shall incorporate a pre-wired terminal strip, which is accessible from the front of the breaker without removing the cover.

D Operation

If required, the breaker shall be provided with the facility for padlocking or keylocking in the open position.

MOLDED CASE CIRCUIT BREAKERS (FROM 100 TO 1250A)**A General**

The molded-case circuit breakers shall comply with IEC 947-1 and 947-2 standards or with the corresponding standards applicable in the member countries (VDE 0660, BS EN 60947):

- They shall be of category A with a rated service breaking capacity (Ics) equal to the ultimate breaking capacity (Icu) on all the operation voltage range for the ratings up to 250A, up to 500V for the greater ratings.
- They shall have a rated operational voltage of 690 V AC (50/60 Hz.).
- They shall have a rated insulation voltage of 750 V AC (50/60 Hz.).
- They shall be suitable for isolation, as defined by IEC 947-2, § 7-27.

Production site organization shall be certified to comply with ISO 9002 standard.

All breakers shall be equipped with necessary auxiliary contacts and controls for connection and monitoring through Building Management System.

The case-case circuit breakers shall be available in fixed or plug-in/withdrawable versions as well as in 3-pole and 4-pole versions as shown on drawings. For plug-in/withdrawable versions, a safety trip shall provide advanced opening to prevent connection and disconnection of a closed circuit breaker.

The case-case circuit breakers shall be designed for both vertical and horizontal mounting, without any adverse effect on electrical performance. It shall be possible to supply power either from the upstream or downstream side.

The case-case circuit breakers shall provide class II insulation (according to IEC 664 standard) between the front and internal power circuits.

The minimum short circuit interrupting capacity shall be:

- 25 KA rms for breakers up to 150 A frame.
- 35 KA rms for breakers with 250 A frame and above.

B Construction, Operation, Environment

For maximum safety, the power contacts shall be insulated in an enclosure made of a thermosetting material from other functions such as the operating mechanism, the case, the trip unit and auxiliaries.

The operating mechanism of the case-case circuit breakers shall be of the quick-make, quick-break type with fault tripping overriding manual operation. All poles shall operate simultaneously for circuit breaker opening, closing and tripping.

The molded case circuit breakers shall be actuated by a toggle or handle that clearly indicates the three positions: ON, OFF and TRIPPED.

In order to ensure suitability for isolation complying with IEC 947-2 § 7-27:

- The operating mechanism shall be designed such that the toggle or handle can only be in OFF position (O) if the power contacts are all actually separated.
- In OFF position, the toggle or handle shall indicate the isolation position.

Isolation shall be provided by a double break on the main circuit.

The case-case circuit breakers shall be to receive a device for locking in the "isolated" position, with up to 3 padlocks.

The case-case circuit breakers shall be equipped with a "push to trip" button in front to test operation and the opening of the poles.

The circuit breaker rating, the "push to trip" button, outgoing circuit identification and the contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.

Current Limiting, Discrimination, Endurance

The case-case circuit breakers shall be capable of greatly limiting currents. For short-circuits, the maximum thermal stress I^2t shall be limited to:

- $10^6 \text{ A}^2 \text{ s}$ for rating up to 250 A.
- $5 \times 10^6 \text{ A}^2 \text{ s}$ for ratings between 400 A and 630 A.

The case-case circuit breakers shall comprise a device, designed to trip the circuit-breaker in the event of high-value short-circuit currents. This device shall be independent of the thermal-magnetic or electronic trip unit.

The case-case circuit breakers, the current ratings of which are identical with the ratings of their trip units, shall ensure discrimination for any fault current up to at least 35 kA rms, with any downstream circuit-breaker having a current rating less or equal to 0.4 times that of the upstream circuit-breaker.

The electrical endurance of the case-case circuit breakers, as defined by IEC 947-2 standard, shall be at least equal to 3 times the minimum required by the standard.

Auxiliaries and Accessories

It shall be possible to equip the case-case circuit breakers with a motor mechanism for electrically controlled operation. An "auto/manual" switch in front shall, when set to the "manual" position, lock out electrical control; remote indication of "manual" or "auto" mode shall be possible.

Closing shall take place in less than 80 ms.

Following tripping due to electrical faults (overload, short-circuit, earth fault), remote reset shall be inhibited.

It shall however be possible if opening was initiated by a voltage release.

The operating mechanism shall be of the stored-energy type only.

The addition of a motor mechanism or a rotary handle shall in no way affect circuit breaker characteristics:

- Only three stable tripping mechanism positions (ON, OFF and TRIPPED) shall be possible with the motor mechanism.
- Suitability for isolation shall be provided by positive contact indication (ON and OFF) in front of the motor mechanism module.

The case-case circuit breakers shall be designed to enable safe on-site installation of auxiliaries such as voltage releases (shunt and undervoltage releases) and indication switches as follows:

- They shall be separated from power circuits
- All electrical auxiliaries shall be of the snap-in type and fitted with terminal blocks
- All auxiliaries shall be common for the entire range
- Auxiliary function and terminals shall be permanently engraved on the case of the circuit breaker and the auxiliary itself.
- The addition of auxiliaries shall not increase the volume of the circuit breaker.

The addition of a motor mechanism module or a rotary handle, etc., shall not mask or block device settings.

It shall be possible to assemble earth fault protection case-case circuit breakers by adding a residual current device (RCD) directly to the circuit breaker case. The resulting device shall

- Comply with appendix B of IEC 947-2 standard
- Be immunized against nuisance tripping as per IEC 255 and IEC 801-2 to -5 standards
- Be capable of working normally down to -25 °C ambient temperature.
- Operate without and auxiliary power supply, i.e. it shall be capable of operating normally on any 2-phase or 3-phase power network with a voltage between 200 V and 440 V, and of tripping the circuit-breaker even in event of voltage dips down to 80V.

Shall have the same size.

It shall be possible to equip the case-case circuit breakers with devices indicating faults without tripping the circuit breaker.

C **Protection Functions**

General Recommendations

Case-case circuit breakers with ratings up to 160 A frame shall be equipped with of:.

- Thermal-magnetic (thermal for overload protection and magnetic for short-circuit protection).

It shall be possible to interchange thermal magnetic trip with electronic trip unit when needed for selectivity or coordination between upstream and downstream breaker electronic trip unit shall be offered at no extra cost if needed for coordination.

- Electronic.

Case-case circuit breakers with ratings equal and over 250 A shall be equipped with electronic trip units.

The trip units shall not augment overall circuit breaker volume.

Electronic trip units shall comply with appendix F of IEC 947-2 standard (measurement of rms current values, electromagnetic compatibility, etc.).

All electronic components shall withstand temperatures up to 125 °C.

Electronic and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorized access to the settings.

Protection settings shall apply to all circuit breaker poles.

Thermal-Magnetic Trip Units (Up to 150A)

Characteristics:

- Adjustable thermal protection,
- Fixed magnetic protection for current ratings up to 200 A
- Adjustable (from 5 to 10 times the current rating) for current ratings greater than 200A.

It shall be possible to ensure neutral protection. The tripping threshold shall be equal to that of the phases, or to a reduced value (generally half of that of the phases).

Electronic Trip Units

Characteristics:

Long time protection (TL)

- Selectable Ir threshold with forty-eight settings from 40 to 100% of the trip unit rating.

Short time protection (ST)

- 1m threshold shall be adjustable from 2 to 10 times the thermal setting 1r,
- The time delay shall be fixed at 40 ms,

Instantaneous protection

- The threshold shall be fixed (between 12 and 19 times In, depending on the rating)

Four-pole devices shall be equipped with a 3-position setting for neutral protection:

Neutral not protected - neutral tripping threshold equal to half the phase value - neutral threshold equal to the phase value.

Load monitoring function

The following monitoring functions shall be integral parts of electronic trip units:

LED for load indication, lighted above 95% of 1r, flashing above 105% of 1r.

A test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.

Universal Electronic Trip Units (160A and Greater)

Characteristics

Short-time protection:

- Selectable Ir threshold with thirty-two settings from 40% to 100% of the trip unit rating.
- Adjustable time delay
- The breaking threshold shall be at 1,21r and the no-breaking threshold after 2 H at 1,051r,

Short time protection (ST)

- 1m threshold shall be adjustable from 2 to 10 times the thermal setting 1r,
- The time delay shall be selectable among 3 values, with or without the constant 1²t function.

Instantaneous protection threshold adjustable from 1.5 to 11 times In.

- Four-pole devices shall be equipped with a 3-position setting for neutral protection (neutral not protected - neutral tripping threshold equal to half the phase value - neutral threshold equal to the phase value).

Thermal Memory

- In the event of repeated overloads, the electronic trip unit shall optimize protection of cables and downstream devices by memorizing temperature variations.

Load monitoring function

A load monitoring function shall be an integral part of universal trip units, indicating four load levels (60%, 75%, 90% and 105%) by LEDs, (flashing LED for 1.5%).

Options

It shall be possible to install all options for the electronic trip unit without increasing the circuit breaker volume; options include:

High-threshold earth-fault protection,

Load monitoring with adjustable threshold using a changeover switch,

LEDs in front to indicate the cause of tripping (long time, short time, instantaneous, earth fault if requested),

Data transmission via a BUS, in particular all the trip unit settings, current measurements for each phase, tripping causes, circuit breaker status.

MOTOR PROTECTION (UP TO 37kW)**A General**

Motor protection against the short-circuit shall be achieved by motor circuit-breakers of molded case type; the combination with control-command devices shall be of type-2 as defined by the IEC standards 947-4.1.

The motor circuit breakers shall comply with IEC standards 957-1 and 957-2 or with corresponding standard applicable in the member countries (VDE 0660, BS EN 60947-2, NF EN 60947-1/2):

- They shall be of category A with a rated service breaking capacity (Ics) equal to the ultimate breaking capacity (Icu).
- They shall have a rated operational voltage of 690 V AC (50/60 Hz.).
- They shall have a rated insulation voltage of 750 V AC (50/60 Hz.).
- They shall be suitable for isolation, as defined by IEC 947-2, § 7-27.

Production site organization shall be certified to comply with ISO 9002 standard.

The motor circuit breakers shall be easily installable in the motor control-command modules. For that, the size characteristics, especially the width, shall be very closed to the other motor control-command devices one's.

The motor circuit breakers shall be designed for both vertical and horizontal mounting, without any adverse effect on electrical performance. It shall be possible to supply power either from the upstream or downstream side.

The motor circuit breakers shall provide class II insulation (according to IEC 664 standard) between the front and internal power circuits.

B Construction, Operation, Environment

All the motor circuit breakers shall have the same size however the rating may be from 1,5 to 80 A.

For maximum safety, the power contacts shall be insulated in an enclosure made of a thermosetting material from other functions such as the operating mechanism, the case, the trip unit and auxiliaries.

The operating mechanism of the case-case circuit breakers shall be of the quick-make, quick-break type with fault tripping overriding manual operation. All poles shall operate simultaneously for circuit breaker opening, closing and tripping.

The molded case circuit breakers shall be actuated by a toggle or handle that clearly indicates the three positions: ON, OFF and TRIPPED.

In order to ensure suitability for isolation complying with IEC 947-2 § 7-27:

- The operating mechanism shall be designed such that the toggle or handle can only be in OFF position (O) if the power contacts are all actually separated.
- In OFF position, the toggle or handle shall indicate the isolation position.

Isolation shall be provided by a double break on the main circuit.

The case-case circuit breakers shall be to receive a device for locking in the "isolated" position, with up to 3 padlocks.

The case-case circuit breakers shall be equipped with a "push to trip" button in front to test operation and the opening of the poles.

The circuit breaker rating, the "push to trip" button, outgoing circuit identification and the contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.

The motor circuit breakers shall have a very high current limiting; the electrical endurance of the case-case circuit breakers, as defined by IEC-947-2, shall be at least equal to 5 times the minimum required by the standard.

Auxiliaries and Accessories

It shall be possible to equip the motor circuit breakers with a direct or extended rotary handle; the addition of a rotary handle shall in no way affect circuit breaker characteristics:

- Positive indication of the 3 contact positions (ON, OFF and TRIPPED).
- Suitability for isolation shall be provided even in the case of extended rotary handle.
- The addition of a rotary handle shall not mask or block device settings.

On motor circuit breakers equipped with a rotary handle, the addition of an early-break switch shall be done easily.

The motor circuit breakers shall be designed to enable safe on-site installation of auxiliaries such as voltage releases (shunt and undervoltage releases) and indication switches as follows:

- They shall be separated from power circuits

- All electrical auxiliaries shall be of the snap-in type and fitted with terminal blocks
- All auxiliaries shall be common for the entire range
- Auxiliary function and terminals shall be permanently engraved on the case of the circuit breaker and the auxiliary itself.
- The addition of auxiliaries shall not increase the volume of the circuit breaker.

C **Protection Functions**

The motor circuit breakers shall be equipped with magnetic trip unit for short-circuit protection; protection settings shall apply to circuit breaker poles.

Characteristics:

- Adjustable magnetic protection with settings from 6 to 14 times the nominal rating of the device,
- The magnetic set up button shall be equipped with an adjustable protection stop in order to allow the setting range to be reduced.

D **Combination Function**

In order to well protect the motor starters, the motor circuit breakers shall:

- Comply with type-2 co-ordination according to IEC 947-4.1 for the combination with the other control-command devices,
- Have compulsory type-2 co-ordination tables, which have been tested in laboratory;

However, the combination tables shall also indicate for each motor rating:

- The circuit-breaker type and set up characteristics,
- The contactor type,
- The thermal relay type with its setting range.

MINIATURE CIRCUIT BREAKERS (FROM 5 UP TO 100A)

A General

MCB shall comply with IEC 157-1 or IEC 947-2, BS EN 60898.

MCB shall have C curve characteristics.

MCB shall be plug-in busbar mounted type available in one, two, three or four poles version.

The breaking capacities of the MCB's shall be at least equal to the prospective fault level at the point of the distribution system where they are installed.

Cascading with upstream breaker based on different time characteristics response shall not be permitted. Only current limiting protection upstream shall be permitted.

MCB can be reverse fed without reduction in performance.

MCB shall have minimum rms symmetrical interrupting capacities equal to 9 KA.

B Construction

The operating mechanism shall be mechanically trip free from the operating handle so as to prevent the contacts from being held closed against short circuit and overload conditions. It shall be of the "automatic resetting type".

The individual operating mechanism of each pole of a multi-pole MCB shall be directly linked within the MCB casing and not by the operating handles.

The operating handle shall be of the toggle type with possibility of padlocking facility and rotary handle.

Each pole shall be provided with bi-metallic thermal element for overload protection and magnetic element for short circuit protection. Current discrimination tables shall be provided for each rating of breaker.

Terminals shall be of the tinner (IP20) in order to minimize the risk of direct contact.

EARTH LEAKAGE RELAY WITH SEPARATE SENSOR (FROM 0.03 TO 25A)**A General**

The relays shall comply with IEC 755 or corresponding standards (UTE C60 130, VDE 664, NFC 61 141).

The relays shall be protected against nuisance tripping caused by switching surges or by lightning surges (^).

The relays shall be of solid state type (mechanical type shall be not accepted).

The relays shall be able to operating in the presence of fault currents with DC components: they shall be of class A (relays sensitive to pulsed residual currents).

B Operating

Each relay shall be able to accept a wide rang of auxiliary supply voltages from 48 to 240 VAC and 48 to 300 VDC.

The relays shall be adjusted in discreet steps for sensitivity adjustment and time-delay adjustments (continuous adjustment shall be not accepted). This steps may be fully discriminated.

The sensitivity, from 0,03 A to 25 A, shall be adjustable using a 24 position fine control switch.

The time delay, from instantaneous to 1 s, shall be adjustable using an 8 position switch.

C Construction

The size of the relays shall be compact (maximum 72 mm wide).

The relays shall be suitable for mounting on symmetrical rail horizontally or vertically.

The range of associated toroidal transformer shall be of the closed type with an inside diameter of 30 to 200 mm.

The smaller sizes of toroids (< 50 mm) may be installed directly on the relay.

D Safety

The relays shall be equipped with one changeover output contact:

A continuity of measurement circuit shall be provided to monitor that the toroid circuit is not open circuit.

EARTH LEAKAGE RELAY WITH SEPARATE SENSOR (FROM 0.03 TO 250A)**A General**

The relays shall comply with IEC 755 or corresponding standards (UTE C60 130, VDE 664, NFC 61 141).

The relays shall be protected against nuisance tripping caused by switching surges or by lightning surges (^).

The relays shall be of solid state type (mechanical type shall be not accepted).

The relays shall be able to operating in the presence of fault currents with DC components: they shall be of class A (relays sensitive to pulsed residual currents).

The relays shall be equipped with a pre-alarm setting; this pre-alarm setting value shall be equal to half the alarm setting value.

B Operating

The different ratings in a given range may be obtained without changing the type of sensor.

The relays shall be adjusted in discreet steps for sensitivity adjustment and time-delay adjustments (continuous adjustment shall be not accepted). This steps may be fully discriminated.

The sensitivity, from 0,03 A to 25 A, shall be adjustable using a 24 position fine control switch.

The time delay, from instantaneous to 1 s, shall be adjustable using an 8 position switch.

The relays shall be equipped with a pre-alarm setting; this pre-alarm setting value shall be equal of half the alarm setting value.

C Construction

The size of the relays shall be compact (maximum 72 mm wide).

The relays shall be suitable for mounting on symmetrical DIN rail horizontally or vertically.

The range of associated toroidal transformer shall be of the closed type with an inside diameter of 30 to 300 mm an open toroidal transformer range shall be available.

The smaller sizes of toroids (< 50 mm) may be installed directly on the relay.

D Safety

The relays shall be equipped with:

- One changeover fail safe output contact without latching for the pre-alarm setting.
- One changeover normal output contact with or without latching for the alarm setting.

A continuity of measurement circuit should be provided to conform o break on the current transformer relay link.

The relays shall be equipped with local indication using LED's:
Green = power supply; red = pre-alarm; red = alarm.

- A. Enclosure Finish for Outdoor Units: Factory-applied finish in manufacturer's standard color, undersurfaces treated with corrosion-resistant undercoating.
- B. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- C. Barriers: Between adjacent switchboard sections.
- D. Insulation and isolation for (main bus of main section and) main and vertical buses of feeder sections.
- E. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 - 1. Space-Heater Control: (Thermostats to maintain temperature of each section above expected dew point)(Manual switching of branch-circuit protective device).
 - 2. Space-Heater Power Source: (Transformer, factory installed in switchboard)(120-V external branch circuit).
- F. Utility Metering Compartment: Fabricated compartment and section complying with utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
- G. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- H. Removable, Hinged Rear Doors and Compartment Covers: Secured by for access to rear interior of switchboard.
- I. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- J. Pull Box on Top of switchboard:

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1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 2. Set back from front to clear circuit-breaker removal mechanism.
 3. Removable covers shall form top, front and sides. Top covers at rear shall be easily removable for drilling and cutting.
 4. Bottom shall be insulating, fire resistive material with separate holes for cable drops into switchboard.
 5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- K. Buses and Connections: Three phase, four wire, unless otherwise indicated.
1. Phase-and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections.
 2. Phase – and Neutral –Bus material: Tin-plated, high-strength, electrical-grade aluminum alloy with copper-or tin-plated, aluminium circuit-breaker line connections.
 3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminium alloy.
 - a. If bus is aluminium, use copper –or tin-plated aluminium for circuit-breaker line connections.
 - b. If bus is copper, use copper for feeder circuit-breaker line connections.
 4. Load Terminals: insulated, rigidly braced, silver-plated, copper runback bus extensions equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions.
 5. Ground bus: ¼ by-2-inch – (6-by-50mm) minimum size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 6. Contact surfaces of buses: Silver plated.
 7. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard’s main and distribution sections. Provide for future extensions form both ends.
 8. Isolation Barrier Access Provisions: Permit Checking of bus-bolt tightness.
 9. Neutral Buses:100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.

10. Neutral Buses: 100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extension for busway feeder neutral bus are braced.

- L. Future Devices: Equip Compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- M. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating: 105 deg. C.

2.11 INSTRUMENTATION:

- A. Instrument Transformers:
 1. Potential Transformers: Secondary voltage rating of 220 V and accuracy class of 0.3 with burdens of W, X and Y as per NEMA.
 2. Current transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3KV.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary to ground over current relays, meters, and instruments.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three –or four-wire systems and with the following features:
 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltage, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
 - i. Accumulated Energy, Megawatt hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.
 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

- C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
 - 1. Meters: 4 inch (100-mm) diameter or 6 inches (150 inch) square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment
 - 2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent
- D. Instrument Switches: Rotary type with off position.
 - 1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
 - 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
- D. Feeder Ammeters: 2-1/2-inch- (64-mm-) minimum size with 90- or 120-degree scale. Meter and transfer device with an off position
- E. Watt-Hour Meters: Flush or semiflush type, rated 5 A, 120 V, 3 phase, 3 wire, with 3 elements, 15- minute-indicating-demand register, and provision for testing and adding pulse initiation.
- F. Recording Demand Meter: Usable as totalizing relay or as indicating and recording maximum-demand meter with IS-minute interval. Meter shall count and control a succession of pulses entering two channels. House in drawout, back-connected case arranged for semiflush mounting.

2.12 CONTROL POWER:

- A. Control Circuits: 220 V, supplied through secondary disconnecting devices from control-power transformer.
- B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 220- V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
- C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for 6mm.sq and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.13 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

- B. Furnish portable test set to test functions of solid-state trip devices without removal from switchboard Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Furnish one portable, floor-supported, roller-based. elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Furnish overhead circuit-breaker lifting device, mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
- E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet Arrange for wall mounting.
- F. Fungus Proofing: Permanent fungicidal treatment for switchboard interior, including instruments and instrument transformers.

2.14 IDENTIFICATION

- A. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- B. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

PART 3 – EXECUTION:

3.1 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.2 EXAMINATION

- A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

- A. Install and anchor switchboards level on concrete bases, 4-inch (100-mm) nominal thickness. Concrete base is specified in Division 16 Section "Electrical Supports and Seismic Restraints," and concrete materials and installation requirements are specified in Division 3.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 2. For switchboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to switchboards.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- C. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- D. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation. 1. Set field-adjustable switches and circuit-breaker trip ranges. F. Install spare-fuse cabinet.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."
- B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit
 2. Test continuity of each circuit
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in IEC 439-1 as appropriate. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments, Equipment, and Reports:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2) Prepare a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 CLEANING

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

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories. Refer to Division 1 Section "Demonstration and Training. "

END OF SECTION

SECTION 016442 - PANEL BOARDS

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 the following:

1. Distribution panel boards (DP) and Power Panel board (PP).
2. Lighting and appliance branch-circuit panel boards (LP).
3. Motor Starter Panel (MSP)
4. Pump control panel (PCP)

1.3 SUBMITTALS

- A. Product Data: For each type of panel board, over current protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panel board and related equipment.
1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of switchboards and over current protective devices.
 - d. UL listing and/or IEC Standard for series rating of installed devices.
 - e. Features, characteristics, ratings, and factory settings of individual over current protective devices and auxiliary components.
 2. Wiring Diagrams: Power, signal and control wiring.
 3. Full selectivity characteristic curves of upstream / down stream breakers.
- C. Field quality –control test reports including the following:
1. Test procedures used.
 2. Test results that comply with requirements.

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3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Operation and Maintenance Data: for panel boards and components to include in emergency, operation, and maintenance manuals.
1. Manufacturer's written instructions for testing and adjusting over current protective devices.
 2. Time-current curves, including selectable ranges for each type of over current protective device.
- E. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated.
- F. Source Limitations: Obtain panel boards, over current protective devices, components and accessories through one source from a single manufacturer.
- G. Product Options: Drawings indicate size, profiles, and dimensional requirements of panel boards and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements".
- H. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, or as per relevant IEC specifications by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 PROJECT CONDITIONS

- A. Environmental limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
1. Ambient Temperature: Not exceeding (40 deg C).
 2. Altitude: Sea Level
- B. Thermal study and heat dissipation study with calculations of all components with guarantee that all necessary ventilation means are provided to ensure that breakers and all components are rated and operating as per design selected rating.

1.5 COORDINATION

- A. Coordinate layout and installation of panel board and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping and encumbrances to workspace clearance requirements.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

1.6 EXTRA MATERIALS

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

1. Keys: six spares for each type of panel board cabinet lock.

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:
1. Panel boards, over current Protective Devices, Controllers, Contactors, and Accessories.
 - a. Schneider.
 - b. Hager.
 - c. Siemens
 - d. Square D.
 - e. Moeller Germany
 - f. Legrand

2.2 MANUFACTURED UNITS:

- A. Locally manufactured panelboard shall not be accepted for LP type panel except for panel makers operating under official license delivered by approved manufacturer.
- B. Enclosures: Flush or Surface (as shown on plans) mounted cabinets.
1. Rated for environmental conditions at installed location.
 - a. Outdoor Locations: IP55.
 - b. Kitchen Areas: IP41.
 - c. Other Wet or Damp Indoor Locations: IP44.
 - d. Indoor areas: IP40.

2.3 DISTRIBUTION AND POWER PANELBOARDS

2.3.1 GENERAL

The contractor shall supply and install the distribution and power panelboards (DP, PP) as indicated on the panelboards schematics and as shown on the drawings and of cubicle type.

Power and Distribution panelboards shall be equipped with thermal magnetic molded case circuit breakers of frame and trip ratings as shown on the drawings.

Branch breakers of UPS power panels (PP-UPS) shall be miniature type (MCB).

Panelboards bus structure and main breaker shall have current ratings as shown in the panelboards schematics.

Panelboards shall have 400 volt duty rating and shall have short circuit current interrupting capacity equal to or greater than the integrated equipment rating shown on the drawings.

Short circuit tests on the overcurrent devices and on the panelboard structure shall be made simultaneously.

Panelboards shall conform to BS EN 60439 Part 2 and IEC 60439, form 2b.

Panelboards circuit numbering shall be such that, starting at the top, odd numbers shall be used in sequence down the left-hand side and even numbers shall be used in sequence down the right-hand side.

Panelboards of main breaker rating 250 A and below shall have a maximum width of 60 cm.

Over voltage protection at feeder entry point shall be coordinated with protection provided upstream in main switchboard feeding distribution panelboard.

Instruments (3 ammeters, one voltmeter, one volt meter selector switch) shall be fully digital 3 pilot lights shall be installed in power and distribution panelboards (DP and PP).

Only local supplier operating under license of an approved type tested European/North American suppliers shall be approved.

Only equipment manufactured in country of origin indicated between brackets shall be approved. Products belonging to approved brand but manufactured in other countries than country of origin indicated above are rejected.

2.3.2 CABINETS AND FRONTS

Panelboard assembly shall be enclosed in a electrozincated sheet steel cabinet. Cabinet shall be of sufficient size to provide a minimum gutter space of 10 cm on all sides. The thickness of the sheet steel shall be minimum 2 mm.

All covers will be equipped with handle.

Fronts shall include doors and have flush, brushed stainless steel cylinder tumbler - type locks with catches and spring loaded door pulls. The flush lock shall not protrude beyond the front of the adjustable indicating trim clamps which shall be completely concealed when the doors are closed. Fronts shall have approved directories with name of panel, number of phases, wires and voltage written on them. Doors shall be mounted by completely concealed steel hinges. Fronts shall not be removable with door in the locked position. A circuit directory card shall provide a space of at least 0.5cm high x 7cm long or equivalent for each circuit.

In addition to covers, detachable panels, of Plexiglas shall be provided to avoid accidental contact with the busbars on the opening of the door and the removing of the metal cover.

The directory shall be typed to identify the load fed by each circuit. Each incoming and outgoing will have an engraved label that will be placed on covers inside the enclosure.

Fronts shall be of code gauge, full finished steel with rust-inhibiting primer and baked enamel finish. Color shall be gray to RAL 7032.

Joints shall be welded, galvanized and reinforced where necessary and galvanized after fabrication.

2.3.3 PANELBOARD BUS ASSEMBLY

Bus for connections to the branch circuit breakers shall be the "Distributed Phase" or "Phase Sequence" Type.

Connection between busbars and breakers shall be made with rigid busbars only.

Three-phase, four-wire bussing shall be such that any three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two or three pole breakers can be installed at any location. All current carrying parts of the bus assembly shall be plated.

Main and neutral buses shall be minimum 98% conductivity rectangular copper bars, provided with bolted-type lugs as necessary.

Buses shall be rigidly supported and insulated and be so designed that branch circuits can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping.

Necessary bussing, drilling and blank plates shall be provided for installation of future circuits when so indicated in the Schedules on the Drawings.

All screws and bolts used for making copper connections shall be equipped with lock washers. Reverted connections will not be acceptable.

Mains shall be equipped with solderless pressure indent type connectors and have means to prevent swiveling of connector.

Neutral busbars shall be full size and shall incorporate one neutral terminal for each single pole and neutral way.

Aluminum shall not be used for any interior panelboard parts.

Back pan or mounting on which buses and branches are mounted shall be rigid to properly support the component parts.

Reinforcing of back pan shall be by flanging or addition of angle iron.

2.3.4 EARTHING

An acceptable terminal bar for equipment earthing conductors shall be provided with minimum number of cable terminations equal to the single pole number of ways of the panelboard.

Cabinets shall be provided with an earth connector welded to it.

2.3.5 MOLDED CIRCUIT BREAKERS

Molded case circuit breakers shall be as specified under "CIRCUIT BREAKERS" have trip settings, and number of poles, as indicated on the Drawings. All circuit breakers shall have their ampere trip rating clearly marked and visible. Rated insulation voltage shall be 750V. Rated impulse withstand voltage shall be 8 KV.

The main circuit breaker shall be Molded Case type Fixed, Manually or motor operated as indicated on the drawings, 3 poles with the following features:

ICS = 40 kA.

1 auxiliary contacts – ON/OFF signaling status.

1 Alarm auxiliary contacts

The branch circuit breakers shall be Molded Case type Fixed, Manually or motor operated as indicated on the drawings, 3 pole with ICU = 35kA.

The main incoming shall be Molded Case type Fixed & manually operated, 3 poles with rotary handle interlocked with the door. It will include the following features:

ICS = 40kA.

- 1 auxiliary contacts - ON/OFF signaling status
- 1 Alarm auxiliary contacts

2.3.6 PANELBOARD INSTALLATION

Panelboard shall be aligned, leveled and securely fastened to the building.

Connecting conduits shall not be used to support the panelboard.

All unused openings in panelboard cabinets shall be properly closed.

Panelboard interiors shall not be installed in cabinets until all conduit connections to the cabinet have been completed.

Trim shall be installed plumb and square to finish painting.

Trim for flush mounted cabinets shall be installed in plaster frame, flush with finished wall.

Concealed surfaces of cabinets shall be given on site a heavy application of emulsified asphalt prior to installation.

Free standing panelboards when installed in electrical close, or rooms with depressed floors shall be provided with galvanized steel support structures to raise the level of the panel to 10 cm above the original floor level.

2.3.7 EARTHING

An acceptable terminal bar for equipment earthing conductors shall be provided with a minimum number of cable terminations equal to the single pole number of ways of the panelboard.

Cabinet shall be provided with a earth connector welded to it.

2.3.8 PANEL BOARD SHORT-CIRCUIT RATING

Fully rated to interrupt symmetrical short-circuits current available at terminals, based on short circuit calculations findings to be submitted by contractor. If required short circuit interrupting capacity is larger than calculated one, on vice versa, the larger figure shall be used.

2.4 LIGHTING PANELBOARD

2.4.1 GENERAL

The contractor shall supply and install the lighting panelboards (LP, ELP) as indicated in the panelboards schedules and as shown on the drawings.

LOCALLY MANUFACTURED LIGHTING PANELBOARD ARE STRICTLY PROHIBITED.

Lighting panelboards shall be equipped with main MCB with residual current device and branch thermal magnetic miniature type circuit and residual current device of trip ratings as shown on the drawings.

Panelboard bus structure and main switch shall have current ratings as shown in the panelboards schedules.

Only panelboards with comb busbar that are 100% manufactured and assembled (with certificate of origin duly submitted by supplier) in France or Germany may be considered but the Engineer will have full authority to reject them with any justification.

Panelboards without copper busbar are not recommended.

Panelboards shall have 400 volt duty rating.

Panelboards circuit numbering shall be such that, starting at the top, odd numbers shall be used in sequence down the left-hand side and even numbers shall be used in sequence down the right-hand side.

Panelboards and protective devices shall be manufactured by General Electric (USA) Square D (U.K), Siemens (Germany), Moeller (German), Legrand (France) and Merlin Gerin (France), Hager (France) or approved equal.

Only equipment manufactured in country of origin indicated between brackets shall be approved. Products belonging to approved brand but manufactured in other countries than country of origin indicated above are rejected.

2.4.2 RESIDUAL CURRENT DEVICE

Residual current device (RCD) shall be current operated type with non adjustable low level earth faults sensitivity of 300 mA, 100mA or 30mA as indicated.

It shall fit in standard lighting panelboards.

A push-to-test mechanism shall be provided to ensure proper operation.

Enclosure shall be glass reinforced.

RCD shall have 9000A interrupting capacity or shall be protected upstream with a 9000 A Breaking capacity device.

RCD shall comply with BS EN 61008-1 or IEE 27.

2.4.3 **EARTHING**

An acceptable terminal bar for equipment earthing conductors shall be provided with minimum number of cable terminations equal to the single pole number of ways of the panelboard.

Cabinets shall be provided with an earth connector welded to it.

2.4.4 **CABINETS AND FRONTS**

Panelboard assembly shall be enclosed in a electrozincated cabinet. Panelboards shall conform to BS EN 60439-3:1991 Part 13 1979 and IEC 439.

Cabinets shall be of sufficient size to provide a minimum gutter space of 10cm on all sides. The thickness of the sheet steel shall be minimum 1.5 mm.

Fronts shall include doors and have flush, brushed stainless steel cylinder tumbler-type locks with catches and spring loaded door pulls. The flush lock shall not protrude beyond the front of the adjustable indicating trim clamps which shall be completely concealed when the doors are closed. Fronts shall have approved directories with name of panel, number of phases, wires and voltage written on them.

Doors shall be mounted by completely concealed steel hinges. Fronts shall not be removable with door in the locked position. A circuit directory card shall provide a space of at least 0.5 cm high x 7 cm long or equivalent for each circuit.

The directory shall be typed to identify the load fed by each circuit.

Fronts shall be of code gauge, full finished steel with rustinhibiting primer and baked enamel finish. Color shall be RAL 7032.

Joints shall be welded, galvanized and reinforced where necessary and galvanized after fabrication.

2.4.5 **PANELBOARD BUS ASSEMBLY**

Bus for connections to the branch circuit breakers shall be the "Distributed Phase" or "Phase Sequence" Type.

Three-phase, four-wire bussing shall be such that any three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two or three pole breakers can be installed at any location. All current carrying parts of the bus assembly shall be plated.

Main and neutral buses shall be minimum 98% conductivity rectangular copper bars, provided with bolted-type lugs as necessary.

Buses of lighting panelboards shall be suitably braced for a minimum short circuit duty equal to 9000 A unless otherwise indicated.

Bus shall be rigidly supported and insulated and be so designed that branch circuits can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping.

Necessary bussing, drilling and blank plates shall be provided for installation of future circuits when so indicated in the Schedules on the Drawings.

All screws and bolts used for making copper connections shall be equipped with lock washers. Riveted connections will not be acceptable.

Mains shall be equipped with solderless pressure indent type connectors and have means to prevent swiveling of connector.

Neutral busbars shall be full size and shall incorporate one neutral terminal for each single pole and neutral way.

Aluminium shall not be used for any interior panelboard parts.

Back pan or mounting on which buses and branches are mounted shall be rigid to properly support the component parts.

Reinforcing of back pan shall be by flanging or addition of angle iron.

Buses, connectors, and terminals shall be silver plated to a minimum thickness of 0.1 mm.

2.5 MOTOR STARTER PANEL

2.5.1 GENERAL

The Contractor shall supply and install the motor starter panel (indicated MSP) of the modular type as indicated in the Schedules, where shown on the Drawings and as herein specified. They shall include bus assembly, cabinet and front, molded case circuit breakers, motor starters, and all necessary parts to install complete unit.

All conditions and stipulations for switchboard manufacturers shall apply to MSP local assembler (16441 parag. 1.4.1G and 2.04).

Miniature circuit breakers with minimum 9 KA RMS short circuit interrupting capacity shall be used only as branch breakers when so indicated on drawings and or Bills of Quantities.

Motor starter panel shall be as in accordance with international standards IEC 439, EN 60439, SB section 13, VDE, BS. Tested and approved by acknowledged test laboratories.

Maximum main breaker, or incomer size shall not exceed 250 Amperes.

2.5.2 CABINET

Motor starter panel shall be similar to IEC Form 2b.

Motor starter panel assembly shall be enclosed in cabinet of high quality steel which gives cathodic protection and long durability. Surface treated doors and covers shall be produced of phosphated high-quality steel-plates.

The finish painting consists of epoxy powder with a high coloring-body density, laid on with an electrostatic process which combines durability and high quality.

Cabinet interior structure and branch devices shall be so designed that the completely assembled MSP can be related before wiring. Cabinets shall be wall mounted, and with separation barrier as per form 2 according to IEC 439-1 (1992).

Cabinets shall be equipped with a three-piece front with doors one for the main breaker and one for starters.

Cabinets shall be IP 50.

2.5.3 BUSSING ASSEMBLY

Line side bussing from the main incoming feeder terminals to all branch circuit breakers and circuit breaker disconnects shall be made without the use of cable.

Busbars shall be made of copper.

Busbars shall be placed in an independent compartment located at the rear of the board.

Busbars shall be vertical arrangement, it shall be used for currents up to 225A. Connections shall be carried out with plugs which can sustain maximum 32 Amp.

Busbars short circuit capacity shall be 16 KA RMS.

Insulation materials shall have self-extinguishing index UL94-40.

2.5.4 MOTOR STARTERS, CIRCUIT BREAKER DISCONNECTS AND BRANCH CIRCUIT BREAKERS

Circuit breakers shall be MCCB bolt-on type for motors **equal to and** larger than 15 hp. and shall be equipped with individually insulated, braced and protected line side connectors. All multiple pole breakers shall be common trip. Provisions for future breakers shall be such that no additional electrical connectors or other mounting hardware will be required to add breakers.

Breakers shall be as specified under circuit breakers.

Circuit breakers shall be miniature MCB type for motors rated below 15 hp.

Unit doors covering circuit breakers and motor starters shall be dual interlocked to prevent unauthorized opening with disconnect handle in the ON position, and to prevent unauthorized moving of the disconnect handle to the ON position with unit door open. Disconnect handles shall be trip indicating by assuming a position midway between ON and OFF. Disconnect handles shall have provisions for a minimum of three padlocks in the OFF position.

Each unit door shall include a starter reset mechanism and additional control devices located inside panel and as specified on the plans.

Motor starters shall be across-the-line magnetic type rated in accordance with NEMA/IEC Standards, sizes and horsepower ratings for motors 15 hp and smaller. Starter contacts shall be double-break silver alloy type and shall be replaceable removing the starter from its mounting. Starter coils shall be replaceable from the front without removing the starter from its mounting. Overload relays shall be melting alloy type. Thermal units shall be one-piece construction and interchangeable. Thermal units must be in place to operate starter.

Motor starters shall be star-delta type or auto transformer type for motors larger than 15 hp.

Soft starters shall be quoted as alternative for all motors larger than 15 hp.

2.5.5 SERVICE CONDITIONS FOR STARTERS

Utilization category AC-3 according to IEC 947-4-1.

2.5.6 FEATURES

The following features must be added in the Motor Starter Panel:

- 1 Hand-off-Auto selector switch per fan.
- Control transformer including single secondary fuse within same starter enclose.
- Control circuit fuse (type Legrand).
- Auxiliary contacts and relays for remote control and interface with BMS.

2.5.7 LABELING

Components of each module shall have individual printed label identifying size, voltage, ampere rating, etc. Starter wiring diagram and overload thermal cutout device installation instruction shall be attached to each starter door.

2.5.8 INTERCABLING

It shall be completely done in factory for all cabling within the Panel.

2.5.9 TERMINAL BLOCKS

Terminal blocks shall be installed and internally connected by the manufacturer, for all internal and external wire number. Each terminal point shall have a large marking area or to be equipped with two marking areas.

In addition, with each group of terminals per unit, a minimum of 20% unconnected extra non-load terminals, but not less than one, shall be provided for the Contractor's external connections.

2.5.10 OPERATING HANDLE

It shall be interlocked with cover to prevent opening of cover while handle is in the "ON" position. The handle must be moved to "OPEN COVER" position for door opening.

This operation needs a door, with cover we cannot make it.

2.6 PUMP CONTROL PANEL

2.6.1 GENERAL:

The Contractor shall supply and install the pump control panel modular type (indicated PCP, EPCP) as indicated in the Schedules, where shown on the Drawings and as herein specified. They shall include bus assembly, cabinet and front, molded case circuit breakers, motor starters, and all necessary parts to install complete unit.

Pump control panel shall be as manufactured by General Electric (USA), Duplex Motor Controller as Manufactured by Square D (USA), Allen Bradley (USA), Cutler Hammer (USA), or approved equal.

Arrangement shall be similar to IEC 439-1 form 2b (1992).

2.6.2 CIRCUIT BREAKERS

Circuit breakers shall be molded case bolt-on for motors equal and larger than 15 hp and miniature type for motors smaller than 15 hp shall be as specified for under "CIRCUIT BREAKERS".

2.6.3 STARTERS

Starters shall incorporate contactors made of a glass polyester case with silver cadmium oxide alloy contacts, molded coils, stainless steel kickout springs, U-type magnet and a shock absorber baseplate. Overload relays shall be three-pole, inverse and ambient compensated type.

2.6.4 CONTROL AND MISCELLANEOUS DEVICES

Control relays shall be the heavy duty, industrial or machine tool type with at least two normally closed and two normally open spare contacts. Relays shall be rated NEMA designation A600 or N600, as required.

Control Power Transformer shall be provided as applicable to limit the control voltage to 220 volts, and to eliminate the need for phase-to neutral voltage. It shall be 2- winding, dry type and of suitable VA rating but not less than 75 volt-amperes.

Automatic Alternator, if any, shall control the operation of two separately enclosed motor starters so that they operate alternately at successive closing of a single pressure or float switch (to equalize equipment wear). The second float or pressure switch is set to start the idle pump in case one pump will not handle the load. Both pumps then working to handle the demand.

Pushbuttons shall be heavy duty, oil tight type with removable contact blocks. Contact ratings shall be 10- ampere continuous current. Pushbuttons shall be provided with chrome-plated metal or anodized aluminum mounting rings.

Selector switches shall be heavy-duty oil tight type with removable contact blocks and bat type lever operators. Contact ratings shall be 10 ampere, continuous current. Selectors shall be provided with chrome-plated metal or anodized aluminum mounting rings.

Indicating lights shall be heavy-duty, oil tight type with glass lenses. Lights shall be equipped with reduced voltage transformers and 6-volt lamps. Indicating lights shall be provided with chrome-plated metal or anodized aluminum mounting rings.

Extra secondary contacts for one or more remote controls terminal wiring blocks, etc. shall be provided as required.

All devices shall be suitable for operating at 220 volts, 50 Hz when connected between phase and neutral.

2.6.5 LABELING

Components of each module shall have individual printed label identifying size, voltage, ampere rating, etc. Starter wiring diagram and overload thermal cutout device installation instruction shall be attached to each starter door.

2.6.6 INTERCABLING

It shall be completely done in factory for all cabling within the Panel.

2.6.7 TERMINAL BLOCKS

Terminal blocks shall be installed and internally connected by the manufacturer, for all internal and external wire number. Each terminal point shall have a large marking area or to be equipped with two marking areas.

In addition, with each group of terminals per unit, a minimum of 20% unconnected extra non-load terminals, but not less than one, shall be provided for the Contractor's external connections.

2.6.8 OPERATING HANDLE

It shall be interlocked with cover to prevent opening of cover while handle is in the "ON" position. The handle must be moved to "OPEN COVER" position for door opening.

2.7 MISCELLANEOUS LIGHTING EQUIPMENT/SHEDDING CONTRACTOR

2.7.1 GENERAL

The Contractor shall supply and install the following miscellaneous lighting equipment.

2.7.2 SHEDDING CONTACTOR/LIGHTING CONTACTOR

Lighting contractor and shedding contactor shall have totally enclosed silver alloy double break power contacts capable of continuously carrying, making and breaking any load within the rating of the contactor without the assistance of auxiliary arcing contacts. Auxiliary arcing contacts are not acceptable. All contacts shall be removable without disturbing line or load wiring.

Coils shall be a.c. operated.

Shedding contactors mounted individually shall be provided with dustproof enclosures, and those mounted in control panels shall be suitable for the purpose.

Contactors shall be factory calibrated, ambient temperature compensated and sealed.

Shedding contactor with time delay service shall have an adjustable time time-delay relay ranging from 60 to 300 seconds.

The magnet and contact movement shall be horizontal. The contacts shall be double break, butt type and each moving contact shall be individually spring loaded.

All fixed and moving contacts shall be of silver cadmium oxide.

The contactor coils shall be wound on molded formers and shall be vacuum impregnated.

Contactors shall comply with:

- IEC 947-1.
- IEC 158-1.
- VDE 0660.
- NFC – 63110.

Contactors shall be rated for 600 volts duty contactors shall be suitable for:

- 10 million mechanical switching operation.
- 600 operations per hour.

Contactors shall be equipped with all necessary auxiliary contacts for interface with Building Management System.

Shedding contactors shall be electrically held type unless otherwise indicated on the drawings and shall be as manufactured General Electric (USA), Telemecanique (France) or approved equal.

2.7.3 PHOTOELECTRIC CELL

It is a detector which reads and translates the intensity of light in terms of switching on and off. It shall be made of cadmium sulphide cell which is a semi-conductor device whose electrical resistance varies with the intensity of light falling on it.

A snap-action single pole switch shall be controlled by the current passing through the cell. A heater mounted on a bimetal strip shall be connected in series with the cell and the two components shall be connected to a power source. Variation in the resistance of the cell due to changes in day light intensity varies the heating effect on the bimetal strip and by careful calibration the switch-on point will be selected.

The cell shall be encased in an impact resistant translucent cover to protect it from damage and ultraviolet rays. The photoelectric cell shall be completely weatherproof and not effected by moisture, vibration or changes in temperature.

Photoelectric cell shall be manufactured by MK, Royce Thompson Electric Limited or approved equal.

2.7.4 MOVEMENT DETECTOR FOR LIGHTING CONTROL

The movement detector shall be suitable for ceiling surface mounting and shall be rated for 10 Amp. 220-V-50Hz.

It shall be equipped with an optical lens which perceives the heat radiated by human body and will be equipped by in ultrasonic sensor.

The infrared pattern of detection shall be 15 m x 12 m and the microwaves pattern of detection shall be adjustable from 1.2 m to 23 m.

Output contacts shall be coordinated to be suitable with corresponding lighting contactor.

2.7.5 TIMER SWITCHES

Timer switches shall be 16-amp rated, one pole, one throw with switching device and 120 minute dial, recess mounted, Switches shall have 20,000 switching cycles guaranteed life.

PART 3-EXECUTION

- A. Install panel boards and accessories according to IEC 60364 and NEMA PB1.1.
- B. Mount top of trim 74 inches (J880 mm) above finished floor, unless otherwise indicated.
- C. Mount plumb and rigid without distortion of box. Mount recessed panel boards with fronts uniformly flush with wall finish.
- D. Install over current protective devices and controllers.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- E. Install filler plates in unused spaces.
- F. Stub four 1-inch (27-GRC) empty conduits from panel board into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."
- B. Create a directory to indicate installed circuit loads after balancing panel board loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panel board Nameplates: Label each panel board with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS:

- A. Ground equipment according to Division 16 Section "Earthing and Bonding."
- B. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each panel board bus, component, connecting supply, feeder and control circuit
 - 2. Test continuity of each circuit
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports.
 - 1. Perform each electrical test and visual and mechanical inspection stated in IEC switches and for molded-case circuit breakers. Certify compliance with test parameters,
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- E. Load Balancing: After Substantial Completion~ but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panel board, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

- F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panel board. Remove panel fronts so joints and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panel board 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect, significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies panel boards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 CLEANING

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

END OF SECTION

SECTION 16443 – MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes motor-control centers for use on ac circuits rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 16 Section "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.
 - 2. Division 16 Section "Transient Voltage Suppression" for low-voltage power, control, and communication surge suppressors.

1.3 SUBMITTALS

- A. Product Data: For each type of controller and each type of motor-control center. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each motor-control center.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current ratings of buses and installed units.
 - d. Vertical and horizontal bus capacities.
 - e. UL listing for series tripping of over current protective devices in combination controllers.
 - f. Features, characteristics, ratings, and factory settings of each motor-control center unit.
 - 2. Wiring Diagrams: Power, signal, and control wiring for class and type of motor-control center. Provide schematic wiring diagram for each type of controller.

-
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around motor-control centers where pipe and ducts are prohibited. Show motor-control center layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Qualification Data: for manufacturer
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For motor-control centers, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data", include the following:
1. Routine maintenance requirements for motor-control centers and all installed components.
 2. Manufacturer's written instructions for testing and adjusting over current protective devices.
- G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 30Km of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association (Kema, TUV, Veritas etc.), and that is acceptable to authorities having jurisdiction.

The MCC shall be TTA assemblies form 4A cellular and withdrawable starter assemblies type of construction

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or Libnor, or one of the National Engineering Control Audit Institute for Certification in Safety Engineering Technologies to supervise on-site testing specified in Part 3.

- C. Source Limitations: Obtain motor-control centers and controllers of a single type through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70.
- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor-control centers, including clearances between motor-control centers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.
- G. **All conditions / stipulations for switchboard manufacturers shall apply to MCC local assemblies (1644 parag. 1.4.1 G and 2.04)**

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver motor-control centers in shipping splits of lengths that can be moved past obstructions in delivery-path as indicated.
- B. Handle motor-control centers according to the following:
 - 1. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."
 - 2. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Owner no fewer than three.
days in advance of proposed interruption of electrical service.
 - 2. Indicate method of providing temporary electrical service.
 - 3. Do not proceed with interruption of electrical service without Owner's written permission.

1.7 COORDINATION

- A. Coordinate layout and installation of motor-control centers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place" Concrete."
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."
- D. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- E. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
 - 2. Indicating Lights: Two of each type installed.

PART 2 – PRODUCTS**2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
 - 2. Telemecanique
 - 3. Eaton Corporation; Moeller
 - 4. General Electric Company; GE Industrial Systems.
 - 5. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
 - 6. Siemens/ Controls.
 - 7. Square D.
 - 8. Schneider

2.2 MOTOR-CONTROL CENTERS

- A. Wiring: NEMA ICS 3.
- B. Enclosures: Surface-mounting cabinets as indicated IP54 or NEMA approved equivalent, unless otherwise indicated to comply with environmental conditions at installed location.
 - 1. Outdoor Locations: IP or NEMA approved equivalent.
 - 2. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
 - 3. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in motor-control center; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
 - 4. Wiring Spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.
- C. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location.

2.3 BUSES

- A. Material: Plated hard-drawn copper, 98 percent conductivity.
- B. Ampacity Ratings: As indicated for horizontal and vertical main buses.
- C. Neutral Buses: Full size unless otherwise indicated.
- D. Equipment Ground Bus: Non insulated, horizontal configuration; adequate for equipment ground conductors; bonded to enclosure.
- E. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or equivalent.
- F. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.

2.4 FUNCTIONAL FEATURES

- A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments indicating panels, blank panels, and other items mounted in compartments of motor-control center.
- B. Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.
 - 1. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized position.
 - 2. Provide units with short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.
 - 3. Equip units in Type B and Type C motor-control centers with pull-apart terminal strips or draw out terminal boards for external control connections.
 - 4. Controller Disconnecting Means: Factory-assembled combination disconnect and controller.
 - a. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to DEC 947-4-1, as certified by an NRTL.
 - b. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
 - c. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- C. Over current Protective Devices: Individual feeder-tap units through 225-A rating shall have draw out mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
- D. Transient Voltage Surge Suppressors: Connect to motor-control center bus.
- E. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of draw out units.
- F. Spare Units: Type, sizes, and ratings indicated; installed in compartments indicated "spare."

2.5 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Elapsed Time Meters: Heavy duty with digital readout in hours.
- F. Meters: Panel type. 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
 - 1. Ammeter: Output current with current sensors rated to suit application.
 - 2. Voltmeter: Output voltage.
 - 3. Frequency Meter: Output frequency.
- G. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - 1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2. Switch-selectable digital display of the following:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Three-Phase Real Power: Plus or minus 2 percent
 - e. Three-Phase Reactive Power: Plus or minus 2 percent
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent
 - i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - 3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

- H. Phase-Failure and Under voltage Relays for Bypass Controllers: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable under voltage setting.
- I. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hardwired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent or loss of supply voltage; with adjustable response delay.
- J. Spare-Fuse Cabinet: Identified cabinet with hinged lockable door.

2.6 FACTORY FINISHES

- A. Finish: Manufacturer's standard grey paint applied to factory-assembled and -tested, motor-control centers before shipping.

PART 3-EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive motor-control centers for compliance with requirements, installation tolerances, and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilotdevice and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

- A. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.
- B. Install motor-control centers on concrete bases.
- C. Comply with mounting and anchoring requirements specified in Division 16 Section "Electrical Supports and Seismic Restraints."

3.4 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

- B. Concrete materials and installation requirements are specified in Division 3.

3.5 IDENTIFICATION

- A. Identify motor-control center, motor-control center components, and control wiring according to Division 16 Section "Electrical Identification."
- B. Operating Instructions: Frame printed operating instructions for motor-control centers, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

3.6 CONTROL WIRING INSTALLATION

- A. Install wiring between motor-control devices according to Division 16 Section "Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts; high temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 16 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 16 Section "Grounding and Bonding."

3.8 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 2. To assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
 3. Report results in writing.
- C. Testing Agency: Owner will have the right to engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- E. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection, except for optional tests, stated in NET A ATS "Motor Control Centers." Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.9 ADJUSTING

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

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain components of motor-control centers! including solid-state controllers. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION

SECTION 16444 - MOTOR STARTERS**PART 1 - GENERAL****1.1 DESCRIPTION**

All motor starters and motor control stations including installation and connection (whether furnished with the equipment specified in other Divisions or otherwise) shall meet these specifications.

1.2 RELATED WORK

- A. Other sections which specify motor driven equipment, except elevator motor controllers.
- B. General electrical requirements and items that are common to more than one Section 16010, BASIC ELECTRICAL MATERIALS AND METHODS.
- C. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents: Section 16060, EARTHING.
- D. For multiple motor control assemblies, which include motor starters: Section 16443, MOTOR CONTROL CENTERS.

1.3 SUBMITTALS

Submit in accordance with Section 16010, BASIC ELECTRICAL MATERIALS AND METHODS:

- A. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. current protection, branch circuit, overcurrent protection, wiring diagrams, starting characteristics, interlocking and accessories.
- B. Manuals:
 - 1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams and information for ordering replacement parts.
 - a. Wiring diagrams shall have their terminals identified to facilitate installation, maintenance and operation.

- b. Wiring diagrams shall indicate internal wiring for each item of equipment and interconnections between the items of equipment.
 - c. Elementary schematic diagrams shall be provided for clarity of operation.
 2. Two weeks prior to the project final inspection, submit four copies of the final updated maintenance and operating manual to the Resident Engineer. (Update manual to include any information necessitated by shop drawing approval).
- C. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certifications to the Resident Engineer:
 1. Certification by the manufacturer that the controllers have passed the factory 24 hour operational test. (This certification must be furnished to the Resident Engineer prior to shipping the controller to the job site.)
 2. Certification by the manufacturer that high voltage motor controller(s) conforms to the requirements of the drawings and specifications. (This certification must be furnished to the Resident Engineer prior to shipping the controller to the job site.).

Certification that the equipment has been properly installed, adjusted, and tested.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE): 519-92 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

C37 Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
- C. National Electrical Manufacturers Association (NEMA):

ICS 1-93	Industrial Control and Systems General Requirements
ICS 1.1-84	Safety Guidelines for the Application, Installation and Maintenance of Solid State Control
ICS 2-93	Industrial Control and Systems, Controllers, Contactors and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
ICS 6-93	Industrial Control and Systems Enclosures
ICS 7-93	Industrial Control and Systems Adjustable-Speed Drives
	ICS 7.1-95 Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drives

- D. National Fire Protection Association (NFPA): 70-99 National Electrical Code (NEC)
- E. Underwriters Laboratories Inc. (UL): 508-99 Industrial Control Equipment

PART 2 – PRODUCTS

2.1 MOTOR STARTER:

Motor Starters shall be built and sized in accordance with NEMA Industrial Control Standards, ICS-1970 or IEC 947 or approved equal. Starters shall be non-reversing, magnetic type unless otherwise indicated or specified.

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

Contactors shall have their contact easily accessible for inspection and maintenance. It shall not be possible to remove the arc-quenching chamber when the contactor is energized.

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

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

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

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

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

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

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

All motors 15 HP and larger shall have their starters equipped with integrated multiple function solid state motor protection for:

- a. Thermal overload
- b. Asymmetry/ phase failure
- c. High overload/stalling

Motor starters larger than 15 hp. and motors for operation under fire shall also have earth fault protection integrated within the solid state motor protection unit.

THE STARTER SHALL BE PROVIDED WITH AUXILIARY CONTACTS FOR THE CONNECTION OF SIGNALING, INTERLOCKING AND OTHER CIRCUITS AS REQUIRED FOR THE CONTROLS.(AT LEAST 2 NO. + 2 C) AND AS REQUIRED BY BUILDING MANAGEMENT SYSTEM.

Unless otherwise indicated, all starters shall be provided with START-STOP pushbuttons, and RED & GREEN pilot lights, all located on the starter front cover.

An overload reset button shall be provided inside the cover. Pushbuttons shall be momentary contact or maintained type as applicable to the function of control.

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

Voltage of control circuit shall not exceed 220 volts.

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

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

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

"Star-Delta" Starters shall provide close transition.

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

Auto-transformer type starter shall not be approved.

Manufactured by Telemecanique (FRANCE), Siemens (GERMANY), ABB (Italy) Lovato (Italy), Kloeckner Moeller (Germany) or approved equal.

2.2 MANUFACTURERS: MAGNETIC MOTOR CONTROLLERS – TWO SPEED

A. Square D – Class 8810 Type S or approved equal

1. Description: (include integral time delay transition between fast and slow speed) include electrical interlock (and integral time delay transition) between slow and fast speeds. Starters shall be electrically and mechanically interlocked to prohibit both starters being energized simultaneously.
2. Coil operating voltage 380volts, 50Hz
3. Coil: be of encapsulated type
4. Poles: as indicated
5. Size required by motor hp
6. Contacts: totally enclosed, double break, silver-cadmium-oxide power contacts.
7. Contact inspection and replacement shall be possible without disturbing line or load wiring
8. Wiring: straight through wiring with all terminal clearly marked.
9. Overload relay: NEMA ICS
 - a- Melting Alloy: with one piece thermal unit construction. Thermal units shall be interchangeable. Overload relay control circuit contact shall be replaceable. Thermal units shall be required for starter to operate.
 - b- Solid state: trip current rating will be established by selection of overload relay and shall be adjustable (3 to 1 current range). The overload shall be self-powered, provide phase loss and phase unbalance protection, have a permanent tamper guard and be ambient insensitive. It will also be available in trip class 10 or 20 and have a mechanical test function
 - c- Outputs: unit will designed for addition of either a normally open or normally closed auxiliary contact and be field convertible
 - d- Reset: unit shall offer both manual reset and remote reset using an external module.
10. Enclosure: NEMA (4x) meet conditions of installation.
11. Auxiliary contacts: NEMA ICS 2, each (normally open and normally closed) contacts in addition to seal-in contact
12. Cover mounted pilot devices: NEMA ICS2, heavy duty
13. Pilot device contacts: NEMA ICS 2, Form Z, rated A150
14. Push Buttons: covered
15. Indicating lights LED
16. Selector switches: rotary type
17. Relays: NEMA ICS2
18. Control power transformers: 220 provide fused (Primary and) secondary and bond unfused leg of secondary to enclosure.

2.3 **MOTOR CIRCUIT PROTECTIVE DEVICE**

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

2.4 **CONTROL PANEL**

Equipment indicated on plan as control panel (CP, ECP) of individual air handler units belonging to chilled water air conditioning system, shall consist of individually mounted combination starters and shall also include all additional control and instrumentation devices as described under corresponding clause in mechanical section.

Individually Mounted Combination Starter

Combination Starters shall comprise motor starters as specified hereinbefore and a molded case circuit breaker for motors 15 Hp and above, and miniature circuit breaker for motors smaller than 15 Hp. in a IP40 enclosure unless otherwise indicated. The circuit breaker may be a magnetic only type in lieu of thermal magnetic to the approval of the Engineer.

Combination starters shall be manufactured by GE (USA), (ABB Italy) Cutler Hammer (USA), Square D (USA), Klockner Moeller (Germany), Telemecanique (FRANCE) or approved equal.

2.5 **SOLID-STATE REDUCED VOLTAGE MOTOR STARTER (SOFT STARTER)**

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

1. The solid-state reduced voltage motor controller shall consist of a power section, a one-piece printed circuit logic board and a field wiring interface terminal board.
2. The power section shall be three-phase, 50 Hz. and rated for the hp, current, and voltage as shown on the drawings. It shall consist of three sets of back-to-back phase controlled power semi-conductors. Maximum current limit shall be 500% for standard units.
3. Resistor/Capacitor snubber networks shall be used to prevent false firing of SCR'S due to dv/dt characteristics of the system.

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4. Fan cooled units shall be supplied with thermal sensors on the heat sink to trip the control protective logic for over-temperature condition. Thermal sensors shall be rated 90 °C maximum.
 5. The one piece logic board shall be mounted for easy testing, service and replacement.
 6. Three-phase current sensing via current transformers for closed loop control to insure motor stability shall be provided.
 7. The logic board shall used quick disconnect plug-in connectors for current transformer inputs, line-and-load voltage inputs, SCR gate firing output circuits and status panel.
 8. The logic circuitry shall include as a minimum:
 - a. Short circuit electronic trip overcurrent protection. Time not to exceed ½ cycle.
 - b. Inverse time running overcurrent protection.
 - c. Auxiliary trip circuitry.
 - d. Gate firing circuit lockout protection on trip.
 - e. Fault relay lockout protection.
 - f. 250%-500% current limit adjustment.
 - g. Minimum and maximum voltage adjustments.
 - h. Voltage stability adjustment.
 9. The logic board soldering shall be treated with a conformal protective coating system.
 10. The logic board shall include, as standard, current and motor slip sensing circuitry that continually monitor motor load and regulate motor voltage to minimize motor kWh energy consumption.
 11. The solid-state logic shall provide phase sequence protection.
 12. External interface circuitry shall include 220-volt or 1120 volt relay logic interface capability.
 13. Tripped functions shall be designed to be cleared by removing power from the solid-state logic board.
 14. Controllers for motors larger than 200 hp shall have additional features as follows:
 - a. well time at current limit with ramp continuation after acceleration.

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- b. Individual light emitting diodes (LEDs) to indicate run, undervoltage, phase loss, phase current unbalance, overcurrent trip, overtemperature, current limit, and of ramp and incorrect phase rotation
 - c. Single-phase protection with built-in short time delay.
 - d. Undervoltage protection with built-in short time delay.
 - e. The power section shall have metal oxide varistor (MOV) type surge suppressors across the SCRs rated 10% above the SCR rated voltage. The power semi-conductors shall be rated with peak inverse voltage at least 2.5 times SCR rated line-to-line voltage. Data shall be made available on tolerances to incoming line voltage surges or line spikes. Data shall include both magnitude and time content of each spike (voltage peaks and volt-seconds) plus tolerance to repetitive surges.
 - f. 100%-120% full load running current trip adjustment.
 - g. 200%-500% current limit adjustment.
15. Two ground lugs shall be furnished, one for incoming and one for outgoing ground connections.
16. Power terminations shall consist of pressure type terminals for top or bottom entrance.
17. Enclosure
- a. Enclosures shall not be less than 16-gauge steel. Type 12 enclosures shall be of welded construction with gasketed heat sink and doors.
 - b. Doors shall include plastic device holders for mounting up to six (eight for above 200 hp motors) operator devices.
 - c. External and internal steel surfaces to be painted shall be thoroughly cleaned and phosphatized prior to application of paint. They shall then be primed with a corrosion-resisting coating. Cabinet and door finish shall be manufacturer's standard.
 - d. Controllers for motors above 200 hp shall include the following:
1. The operating handle of the disconnect, when supplied, shall always remain connected to the breaker or switch. The operating handle shall not be mounted on the door of the enclosure, but on the controller for safe "stand-aside" operation. The position of the operating handle will indicate ON or OFF position of switch or circuit breaker and include provision for padlocking in the OFF position.

2. Interlock provisions shall prevent unauthorized opening or closing of the starter door with the disconnect in the ON position.
3. The structure, when floor-mounted, shall be provided with adequate lifting means and shall be capable of being rolled or lifted into installation position and bolted to the floor.
4. A door-mounted status panel shall provide individual light emitting diodes (LEDs) to indicate run, undervoltage, phase overtemperature, current limit, end of ramp and incorrect phase rotation.

2.6 MOTOR STARTERS, GENERAL

- A. Motor starters shall be in accordance with the requirements of the IEEE, NEC, NEMA (ICS 1, ICS 1.1, ICS 2, ICS 6, ICS 7 and ICS 7.1) and UL.
- B. Shall have the following features:
 1. Separately enclosed unless part of another assembly.
 2. Circuit breakers and safety switches within the motor controller enclosures shall have external operating handles with lock-open padlocking provisions and shall indicate the ON and OFF positions.
 3. Motor control circuits:
 - a. Shall operate at not more than 120 volts.
 - b. Shall be grounded except as follows:
 - 1) Where isolated control circuits are shown.
 - 2) Where manufacturers of equipment assemblies recommend that the control circuits be isolated.
 - c. Incorporate a separate, heavy duty, control transformer within each motor controller enclosure to provide the control voltage for each motor operating over 120 volts.
 - d. Incorporate over current protection for both primary and secondary windings of the control power transformers in accordance with the NEC.
 4. Overload current protective devices:
 - a. Overload relay (thermal or induction type)
 - b. Overload relay (solid state type)
 - c. One for each pole.

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- d. Manual reset on the door of each motor controller enclosure.
 - e. Correctly sized for the associated motor's rated full load current.
 - f. Check every motor controller after installation and verify that correct sizes of protective devices have been installed.
 - g. Deliver four copies of a summarized list to the Resident Engineer which indicates and adequately identifies every motor controller installed. Include the catalog numbers for the correct sizes of protective devices for the motor controllers.
- 5. Hand-Off-Automatic (H-O-A) switch is required unless specifically stated on the drawings as not required for a particular starter. H-O-A switch is not required for manual motor starters.
 - 6. Incorporate into each control circuit a 120-volt, solid state time delay relay (ON delay), minimum adjustable range from 0.3 to 10 minutes, with transient protection. Time delay relay is not required where H-O-A switch is not required.
 - 7. Auxiliary contacts, pilot lights, pushbuttons and other devices and accessories as shown on the drawings or otherwise required.
 - 8. Enclosures:
 - a. Shall be the NEMA types shown on the drawings for the motor controllers.
 - b. Shall be the NEMA types which are the most suitable for the environmental conditions where the motor controllers are being installed.
 - c. Doors mechanically interlocked to prevent opening unless the breaker or switch within the enclosure is open.
 - d. Enclosures shall be primed and finish coated at the factory with the manufacturer's prime coat and standard finish.
- C. Motor controllers incorporated with equipment assemblies shall also be designed for the specific requirements of the assemblies.
 - D. For motor controllers being installed in existing motor control centers or panelboards, coordinate with the existing centers or panelboards.
 - E. Additional requirements for specific motor controllers, as indicated in other sections, shall also apply.
 - F. Provide a disconnecting means or safety switch near and within sight of each motor.

- G. Refer to paragraph, MOTOR CONTROL STATIONS, in this section for additional requirements.

2.7 MANUAL MOTOR STARTERS

- A. Shall be in accordance with applicable requirements of 2.1 above.
- B. Manual motor starters.
1. Starters shall be AC, general-purpose Class A, manually operated type with full voltage controller for induction motors, rated in horsepower.
 2. Units shall include overload // and low voltage // protection, red pilot light, // NO // NC // auxiliary contact // and toggle operator.
- C. Fractional horsepower manual motor starters.
1. Starters shall be AC, general-purpose Class A, manually operated with full voltage controller for fractional horsepower induction motors.
 2. Units shall include thermal overload protection, red pilot light and toggle operator.
- D. Motor starting switches.
1. Switches shall be AC, general-purpose Class A, manually operated type with full voltage controller for fractional horsepower induction motors.
 2. Units shall include thermal overload protection, red pilot light // low voltage protection //, // NO // NC // auxiliary contact // and toggle operator.

2.8 ACROSS-THE-LINE CONTROLLERS

- A. Manual Controller: NEMA ICS 2, general purpose, Class A, with toggle action and overload element.
- B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
 2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

3. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 10 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

2.9 REDUCED-VOLTAGE CONTROLLERS

- A. Star-Delta Controller: NEMA ICS 2, closed transition with adjustable time delay.
- B. Part-Winding Controller: NEMA ICS 2, closed transition with separate overload relays for starting and running sequences.
- C. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition
- D. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B_T polyphase, medium induction motors.
 1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.
 2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 3. LED indicators showing motor and control status, including the following conditions:
 - a. Control power available.
 - b. Controller on.
 - c. Overload trip.
 - d. Loss of phase.
 - e. Shorted silicon-controlled rectifier.
 - f. Ground fault relay.
 4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.
 5. Motor running contactor operating automatically when full voltage is applied to motor.

2.10 MULTISPEED CONTROLLERS

- A. Multispeed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
1. Compelling relay to ensure that motor will start only at low speed.
 2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
 3. Decelerating relay to ensure automatically timed deceleration through each speed.

2.11 VARIABLE SPEED MOTOR CONTROLLERS

- A. Shall be in accordance with applicable portions of 2.1 above.
- B. Shall be solid state, micro processor-based with adjustable frequency and voltage, three phase output capable of driving standard NEMA B design, three phase alternating current induction motors at full rated speed. The drives shall utilize a full wave bridge design incorporating diode rectifier circuitry with pulse width modulation (PWM). Other control techniques are not acceptable. Silicon controlled rectifiers (SCR) shall not be used in the rectifying circuitry. The drives shall be designed to be used on variable torque loads and shall be capable of providing sufficient torque to allow the motor to break away from rest upon first application of power.
- C. Shall be rated for input power of 380 volts, three phase, 50 Hz. Unit shall be capable of operating within voltage parameters of plus 10 to minus 10 percent of line voltage, and be suitably rated for the full load amps of the maximum watts (HP) within its class.
- D. Each controller shall be factory tested at maximum watts (HP), rated full load current and at an ambient temperature of 40 degrees C for a period of not less than 24 hours. If a component fails, it shall be replaced and the test restarted for the full time period. A certified copy of the factory Test Report shall be furnished to the Resident Engineer prior to shipping the controller to the job site.
- E. Controllers shall have the following features:
1. Isolated power for control circuits.
 2. Manually re-settable motor overload protection for each phase.
 3. Adjustable current limiting circuitry to provide soft motor starting. Maximum starting current shall not exceed 200 percent of motor full load current.

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4. Independent acceleration and deceleration time adjustment, manually adjustable from 2 to 30 seconds. (Set timers to the equipment manufacture's recommended time in the above range.)
 5. Provide 4 to 20 ma current follower circuitry for interface with mechanical sensor devices.
 6. Automatic frequency adjustment from 50 Hz to 60 Hz.
 7. Provide circuitry to initiate an orderly shutdown when any of the conditions listed below occur. The controller shall not be damaged by any of these electrical disturbances and shall automatically restart when the conditions are corrected:
 - a. Incorrect phase sequence.
 - b. Single phasing.
 - c. Over voltage in excess of 10 percent.
 - d. Under voltage in excess of 10 percent.
 - e. Running overcurrent above 110 percent (shall not automatically reset for this condition.)
 - f. Instantaneous overcurrent above 150 percent (shall not automatically reset for this condition).
 - g. Surge voltage in excess of 1000 volts.
 - h. Short duration power outages of 12 cycles or less (i.e., distribution line switching, generator testing, automatic transfer switch operations.)
 - //8. Provide automatic shutdown on receipt of a power transfer warning signal from an automatic transfer switch. Controller shall automatically restart motor after the power transfer.//
- F. Minimum efficiency shall be 95 percent at 100 percent speed and 85percent at 50 percent speed.
- G. The displacement power factor of the controller shall not be less than 95 percent under any speed or load condition.
- H. Controllers shall include a door interlocked fused safety disconnect switch or door interlocked circuit breaker switch which will disconnect all input power.

- I. Include a by-pass starter with circuitry to protect and isolate the variable speed controller. When the variable speed controller is in the by-pass mode, the solid-state components shall be isolated from the power supply on both the line and motor side.
- J. The following accessories are to be door mounted:
 - 1. AC Power on light.
 - 2. Ammeter (RMS motor current).
 - 3. HAND-OFF-AUTOMATIC switch.
 - 4. Manual speed control in HAND mode.
 - 5. System protection lights indicating that the system has shutdown and will not automatically restart.
 - 6. System protection light indicating that the system has shutdown but will restart when conditions return to normal.
 - 7. Manual variable speed controller by-pass switch.
 - 8. Diagnostic shutdown indicator lights for each shutdown condition.
 - 9. Provide two N.O. and two N.C. dry contacts rated 120 volts, 10 amperes, 60 HZ for remote indication of the following:
 - a. System shutdown with auto restart.
 - b. System shutdown without auto restart.

System running.

- 10. Incorporate into each control circuit a 120-volt, time delay relay (ON delay), adjustable from 0.3-10 minutes, with transient protection. Provide transformer/s for the control circuit/s.
- 11. Controller shall not add any current or voltage transients to the input AC power distribution system nor shall the controller be affected by transients from other devices on the AC power distribution system. Controllers shall be protected to comply with IEEE C37.90.1 and UL-508. Line noise and harmonic voltage distortion shall not exceed the values allowed by IEEE 519.

2.12 MOTOR CONTROL STATIONS

- A. Shall have the following features:
 - 1. Designed for suitably fulfilling the specific control functions for which each station is being installed.
 - 2. Coordinate the use of momentary contacts and maintained contacts with the complete motor control systems to insure safety for people and equipment.

-
3. Each station shall have two pilot lights behind red and green jewels and a circuit to its motor controller. Connect the lamps so they will be energized as follows:
 - a. Red while the motor is running.
 - b. Green while the motor is stopped.
 4. Where two or more stations are mounted adjacent to each other, install a common wall plate, except where the designs of the stations make such common plates impracticable.
 5. Identify each station with a permanently attached individual nameplate, of laminated black phenolic resin with a white core and engraved lettering not less than 6 mm (1/4-inch) high. Identify the motor by its number or other designation and indicate the function fulfilled by the motor.
- B. Components of Motor Control Circuits:
1. Shall also be designed and arranged so that accidental faulting or grounding of the control conductors will not be able to start the motors.
 2. Use of locking type STOP pushbuttons or switches, which cause motors to restart automatically when the pushbuttons or switches are released, will not be permitted.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor control equipment in accordance with manufacturer's recommendations, the NEC, NEMA and as shown on the drawings.
- B. Install Variable Speed Motor Controllers in accordance with manufacturers recommendations, the NEC, as shown on the drawings and in accordance with NEMA ICS 7.1.C.
- C. Furnish and install heater elements in motor starters to match the installed motor characteristics.

3.2 SPARE PARTS

Two weeks prior to the final inspection, provide one complete set of spare fuses (including heater elements) for each starter/controller installed on this project.

END OF SECTION

SECTION 16445 - MOTORS**PART 1 - GENERAL****1.1 DESCRIPTION:**

This section specifies the furnishing, installation and connection of motors.

1.2 RELATED WORK:

- A. Section 16010, BASIC ELECTRICAL MATERIALS AND METHODS: General electrical requirements that are common to more than one Section of Division 16.
- B. Section 16444, MOTOR STARTERS : Starters, control and protection for motors.
- C. Section 16443, MOTOR CONTROL CENTERS: Multiple motor control assemblies, which include motor starters.
- D. Other sections specifying motor driven equipment in Divisions 14 and 15.

1.3 SUBMITTALS:

- A. In accordance with Section 16010, BASIC ELECTRICAL MATERIALS AND METHODS, submit the following:
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, materials, horsepower, RPM, enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets and application data.

- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Resident Engineer:
1. Certification that the motors have been properly applied, installed, adjusted, lubricated, and tested.

1.4 APPLICABLE PUBLICATIONS:

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Electrical Manufacturers Association (NEMA):
MG 1-98 Motors and Generators
MG 2-01 Safety Standard and Guide for Selection, Installation and Use of Electric Motors and Generators
- C. National Fire Protection Association (NFPA):
70-02 National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 MOTORS:

- A. For alternating current, fractional and integral horsepower motors, IEC 34 Standards, IEC 72, Standard and NEMA Publications MG 1 and MG 2 shall apply.
- B. Voltage ratings shall be as follows:
1. Single phase :
 - a. Motors connected to 220-volt systems: up to 0.75 HP unless otherwise noted.
 2. Three phase:
 - a. Motors connected to 380-volt systems: Larger than 0.75HP
- C. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation.
- D. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.

E. Motor Enclosures:

1. Shall be the NEMA types shown on the drawings for the motors.
2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed.
3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

F. Additional requirements for specific motors, as indicated in other sections, shall also apply.

G. Energy-Efficient Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 Watts or more shall meet the minimum full-load efficiencies as indicated in the following table, and as specified in this specification. Motors of 746 Watts or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

Minimum Efficiencies Open Drip-Proof				Minimum Efficiencies Totally Enclosed Fan-Cooled			
Ratingk W (HP)	1200 RPM	1800 RPM	3600 RPM	Ratingk W (HP)	1200 RPM	1800 RPM	3600 RPM
0.746 (1)	82.5 %	85.5%	77.0 %	0.746 (1)	82.5 %	85.5 %	77.0 %
1.12 (1.5)	86.5 %	86.5%	84.0 %	1.12 (1.5)	87.5 %	86.5 %	84.0 %
1.49 (2)	87.5 %	86.5%	85.5 %	1.49 (2)	88.5 %	86.5 %	85.5 %
2.24 (3)	88.5 %	89.5%	85.5 %	2.24 (3)	89.5 %	89.5 %	86.5 %
3.73 (5)	89.5 %	89.5%	86.5 %	3.73 (5)	89.5 %	89.5 %	88.5 %
5.60 (7.5)	90.2 %	91.0%	88.5 %	5.60 (7.5)	91.0 %	91.7 %	89.5 %
7.46 (10)	91.7 %	91.7%	89.5 %	7.46 (10)	91.0 %	91.7 %	90.2 %
11.2 (15)	91.7 %	93.0%	90.2 %	11.2 (15)	91.7 %	92.4 %	91.0 %
14.9 (20)	92.4 %	93.0%	91.0 %	14.9 (20)	91.7 %	93.0 %	91.0 %

18.7 (25)	93.0 %	93.6%	91.7 %	18.7 (25)	93.0 %	93.6 %	91.7 %
22.4 (30)	93.6 %	94.1%	91.7 %	22.4 (30)	93.0 %	93.6 %	91.7 %
29.8 (40)	94.1 %	94.1%	92.4 %	29.8 (40)	94.1 %	94.1 %	92.4 %
37.3 (50)	94.1 %	94.5%	93.0 %	37.3 (50)	94.1 %	94.5 %	93.0 %
44.8 (60)	94.5 %	95.0%	93.6 %	44.8 (60)	94.5 %	95.0 %	93.6 %
56.9 (75)	94.5 %	95.0%	93.6 %	56.9 (75)	94.5 %	95.4 %	93.6 %
74.6 (100)	95.0 %	95.4%	93.6 %	74.6 (100)	95.0 %	95.4 %	94.1 %
93.3 (125)	95.0 %	95.4%	94.1 %	93.3 (125)	95.0 %	95.4 %	95.0 %
112 (150)	95.4 %	95.8%	94.1 %	112 (150)	95.8 %	95.8 %	95.0 %
149.2 (200)	95.4 %	95.8%	95.0 %	149.2 (200)	95.8 %	96.2 %	95.4 %

H. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at , 1800 RPM .

I. Premium efficiency motors shall be used where energy cost/kW x (hours use/year) > 50.

PART 3 - EXECUTION

3.1 INSTALLATION:

Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

3.2 FIELD TESTS

Megger all motors after installation, before start-up. All shall test free from grounds.

END OF SECTION

SECTION 16511 – INTERIOR LIGHTING

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 the following:
1. Interior lighting fixtures, lamps, and ballasts.
 2. Emergency lighting units.
 3. Exit signs.
 4. Lighting fixture supports.
 5. Retrofit kits for fluorescent lighting fixtures.
- B. Related Sections include the following:
1. Division 16 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.
 2. Division 16 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
 3. Division 16 Section "Dimming Controls" for architectural dimming systems.

1.3 DEFINITIONS

- A. BF: Ballast factor.
- B. CRT: Color-rendering index.
- C. CU: Coefficient of utilization.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.
- G. RCR: Room cavity ratio.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
1. Physical description of lighting fixture including dimensions.
 2. Emergency lighting units including battery and charger.

3. Ballast.
4. Energy-efficiency data.
5. Required Lux Level

Parking circulation	100 lux
Parking car storage	50 lux
Corridor	150 lux
Kitchen	300 lux
Office	500 lux
Electro mechanical room	200 lux
Storage	200 lux
6. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 15 Section "Diffusers, Registers, and Grilles."
7. Life, output, and energy-efficiency data for lamps.
8. Photometric data, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.
 - b. Photometric data shall be certified by a manufacturer's laboratory in country of origin.
9. Detailed calculations shall based on software shall be provided for all emergency lighting units which should provide a minimum of 5 lumens per m.sq.

For all lighting illuminance levels in public areas results based on software output shall be provided.

Illuminance levels shall assume 0.70 maintenance factor in parking areas, storages and electro mechanical rooms.

A 0.8 maintenance factor shall be assumed in clean areas. Working plane in all public areas shall be at or 0.20 m above floor level except for control room and offices where it will be assumed at 0.85 m.

Calculation of outdoor lighting shall be based on software and shall ensure a uniformity of 0.25 minimum.

All illuminance levels shall be based on British IEE lighting handbook or French AFNOR or German DIN Regulations.

- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
 - 1. Wiring Diagrams: Power and control wiring.
- C. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Lighting fixtures.
 - 2. Suspended ceiling components.
 - 3. Structural members to which suspension systems for lighting fixtures will be attached.
 - 4. Other items in finished ceiling including the following:
 - a. Air outlets and inlets.
 - b. Speakers.
 - c. Sprinklers.
 - d. Smoke and fire detectors.
 - e. Occupancy sensors.
 - f. Access panels.
 - 5. Perimeter moldings.
- D. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:
 - 1. Lamps: Specified units installed.
 - 2. Accessories: Cords and plugs.
- E. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.
- F. Qualification Data: For agencies providing photometric data for lighting fixtures.
- G. Field quality-control test reports.
- H. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
- I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited in country of origin.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated.
- C. Comply with NFPA 70.
- D. Mockups: Provide interior lighting fixtures for room or module Mockups, complete with power and control connections.
 - 1. Obtain Architect's approval of fixtures for mockups before starting installations.
 - 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment fire-suppression system, and partition assemblies.

1.7 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
 - 2. Warranty Period for Emergency Fluorescent Ballast (and) Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion Full warranty shall apply for first year, and prorated warranty for the remaining six years.
- B. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.

2. Warranty Period for Electromagnetic Ballasts: Three years from date of Substantial Completion.
- C. Special Warranty for T5, T8, T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
1. Warranty Period: One, Two year(s) from date of Substantial Completion.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 3. Battery and Charger Data: One for each emergency lighting unit.
 4. Ballasts: 1 for every 50 of each type and rating installed. Furnish at least one of each type.
 5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2-PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- B. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 3. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Fixtures: False ceiling compatibility to be ensured for recessed fixtures.
- B. Metal Parts: Free of burrs and sharp corners and edges.
- C. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent -warping and sagging.
- D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured inoperating position.
- E. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent
 - 4. Laminated Silver Metallized Film: 90 percent.
- F. Plastic Diffusers, Covers, and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least (3.175 mm)].
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass, unless otherwise indicated.
- G. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic-interference. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. Electronic Ballasts: Designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.
 - 1. Sound Rating: A, except B for T12/HO and T12/Slimline lamp ballasts.
 - 2. Total Harmonic Distortion Rating: Less than 10 percent.
 - 3. Transient Voltage Protection: IEEE C62.41, Category A or better.
 - 4. Operating Frequency: 20 kHz or higher.
 - 5. Lamp Current Crest Factor: 1.7 or less.
 - 6. BF: 0.85 or higher.
 - 7. Power Factor: 0.98.

-
8. Parallel Lamp Circuits; Multiple lamp ballasts shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
- B. Electronic Programmed-Start Ballasts for T5 Lamps: Comply with the following:
1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: A.
 4. Total Harmonic Distortion Rating: Less than 20 percent.
 5. Transient Voltage Protection: IEEE C62.41, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. BF: 0.95 or higher, unless otherwise indicated.
 9. Power Factor: 0.95/ 0.98 or higher.
- C. Electromagnetic Ballasts: energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
1. Ballast Manufacturer Certification: Indicated by label.
- D. Single Ballasts for Multiple Lighting Fixtures: Factory-wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- E. Ballasts for Low-Temperature Environments:
1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
 2. Temperatures Minus 20 Deg F (Minus 17 deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
- F. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
- G. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
1. Dimming Range: 100 to 5 percent of rated lamp lumens.
 2. Ballast Input Watts: Can be reduced to 20 percent of normal.
 3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

H. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
 - a. High-Level Operation: 100 percent of rated lamp lumens.
 - b. Low-Level Operation: 30 percent of rated lamp lumens.
2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic programmed rapid-start type, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor. 1.7 or less.
8. BF: 0.95 or higher, unless otherwise indicated.
9. Power Factor: [0.95] [0.98] or higher.
10. Interference: Comply with 47CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment
11. Ballast Case Temperature: 75 deg C, maximum.

B. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

1. Dimming Range: 100 to 5 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamptype indicated.

2.5 EMERGENCY FLUORESCENT POWER UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.

1. Emergency Connection: Operate 1 fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.

2. Night-Light Connection: Operate one fluorescent lamp continuously.
 3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 4. Battery: Sealed, maintenance-free, nickel-cadmium type.
 5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
 6. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.
- B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from lighting fixture. Comply with UL 924.
1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 2. Night-Light Connection: Operate one fluorescent lamp in a remote fixture continuously.
 3. Battery: Sealed, maintenance-free, nickel-cadmium type.
 4. Charger: Fully automatic, solid-state, constant-current type.
 5. Housing: NEMA 250, Type 1 enclosure.
 6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.6 BALLASTS FOR HID LAMPS

- A. Electromagnetic Ballast for Metal-Halide Lamps: Include the following features, unless otherwise indicated:
 1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
 3. Normal Ambient Operating Temperature: 104 deg F (40 deg C)
 4. Open-circuit operation that will not reduce average life.
 5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- B. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
 1. Lamp end-of-life detection and shutdown circuit.
 2. Sound Rating: A.
 3. Total Harmonic Distortion Rating: Less than 15 percent.
 4. Transient Voltage Protection: IEEE C62.41, Category A or better.
 5. Lamp Current Crest Factor: 1.5 or less.
 6. Power Factor: 90 or higher.
 7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
 8. Protection: Class P thermal cutout.
 9. Retain subparagraph and associated subparagraphs below for bi-level ballasts.

10. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
 - a. High-Level Operation: 100 percent of rated lamp lumens.
 - b. Low-Level Operation: 35 percent of rated lamp lumens.
 - c. Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color rendering capability.
11. Continuous Dimming Ballast: Dimming range shall be from 100 to percent of rated lamp lumens without flicker.
 - a. Ballast Input Watts: Reduced to a maximum of 50 percent of normal at lowest dimming setting.
 - b. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
- C. Auxiliary Instant-On Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent light output
- D. High-Pressure Sodium Ballasts: Electromagnetic type, with solid-state igniter/starter. Igniter-starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
 1. Instant-Restrike Device: Integral with ballast or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
 - a. Restrike Range: 105- to 130-V ac.
 - b. Maximum Voltage: 250-V peak or 150-V ac RMS.
 2. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C)
 3. Open-circuit operation shall not reduce average lamp life.

2.7 GENERAL LIGHTING INSTALLATIONS (1633)

- A. TUNGSTEN-HALOGEN LAMPS: tubular, quartz, resistant to high temperatures. Guaranteed rated life is to be above 2000 hours and luminous output above the following:
 1. 9500 lumens for 500 W lamps.

The halogen mains voltage lamp with E27 base shall have a rated average life of 2000 hours with a lumen output of 2400 lumen minimum for 150 watts lamp and 4000 lumen minimum for 250 watts lamp and 1400 lumen minimum for 100-watt lamp.

Lamp shall have a 32 mm diameter and 105 mm length.

2.8 ELECTRONIC TRANSFORMER OF LOW VOLTAGE HALOGEN

Electronic transformer shall be VDE testade and shall comply with European standards for safety operation (IEC 1046) and EMC (EN 55015), power factor shall be 0.99 and IOSUU shall be less than 10 watt.

Transformer shall be dimmable operating frequency shall be 40 KHz.

Transformer shall have built-in short circuit and overload protection transformer shall also comply with EN 60555-2 for harmonic distortion.

Electromagnetic low voltage halogen transformer 220V/12V shall be used only if:

- Lamps are not on dimmable circuits.
- Transformer is manufactured by corresponding lighting fixtures supplier or approved by that same supplier locally manufactured electromagnetic transformers for low voltage halogen lamps are strictly prohibited.

2.9 LOW VOLTAGE HALOGEN LAMPS

Low voltage halogen lamps with aluminum reflector (cap B15D) shall consist of a low-voltage halogen burner optically positioned in a lightweight highly glossy anodized aluminum reflector with an integral protective front glass. The optical positioning of the burner at the focal point of the reflector shall result in a high-density beam with a clearly defined beam spread.

Correlated color temperature shall be 3000 deg. K. lamp life shall be 2000 hours minimum.

Luminous intensity shall be:

- For 20 W (18 deg) 1500 candela.
- For 35 W (15 deg) 3500 candela.
- For 50 W (22 deg) 2000 candela.

2.10 LOW VOLTAGE HALOGEN LAMPS DICHROIC REFLECTOR

The technology of lamp shall be based on the application of a heat-reflecting coating on the inner lamp burner. The lamp shall have a compact and precision-shaped double-ended burner, which shall enable the infrared reflecting coating to perform to its fullest potential.

VOLTAGE	WATTAGE	BEAM ANGLE DEGS.	CAP/BASE	LUMINOUS INTENSITY	AVERAGE LIFE
12	20	8	GU5.3	6500	5000
12	20	36	GU5.3	1000	5000
12	30	8	GU5.3	11000	5000
12	30	24	GU5.3	3350	5000
12	30	36	GU5.3	1600	5000
12	30	60	GU5.3	750	5000
12	35	8	GU5.3	14000	5000
12	35	24	GU5.3	4400	5000
12	35	36	GU5.3	2200	5000
12	35	60	GU5.3	1050	5000
12	45	8	GU5.3	16000	5000
12	45	24	GU5.3	5450	5000
12	45	36	GU5.3	2850	5000
12	45	60	GU5.3	1300	5000

2.11 EXIT SIGNS

- A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
1. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type. .
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

- f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
- g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.12 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

- 1. Battery: Sealed, maintenance-free, lead-acid type.
- 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
- 3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
- 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
- 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
- 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
- 7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
- 8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
- 9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.13 FLUORESCENT LAMPS

- A. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches 1220mm, 2800 initial lumens minimum, CRI 75 minimum, color temperature as shown on schedule, and average rated life 20,000 hours, unless otherwise indicated.
- B. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches mm), 1300 initial lumens minimum, CRI 75 minimum, color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.
- C. T5 rapid-start low-mercury lamps, rated 28 W maximum, nominal length of 45.2 inches 50 mm, 2900 initial lumens minimum, CRI 85 minimum, color temperature as shown on schedule, and average rated life of 20,000 hours, unless otherwise indicated.
- D. Compact Fluorescent Lamps: 4-Pin, color temperature as shown on schedule, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.
 - 1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
 - 2. 18 W: T4-, double or triple tube, rated 1200 initial lumens (minimum).
 - 3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
 - 4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
 - 5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
 - 6. 55 W: T4, triple tube, rated 4300 initial lumens (minimum).

2.14 HID LAMPSA.

- A. High-Pressure Sodium Lamps: CRI 21 minimum, color temperature, and average rated life of 24,000 hours, minimum.
 - 1. Dual-Arc Tube Lamps: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
- B. Metal-Halide Lamps: minimum CRI 65 and color temperature as shown on schedule.
- C. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature as shown on schedule.
- D. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80 and color temperature as shown on schedule.

2.15 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Single-Stem Hangers: 1/2-inch, 13-mm steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- B. Twin-Stem Hangers: Two, 1/2-inch, 13-mm steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- C. Wires: 2.5mm.sq.
- D. Rod Hangers: 3/16-inch 5-mm minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
 - 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 - 4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- C. Suspended Lighting Fixture Support:
 - 1. Pendants and Rods: Where longer than 48 inches (1200mm), brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.

- 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
- D. Adjust aimable lighting fixtures to provide required light intensities.
- E. Connect wiring according to Division 16 Section "Conductors and Cables."
- F. All emergency battery operated lighting fixtures shall be connected directly to nearest panelboard feeding the area through unswitched power supply.

3.2 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

SECTION 16521 – EXTERIOR LIGHTING

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 the following:
1. Exterior luminaires with lamps and ballasts.
 2. Luminaire-mounted photoelectric relays.
 3. Poles and accessories.
 4. Luminaire lowering devices.
- B. Related Sections include the following:
1. Division Section 16511 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

- A. CRI: Color-rendering index.
- B. HTD: High-intensity discharge.
- C. Luminaire: Complete lighting fixture, including ballast housing if provided.
- D. Pole: Luminaire support structure, including tower used for large area illumination.
- E. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.
- B. Live Load: Single load of 500 ibf (2224 N), distributed as stated in AASHTO LTS-4.
- C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
1. Wind speed for calculating wind load for poles in height is 120 km/h.

1.5 SUBMITTALS

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
 2. Details of attaching luminaires and accessories.
 3. Details of installation and construction.
 4. Luminaire materials.
 5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
 - a. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
 - b. Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 6. Photoelectric relays.
 7. Ballasts, including energy-efficiency data.
 8. Lamps, including life, output, and energy-efficiency data.
 9. Materials, dimensions, and finishes of poles.
 10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
 11. Anchor bolts for poles.
 12. Manufactured pole foundations.
- B. Shop Drawings:
1. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
 2. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
 3. Wiring Diagrams: Power and control wiring.
- C. Samples for Verification: For products designated for sample submission in Exterior Lighting Device Schedule. Each sample shall include lamps and ballasts.
- D. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying load imposed by luminaire has been included in design
- E. Qualification Data: For agencies providing photometric data for lighting fixtures.

- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For [Luminaires] [and poles] [luminaire lowering devices] to include in emergency, operation, and maintenance manuals.
- H. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited in Europe.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent European agency, with the experience and capability to conduct the testing indicated.
- C. Electrical Components, Devices, and Accessories: Listed and labeled by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE C2, "National Electrical Safety Code."
- E. Comply with NFPA 70.
- F. All outdoor lighting fixtures shall be chromium plated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 300mm above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.

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2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 4. Warranty Period for Lamps: Replace lamps and fuses that fail within 12 months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.
 5. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 3. Ballasts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 4. Globes and Guards: 10 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 3. Basis of Design Product: The design of each item of exterior luminaire and its support is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LUMINAIRES, GENERAL REQUIREMENTS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- E. Exposed Hardware Material: Stainless steel.
- F. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat and UV radiation.
- G. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent
 - 3. Diffusing Specular Surfaces: 75 percent
- I. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- J. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- K. Factory-Applied Finish for Steel Luminaires:
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust if present, from uncoated steel.

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2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors.
 - b. Color: Match Architect's sample of manufacturer's standard color.
 - c. Color: As selected by Architect from manufacturer's full range.
- L. Factory-Applied Finish for Aluminum Luminaires:
1. Natural Satin Finish: Provide fine, directional, medium satin polish and seal aluminum surfaces with clear, hard-coat wax.
 2. Class I, Clear Anodic Finish: Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: clear coating 0.018 mm or thicker.
 3. Class I, Color Anodic Finish: (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electronically deposited color coating 0.018 mm or thicker.
 - a. Color: as indicated in Schedules.
- 2.3 FLUORESCENT BALLASTS AND LAMPS** refer to Interior Lighting Section.
- A. Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) minus 0 deg.
- 2.4 BALLASTS FOR HID LAMPS** refer to Interior lighting Section.
- Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) minus 0 deg.
- 2.5 HIP LAMP:** refer to Interior Lighting Section.
- 2.6 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS**
- A. Structural Characteristics:
1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping hi steady winds of speed indicated in Part 1 with a gust factor of 1.3.
 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of **1.1** to obtain the equivalent projected area to be used in pole selection strength analysis.

- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
 - 3. Anchor-Bolt Template: Plywood or steel.
- D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."
- E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction.

2.7 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); 1-piece construction up to 40 feet < 12 m} in height with access handhole in pole wall.
 - 1. Shape: Round.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - 1. Adapter fitting welded to pole and bracket, then bolted together with stainless steel bolts.
 - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 - 3. Match pole material and finish.

- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 3 m above finished grade.
- F. Intermediate Handhole and Cable Support: Weathertight, 26-by-127-mm handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
- G. Grounding and Bonding Lugs: Welded 13-mm threaded lug, complying with requirements in Division 16 Section "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- I. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
- J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- K. Galvanized Finish: After fabrication, hot-dip galvanized complying with ASTM A 123/A 123M.
- L. Factory-Painted Finish:
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel.
 - 2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
 - 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected by Owners from manufacturer's full range.

2.8 DECORATIVE POLES

- A. Pole material:
 - 1. Stainless steel, or Aluminium as shown on schedules.
- B. Mounting Provisions
 - 1. Bolted to concrete slab.
- C. Fixture Brackets:
 - 1. Cast aluminium or as indicated on schedule.
- D. Pole Finish (as per I.D).

2.09 POLE ACCESSORIES

- A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
- B. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept (ballast).

2.10 REQUIREMENTS FOR INDIVIDUAL EXTERIOR LIGHTING DEVICES

- A. Exterior lighting Device Type
 - 1. Basis-of-Design Product: Insert manufacture's name; product name or designing or a comparable product by one of the following:
 - 2. Voltage: 220Vac
 - 3. Nominal Dimensions
 - 4. Lamps
 - 5. Ballast Types and Features.
 - 6. Photoelectric Control: Integrally mounted.
 - 7. Lens
 - 8. Reflector
 - 9. Focusing and Aiming Provisions.
 - 10. Cutoff Category
 - 11. Nominal Beam Spread for Floodlights
 - 12. Internal Light Shield
 - 13. Photometric Performance of Installed Units:
 - a. Spot Intensity: Minimum initial horizontal illumination at grade.
 - b. Average Intensity: Minimum average initial horizontal illumination at grade
 - c. Uniformity.
 - d. Ballast Factor.
 - e. Minimum Luminaire Efficacy Rating.
 - f. Pole Description.

- 14. Ballast Factor.
- 15. Minimum Luminaire Efficacy Rating.
- 16. Pole Description.
 - a. Material or Type.
 - b. Luminaire Support Components and Accessories:
 - c. Mounting Provisions.
 - d. Luminaire Mounting Height above finished grade.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming.

3.2 POLE INSTALLATION

- A. Align pole foundations and poles for optimum alignment of luminaires and their mounting provisions on the pole.
- B. Install on concrete base with top 100mm above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3 Section "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Install on concrete base with top (100mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3 Section "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 16 Section "Raceways and Boxes." In concrete foundations, wrap conduit with 0.010-inch- (0.254mm) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

- A. Ground metal poles and support structures according to Division 16 Section "Grounding and Bonding".
 - 1. Install grounding electrode for each pole, unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 16 Section "Grounding and Bonding."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - 1. Verify operation of photoelectric controls.
- C. Illumination Tests:
 - 1. Measure light intensities at night with photometric.
- D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

SECTION 16714

STRUCTURED CABLING SYSTEM (SCS)

PART 1 – GENERAL

1.1 OVERVIEW

- A. The scope of this project includes the complete supply and installation of a cabling system for voice and data (as per the drawings) that meets or exceeds the enclosed specifications. Contractor to provide the fiber optic cables and CAT6 UTP cable for data and voice outlet. Contractor shall also supply the CAT 3 telephone vertical and horizontal cables feeders
- B. All cabling systems are based on a physical star cabling topology that is defined in accordance with national standards.
- C. The proposed cabling system must be applications-independent and network technology neutral
- D. Product specifications, general design considerations, and installation guidelines are provided in this written document.
- E. Furnish and install complete with all accessories a Structured Cabling System (SCS). The SCS shall serve as a vehicle for transport of data and voice telephony signals throughout the network from designated demarcation points to outlets located at various desks and in apartments and other locations as indicated on the contract drawings and described herein.
- F. SCS system supporting telecommunications systems shall comply with detailed specifications in this section and shall consist of cabling that includes data backbone optical fiber cables, data backbone copper cables, voice backbone copper cables, patch panels, connecting hardware, horizontal data copper cables, and jacks at terminal Outlets (TOs) for voice, data, and telecommunications system services. Locations of equipment shall be as indicated on drawings, unless directed otherwise by Owner's Representative.
- G. Manufacturers
Approved manufacturers: 3M , Commscope Systimax Legrand, Hubbell, Amp, Krone, Simeon or approved equal

Any deviation or substitutions offered as part of this specification must be pre-approved by the owner or owners' representative. Any submittals in response to any part of this specification that do not meet the product requirements as defined, may be rejected without further consideration, or may cause monetary charges to be incurred by the submitter.

- H. Wiring utilized for telephone company central office voice service shall originate at a demarcation point the cross connect provided by the telephone company (Ogero). Installation, termination and identification of wiring between final voice outlets, Telecom Room (TR)s and final interface in point of Ogero in 1st Basement shall be considered part of the contractors work.
- I. Horizontal wiring utilized for data and voice communications shall originate at owner provided hubs and concentrators wall mounted, equipment vertical equipment racks located at the utility room in each apartment or as indicated on drawings. Wiring, terminations and patch bays between these designated demarcation points and outlet locations designated on the plans shall be considered part of the contract. Telecommunication Outlets (TO) shall be furnished, wired and installed by the SCS system contractor.
- J. The system shall utilize a network of fiber optic for the riser, and Cat 6 shielded twisted pair for the horizontal, station cables. Cables and terminations shall be provided and located as shown and in the quantities indicated on the drawings.
- K. Fiber cables shall terminate on fiber patch panels and/or modular patch panels located in all demarcation and termination points shown on the drawings as IDF / Distribution Switch.
- L. All cables and terminations shall be identified at all locations.
- M. All cables shall terminate in an alphanumeric sequence at all termination locations.
- N. All balanced twisted pair cable terminations shall comply with, and be tested to ANSI/TIA-568-C standards for Category 6 installations.
- O. Available and unused pairs between the in telecom room or closets shall be terminated and shall be identified as spare at each location.
- P. Station cables shall terminate on one, two or three gang wall plates equipped as shown on the drawings.

A. Related sections

- A. Raceways: 16130
- B. Earthing System: 16060

B. References

- ANSI/TIA-568-C.0: Generic Telecommunications Cabling for Customer Premises, published 2009

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- ANSI/TIA-568-C.1: Commercial Building Telecommunications Cabling Standard, 2009
 - ANSI/TIA-568-C.2: Balanced Twisted-Pair Telecommunication Cabling and Components Standard, 2009
 - ANSI/TIA-568-C.3: Optical Fiber Cabling Components Standard, 2008
 - ANSI/TIA-862: Building Automation Systems Cabling for Commercial Buildings, 2002
 - ANSI/TIA-569-B: Commercial Building Standard for Telecommunications Pathways and Spaces.
 - ANSI/TIA-606-A: Administration Standard for Commercial Telecommunications Infrastructures, 2002
 - ANSI/TIA-758-A: Customer-owned Outside Plant Telecommunications Infrastructure Standard, 2005
 - International Standards Organization/International Electrotechnical Commission ISO/IEC 11801, Amendment 1, 2009: Generic Cabling for Customer Premises, Class E_A
 - Underwriters Laboratories (UL®) Cable Certification and Follow Up Program.

1.2 Definitions

- A. Structured Cabling System (SCS): A SCS is defined as all required cabling including hardware, termination blocks, cross connect wire or cordage, patch panels, patch cords, telecommunication outlets, work area cords, UTP and fiber optic cable installed and configured to provide computer data and voice connectivity from each data or voice device to the network file server or voice network/switch designated as the service point of the local area network.
- B. Work Area Subsystem: The connection between the telecommunications outlet and the station equipment in the work area is provided by the Work Area Subsystem. It consists of cords, adapters, and other transmission electronics.
- C. Horizontal Subsystem: The Horizontal subsystem Provides connections from the horizontal cross connect (copper patch panel inside communication units of apartments) to the Telecommunication Outlets (TOs) in the work areas. It consists of the horizontal transmission media, the associated connecting hardware terminating this media and TOs in the work area. Each floor of a building is served by its two Horizontal Subsystems. One subsystem which can be considered as a second level backbone from the IDF/ Distribution switch located in the telecom low current closet inside public corridors and going to communication units (CU) inside each apartment or retail. One horizontal subsystem starting from communication unit (CU) inside each apartment or retail and going to final voice (telephone) or data outlets.

- D. Riser Backbone: The Riser Backbone subsystem links the main fiber patch panel in the equipment room in 1st Basement to intermediate distribution frame (IDF) and horizontal cross connects in the floor telecommunications closets. It consists of the backbone transmission media between these locations and the associated connecting hardware terminating this media. It is normally installed in a star topology; with first-level backbone cables beginning at the main fiber patch panel. Second-level backbone cables begin at intermediate distribution frame.
- E. Equipment Subsystem: The Equipment Subsystem consists of shared (common) electronic communications equipment in the equipment room, main cross connect or telecommunications room and the transmission media required terminating this equipment on the distribution hardware.
- F. The Administration Subsystem: The Administration Subsystem links all of the subsystems together. It consists of labeling hardware for providing circuit identification and patch cords or jumper wire used for creating circuit connections at the cross connects.

1.3 Submittals

Environmental Statement

- Manufacturer must provide compliance statement to the European Restriction of use of certain Hazardous Substances (RoHS) Directive, 2002/95/EC.
- Manufacturer must provide Environmental declarations for all products.

Product Data

- Provide manufacturer's catalog information showing dimensions, colors, and configurations.
- Submittals shall include all items called for in PART 2 – PRODUCTS of this document and the manufacturers cut sheets for the following:
- All fiber optic and balanced twisted pair cable: to include patch cords, cross connect wire and cross connect cordage.
- All connectors and required tooling.
- All termination system components for each cable type.
- All ER, MC, EF and TR equipment frame types, hardware (and LAN equipment if applicable).
- All grounding and surge suppression system components.
- All test equipment to be used for fiber and balanced twisted pair channels
- A Performance Specification showing manufacturer's Guaranteed Channel Performance over the full swept frequency range.

Manufacturer's Instructions

- Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements.

-
- Include instructions for storage, handling, protection, examination, preparation, operation and installation of product.

Pre-Qualification Certificate

- Contractor shall submit the following documents with project proposal:
- A letter of approval from the manufacturer indicating completion of pre-qualification requirements.
- Training certificates for design, engineering and installation of the proposed products, for the relevant staff involved in the design and installation of this project.

Bid

Vendor shall submit complete detailed bids. Lump sum bids will not be accepted.

Material Guarantee

The wiring vendor (installer) shall guarantee at the time of the bid that all Category 6E and fiber optic cabling and components meet or exceed specifications (including installation) of ANSI/TIA-568-C.0, ANSI/TIA-568-C.1 568-C.2, ANSI/TIA-568-C.3 and ANSI/TIA-569-B.

Material Provided

The successful wiring vendor (installer) shall be certain that all correct parts are ordered per Products Section of this document and installed in accordance with manufacturers design and installation guidelines. Vendor shall submit complete parts and part numbers prior to installation of equipment.

Warranty Documentation

- Warranty shall be for 20 years.
- Complete documentation regarding the manufacturer's warranty shall be submitted as part of the proposal. This shall include, but is not limited to: a sample of the warranty that would be provided to the customer when the installation is complete and documentation of the support procedure for warranty issues.
- A systems application assurance manual documenting the vendor supported applications and application guidelines shall be provided as part of the submittals

1.4 Qualifications**Manufacturer**

- The Manufacturer shall confirm in writing compliance to the requirements within this document and supported by original documentation.

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- All SCS solutions requested shall be supplied and guaranteed by a single manufacturer. Manufacturers are to confirm in writing whether 3rd party manufacturers are utilized for their copper, fibre cable and software.
 - The manufacturer shall be a publicly listed company with confirmation that their 2008 revenues in Copper and Fibre Structured Cabling Solutions (excluding accessories such as racks, labeling or containment solutions) exceeds \$500 million.
 - The Manufacturer shall have had a local office with resident support staff for a minimum of 5 years (a minimum of 2 RCDD certified – BICSI – technical support staff to the client and registered installer) or regional support staff for a minimum of 10 years.
 - Preference will be given to racks, cabinets and associated routing pathways provided by the same manufacturer as the cabling system.
 - Manufacturer shall have a minimum of ten (10) years experience in the manufacture of the specified cabling products and shall be ISO 9001/14000 Certified.
 - Cabling Manufacturer shall provide a minimum of Five (5) reference projects in the country with a minimum of 5000 outlets of Category 6 and at least Three (3) working reference projects utilizing Real Time Infrastructure Management (RTIM) systems. The Vendor must have completed these projects within the last Five (5) years.

Manufacturer Environmental Program

- The company shall provide evidence of its compliance to : The Registration, Evaluation, Authorization and restriction of Chemicals (REACH), Regulation (EC) No 1907/2006 Or other national/international equivalent standard, directive or regulation.
- The company shall provide evidence of its compliance to: The restriction of the use of certain hazardous substances in electrical and electronic equipment, RoHS, Directive (EC) No 2002/95/EC. Or other national/international equivalent standard, directive or regulation.
- The company shall provide evidence of its program to measure and minimise its environmental and energy impact and consumption, this shall be in the form of an existing statement on the companies environmental status with a specific measurement of its carbon foot print.
- To ensure the company has an effective environmental management system, the company shall provide evidence of its compliance to Environmental Management Standard International Standards Organization ISO 14001:2004

Contractor

- The contractor selected to provide the installation of this system shall be certified by the manufacturing company in all aspects of design, installation and testing of the products described herein.
- The contractor shall utilize the authorized manufacturer components and distribution channels in provisioning this Project.

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- Contractor shall have a minimum of five (5) years of recent experience on structured cabling systems of similar type and size.
 - Contractor and design firm shall be in compliance with all federal, state and local statutes regarding qualifications of firms.
 - The contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.
 - The contractor shall own and maintain the tools and equipment approved by the cabling system manufacturer for successful installation and testing of optical and Category 6 / Class E balanced twisted pair distribution systems.
 - The contractor shall have personnel who are adequately trained in the usage of such tools and equipment.
 - The contractor shall provide written confirmation from the Manufacturer that they have the required skills and certified engineers to support the Intelligent Infrastructure Solution within the Data Centre. Installation and Maintenance, D&E, Data Centre and Intelligence.
 - Contractor shall submit a resume of qualification with the Contractor's proposal indicating the following:
 - A list of recently completed projects of similar type and size with contact names and telephone numbers for each.
 - A list of test equipment proposed for use in verifying the installed integrity of metallic and fibre optic cable systems on this project.
 - A technical resume of experience for the contractor's Project Manager and on-site installation supervisors who will be assigned to this project.
 - A list of technical product training attended by the contractor's personnel that will install the SCS system.
 - Any sub-Contractor, who will assist the SCS contractor in performance of this work, shall have the same training and certification as the SCS contractor.

Cable Pathway

Extension of all data and voice cables shall be within raceway, conduit, cable tray or other designated cable delivery system provided and installed by the (CONTRACTOR) contractor where concealed in walls and exposed above ceilings in plenum spaces.

Hardware

Required hardware includes, but is not limited to, termination blocks, fastening devices, data outlets, voice outlets, connectors and all required accessories to comply with this specification.

1.5 Grounding and bonding

All grounding and bonding shall meet the National Electrical Code (NEC®) as well as local codes, which specify additional grounding and/or bonding requirements.

Bonding and Grounding

Communication bonding and grounding shall be in accordance with the NEC® and NFPA. Horizontal cables shall be grounded in compliance with ANSI/NFPA 70 and local

requirements and practices. Horizontal equipment includes cross connect frames, patch panels and racks, active telecommunication equipment and test apparatus and equipment. When required by local code, provide a Telecommunications Bonding Backbone utilizing 25mm.sq or larger bonding conductor that provides direct bonding between equipment rooms and telecommunications rooms (See ANSI/TIA-J-STD-607-A). This is part of the grounding and bonding infrastructure (part of the telecommunications pathways and spaces in the building structure), and is independent of equipment or cabling.

Product warranty and application assurance

The Structured Connectivity Solutions (SCS) Extended Product Warranty and Application Assurance as detailed below

1.6 Extended Product Warranty

- The Extended Product Warranty covers all passive Registered SCS components (i.e., cable and connectivity components that make up the passive data and telecommunications signal transmission infrastructure). “Passive Components” are defined as SCS components that exhibit no gain or contribute no energy. The manufacturer warrants, from the original installation completion date, the following:
- that the Passive Components of Registered SCS will be free from manufacturing defects in material and workmanship under normal and proper use;
- that all Passive Components in the SCS meet or exceed the Category 6E component specification of the ANSI/TIA-568-C series of standards;
- that the Registered SCS installation will meet or exceed the Category 6E permanent link requirements of ANSI/TIA-568-C series of standards;
- that the Registered SCS installation will meet or exceed the Category 6E channel requirements of ANSI/TIA-568-C series of standards and ISO/IEC 11801, Amendment 1, Class EA standard;
- that the Registered SCS will additionally meet or exceed the Guaranteed Channel Performance in the SCS Performance Specifications Addendum in effect at the time of installation.
- Under the Extended Product Warranty, the manufacturer will (or will authorize a registered installer to) either repair or replace the defective Registered SCS product at the manufacturers cost. The manufacturer will pay a registered installer for the cost of labour to repair or replace any such defective product on behalf of the manufacturer, provided, that such repair or replacement and associated labour costs receive the prior written approval of the manufacturer.

Application Assurance

- The Application Assurance covers the Registered SCS to support operations of the application(s) that the system was designed to support, as well as the additional supported application(s) defined below.

- The Application Assurance also covers the following additional applications: in accordance with application standards specifications, any application introduced in the future by recognized standards or user forums that use the relevant ANSI/TIA-568-C series or ISO/IEC 11801 link/channel specifications for cabling, to the extent that such applications are defined to operate over the guaranteed channel performance and/or the installed channel topologies.

Term of Warranty

- Twenty years from the date of issuance of the registration certificate or installation, whichever is earlier.
- Moves, additions, or changes are covered by the original registration certificate if performed by a register installer of the manufacturer.

1.7 Special requirements for cable routing and installation**Cabling**

- All communications cabling used throughout this project shall comply with the requirements as outlined in the National Electric Code (NEC®) Articles 725, 760, 770, and 800 and the appropriate local codes.
- All balanced twisted pair cabling shall bear CMP (Plenum Rated), CMR (Riser Rated) and/or appropriate markings for the environment in which they are installed.
- All fiber optic cabling shall bear OFNP (Plenum Rated), OFNR (Riser Rated) and/or appropriate markings for the environment in which they are installed.

Cable Pathway

- In suspended ceiling and raised floor areas where duct, cable trays or conduit are not available, the Contractor shall bundle, in bundles of 50 or less, horizontal cabling with cable ties snug, but not deforming the cable geometry.
- Cable bundles shall be supported via "J" hooks attached to the existing building structure and framework at a maximum of five (5) foot intervals.
- Plenum rated cable ties shall be used in all appropriate areas.
- The contractor shall adhere to the manufacturers' requirements for bending radius and pulling tension of all data and voice cables.
- Cables shall not be attached to lift out ceiling grid supports or laid directly on the ceiling grid.
- Cables shall not be attached to or supported by fire sprinkler heads or delivery systems or any environmental sensor located in the ceiling air space.

Contractor Responsibility

The contractor shall be responsible for damage to any surfaces or work disrupted as a result of his work. Repair of surfaces, including painting, shall be included as necessary.

Work external to the building

- Any work external to the confines of this building and going to nearest handhole of broadband network of B.C.D as shown on the drawings shall be governed by the provisions of this specification and the applicable drawings.
- Only cabling products approved by the manufacturer for outside use shall be installed in locations external to the confines of the building.

Separation from EMI Sources:

- Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded/ shielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
- Separation between open communications cables or cables in nonmetallic raceways and unshielded/ shielded power conductors and electrical equipment shall be as follows:
 - Electrical Equipment Rating Less Than 2 kVA: A minimum of 127 mm.
 - Electrical Equipment Rating between 2 and 5 kVA: A minimum of 300 mm.
 - Electrical Equipment Rating More Than 5 kVA: A minimum of 610 mm.
- Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - Electrical Equipment Rating Less Than 2 kVA: A minimum of 610 mm.
 - Electrical Equipment Rating between 2 and 5 kVA: A minimum of 150 mm.
 - Electrical Equipment Rating More Than 5 kVA: A minimum of 300 mm.
- Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - Electrical Equipment Rating between 2 and 5 kVA: A minimum of 76 mm.
 - Electrical Equipment Rating More Than 5 kVA: A minimum of 150 mm.
- Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 1200 mm.
- Separation between Communications Cables and Fluorescent Fixtures: A minimum of 127 mm.

PART 2 – PRODUCTS**2.1 Materials and Equipment**

- A. Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to installation. Materials and equipment shall conform to the respective publications and other requirements specified below and to the applicable requirements of NFPA 70.

2.2 GENERAL WIRING

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

CM Communications cable

CMP Plenum – rated communications cable

CMR Riser – rated communications cable

- E. Initial cable inspection: The contractor shall inspect all cable prior to installation to verify that it is identified properly on the reel identification label, that it is of proper gauge, containing the correct number of pairs, etc. Note any buckling of the jacket that would indicate possible problems. Damaged cable or any other components failing to meet specifications shall not be used in the installation.

2.3 Communications Cable Management and Ladder Rack**Cable Management**

- A. Vertical cabinet cable management, comply with the following:
- Construction: Patch cords shall be organized by rack-mount space, enabling an easier tracing of individual cables during moves, additions, and changes.
 - Frame: High strength aluminum
 - Cable openings: 1 RU (44.5 millimeters [1.75 inches]) high openings, edge-protected cable ports, and slots for cable straps. Cable openings shall align with rack mounting spaces in cabinet.
 - Adjustability: Adjusts front-to-rear along side of cabinet

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- Access: Shall allow back-to-back installation, with provision of front-to-back cable managers
 - Front-to-back cable managers: Telescoping channels shall connect front and rear vertical cable managers
 - Ring vertical cable managers: Mount onto horizontal mounting rails to provide cable management inside cabinet with rounded edge heavy duty plastic rings.
 - Finish: Textured black powder coat

B. Vertical rack cable management, Comply with following specifications:

- Construction: Allows patch cords to be organized by rack-mount space, enabling an easier tracing of individual cables during moves, additions, and changes
- Frame: High strength aluminum
- Cover: Snap-on construction, which opens to left or right
- Cable openings: 1 RU (44.5 millimeters [1.75 inches]) high openings, edge-protected cable ports, and slots for cable straps. Cable openings shall align with rack mounting spaces in cabinet.
- Hardware: Includes square neck carriage bolts for one-handed assembly, along with acorn nuts for section attachment screws to protect cables
- Cable management spools: Shall be provided to support copper and optical fiber patch cords with following features:
 - Construction: High strength aluminum to resist bending or warping under heavy cable loads.
 - Shape: Circular shape with smooth surface to protect cable sheaths and a front plate to hold cables in position. Spools shall comply with TIA/EIA bend radius requirements.
 - Hardware: Pre-tapped for #10-32 machine screws.
 - Finish: Textured black powder coat

C. Horizontal cable management, Comply with following specifications:

- Construction: Made of high strength aluminum, it provides a horizontal pathway for patch cords and multimedia applications using coaxial, copper, and optical fiber cables. Cable manager shall have wide contoured cable guides to separate and organize patch cords, enabling an easier tracing of individual cables during moves, additions, and changes.
- Style: Closed rack-mount trough style, with Square shaped finger openings at top and bottom of trough
- Cable openings: Provides flanged pass-through slots to allow routing of patch cords to rear of rack
- Cable guides: Offset 33 millimeters (1.3 inches) or 66 millimeters (2.6 inches) from front of rack to maintain required bend radius of cabling
- Finish: Textured black powder coat

Cable Runways

- A. General design specifications: Equipment shall be ladder rack style runways designed for use in telecommunications and equipment rooms for providing cable pathways over racks and cabinets. Equipment and accessories shall be constructed of high strength aluminum or steel as specified, with smooth formed surfaces and edges that protect cabling from damage and maintain specified cabling bend radius.
- Construction: Cable runways and related fittings shall be fabricated from high strength welded steel tubing having cross-sectional dimensions 10 millimeters (0.38 inches) by 38 millimeters (1.5 inches), and 1.7 millimeters (0.065 inches) thickness steel.
 - Finish: Cable runways shall have a textured black powder coat
 - Ladder rack system, comply with following specifications:
 - a) Cable runway straight sections: Cross members shall be welded at 30.5 centimeters (12 inches) intervals.
 - b) Cable runway bends: Bend shall consist of 3 cross members welded at approximately 23 degree increments. Cable runway bends shall have either outside or inside bend depending on application.
 - c) Cable runway curves: Shall create 90 degree gradual sweep in horizontal plane for cable runway runs. Runway shall be designed for cabling in conformance with cable bend radius requirements. Cross members shall be welded at approximately 23 degree increments.
- B. Support system accessory: Comply with following specifications: See Appendix 3 for approved manufacturer part #'s.
- Triangular support bracket: Provides wall support for cable runway.
 - Wall angle support: Provide wall support for cable runway with a steel support angle fitting that is cut and drilled to accommodate cable runway width specified or indicated
 - Threaded ceiling support: Provides ceiling support for cable runway
 - Foot support: Provides wall or floor support for cable runway, as selected in field
- C. Wall-to-rack accessory: Comply with following specifications:
- General design: Provide a flexible solution for cable runway support between telecommunications racks and wall surfaces
 - Construction: Accessory shall include cable runway, wall angle support bracket, rack-to-runway mounting plate, end caps, and J anchor bolts.
- D. Radius drop accessory: Comply with following specifications:
- General design: Mount to a cable stringer or runway cross member, as specified or indicated, to maintain minimum acceptable bend radius

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- Construction: Formed sheet steel with 76 millimeters (3 inches) bend radius.
- E. Junction System Accessory: Comply with following specifications: See Appendix 3 for approved manufacturer part #'s.
- General design: Provide a system to mechanically connect sections of cable runway that are spliced together
 - a) Butt splice: Create an end-to-end splice with cable runway
 - b) Junction splice: Create a 90 degree splice with cable runway
 - c) 90 degree runway splice: Create a vertical-to-horizontal splice with cable runway
- F. Elevation accessory: Comply with following specifications: See Appendix 3 for approved manufacturer part #'s.
- General design: Support cable runway above a continuous row of racks or cabinets. Elevation accessory shall provide additional space between tops of racks or cabinets and cable runway, to create a smooth vertical to horizontal transition of cables.
 - Construction: Provide incremental elevation separation adjustable from 76 millimeters (3.0 inches) to 51 millimeters (2.0 inches). It shall be mountable in both perpendicular and parallel orientation to connected rack or cabinet.
- G. Rack accessory: Includes a single pair of brackets and assembly hardware. It shall attach to top of rack with a rack-to-runway mounting plate.
- H. Cabinet accessory: Includes 2 pairs of brackets and assembly hardware. Accessory shall attach directly to top of cabinet.
- I. Miscellaneous accessories: Comply with following specifications: See Appendix 3 for approved manufacturer part #'s.
- General design: Provide closure for cable runway systems to protect supported cabling.
 - End closing kit: Use to close an unspliced end of cable runway. Accessory includes a runway end closing bar, clamp plates, and related hardware.
 - Protective end caps: Use to cover and protect exposed ends of cable runway, reducing chance of personnel injury and equipment damage. Caps shall be constructed from fire-retardant flat black colored rubberized material.
- J. Jumper tray accessory: Comply with following specifications: See Appendix 3 for approved manufacturer part #'s.
- General design: Accessory shall have 2 styles available to provide upper and lower horizontal-to-vertical cable management, to maintain minimum acceptable bend radius.
 - Construction: Strong lightweight aluminum for wall mounting
 - Jumper tray shall:
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- a) Telescope to adjust cable entry and exit positions.
- b) Provide 3.8 centimeters (1 1/2 inches) bend radius for compliant installation of cabling. It shall have slotted holes allowing bend radius location to be adjusted.

Communications Backbone Cabling

Communications Copper Backbone Cabling

General Requirements

- A. Provide Multi-paired trunk backbone cable for all voice backbone applications where indicated on plan. Provide sufficient pair count to support 100% expansion at the outlet locations.

- B. **CAT 3 UTP cable specifications (for voice feeders) & subfeeders**

Die-electric

- C. **Materials** **Riser**

Primary Insulation	PVC
Overall Jacket	Flame retardant thermoplastic

- D. **Electrical Characteristics**

Characteristics impedance	100±15Ω (0.772 to 16MHz)
Maximum resistance unbalance	5%
Maximum capacitance unbalance	330 pF/100meters
Maximum delay skew	45ns /100meters

- E. **Transmission specifications**

Freq. (MHz)	INS. LOSS (dB/100m)	Next loss (dB)	ACR (dB)	Structural return loss (dB)
1	2.6		38.7	12.0
4	5.6		26.7	12.0
8	8.5		19.3	12.0
10	9.7		16.6	12.0
16	13.1		10.1	12.0

Category 6/Class E Twisted-Pair (UTP) Cable for Voice and Data

- A. General specifications: Cable shall have a round overall cable geometry with Mylar[®] bisector tape, and 4 pairs of #23 AWG (0.574 millimeters) bare copper.. Cable color shall be specified or selected by Owner's Representative from manufacturer's standard colors.
- B. Basis for Design Specification: 3M Cat 6E UFTP cable – See Appendix 3 for specific product numbers
- C. Construction specifications (by type):
 - 1. LSZH cable: Solid copper conductors with non-halogen high-density polyethylene (HDPE) insulation and a low smoke, zero halogen, compound jacket to achieve a LSZH rating by applicable IEC standards
 - 2. OSP outdoor cable rated for wet locations: Solid copper conductors with polyethylene insulation, polyolefin fluted center member with flooding compound, and black polyethylene jacket
- D. Comply with following general physical specifications:
 - 1. Maximum pulling tension: 110 Newton's (25 pound-force)
 - 2. Operating temperature: –20 to 60 degrees C [–4 to 140 degrees F]
- E. Channel performance: Comply with following cable performance specifications. Data shall be guaranteed performance for worst-case channels utilizing 4-pair series cables with full cross-connects, CPs, and work area outlets (i.e., 4 connectors in a channel) for length up to 100 meters (328 feet).

Electrical performance

Frequency (MHz)		4	10	20	62,5	100	250	500	550**
Attenuation (max) (dB/100 m)	Typical value	3,6	5,6	8	14,2	18,1	28,9	41,2	43,5
	Cat 6A* (min.)	3,8	5,9	8,4	15	19,1	31,1	45,3	-
NEXT (dB)	Typical value	90	90	82	75	72	65	60	59
	Cat 6A* (min.)	65,3	59,3	54,8	47,4	44,3	38,3	33,8	-
PSNEXT (dB)	Typical value	87	87	79	72	69	62	57	56
	Cat 6A* (min.)	63,3	57,3	52,8	45,4	42,3	36,3	31,8	-
ELFEXT (dB)	Typical value	80	80	77	71	67	52	46	45
	Cat 6A* (min.)	58	50	44	34,1	30	22	16	-
PS ELFEXT (dB)	Typical value	77	77	74	68	64	49	43	42
	Cat 6A* (min.)	55	47	41	31,1	27	19	13	-
Return Loss (dB)	Typical value	25	26	26	23	22	19	16,7	16
	Cat 6A* (min.)	23	25	25	21,5	20,1	17,3	15,2	-
PS ANEXT (dB)	Typical value	85	85	85	85	80	73	68	67
	Cat 6A* (min.)	76,5	72,5	69,5	64,5	62,5	56,5	52	-

* Category 6a acc. Draft IEC 61156-5 Ed.2

** Only for information

F. Standards compliance:

1. General standards: Comply with applicable standards referenced in Division 01, Section 01 42 19
2. Comply with following application standards:
 - a) Voice, facsimile, modem, Switched 56, T-1, and ISDN
 - b) RS-232, RS-422, and RS-485
 - c) IEEE 802.3 1Base5, 10BaseT, 100BaseT, 1000BaseT, and 10GBaseT
 - d) IEEE 1394B transfer modes S100 and S400
 - e) IEEE 802.5 (token ring) at 4 megabits per second and 16 megabits per second at 100 meters (328 feet)
 - f) TP-PMD technology at 100 megabits per second
 - g) ATM at 155 megabits per second, 622 megabits per second, and 1 gigabit per second using parallel transmission schemes
 - h) AES/EBU digital audio and 270 megabits per second digital video
 - i) 77 channels (550 megahertz) of analog broadband video
3. Comply with following BAS application specifications:

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- a) Operating voltages for dry locations: 0 to 30 Vac at 60 hertz, 0 to 70.7 Vac for audio frequencies, and 0 to 60 Vdc
 - b) Operating currents at 25 degrees C (77 degrees F) ambient temperature
 - (1) 1 current-carrying pair per cable: 1.5 amperes on each conductor
 - (2) 2 to 4 current-carrying pairs per cable: 3.36 amperes for all pairs
 - (3) Audio frequencies and 1 current-carrying pair per cable: 1 ampere on each conductor

Communications Copper Cable Splicing and Terminations

A. Equipment Support Cabinet

- 1. Fully enclosed, lockable, modular steel construction and treated to resist corrosion
- 2. IDF cabinet shall be wall mount, swing type and provide 19 inch rack mounting
- 3. Rack shall be designed to allow for left or right hand swing. Minimal dimensions shall be 60cm x 60cm x 60cm.
- 4. Cabinet shall be mounted on ply wood backboard.

B. Equipment Racks for IDF /MDF

- 1. Floor mounted close frame:

Floor mounted equipment racks shall be aluminum relay racks with uprights to mount equipment 480mm (19 inches) wide. Uprights shall be 75mm deep channel, 32mm wide, drilled and tapped 12-24 in a 13mm patten. Racks shall be provided with a standard top cross-member, and predrilled base plate to allow floor fastening. Close frame equipment racks shall be 2.1m in height and painted black. AC outlets shall be provided as shown.

- 2. Cable Guides:

Cable guides shall be specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 480mm (19inch) equipment racks. Cable guides shall consist of ring or bracket-like devices mounted on rack panel for horizontal use or individually mounted for vertical use. Cable guides shall mount to racks by screws and /or nuts and lock washers.

- 3. Equipment Mounting Backboard:

Plywood backboards shall be provided, sized as shown, painted with white or light colored paint.

C. Category 5 Multi-Pair Patch Panels (shown as TC on drawings)

1. General specifications: Construct patch panel of high strength steel with black powder finish and design for wall or 19-inch rack mounting. Panels shall be available in 25-pair and 50-pair configurations, with height of 1 RU of 44.5 millimeters (1.75 inches) for each group of 24 ports. Unit shall accommodate vertical and horizontal cord organizers available to facilitate patch cord management.
 - a) Provide 8-pin RJ-45 modular patch jacks on the front of the panel and 50-pin female patch connections on the back
2. Comply with following standards:
 - a) TIA/EIA-568-B.1
 - b) TIA/EIA-568-B.2
 - c) ISO/IEC 11801
 - d) CENELEC EN-50173
3. Application standards: Support application standards specified for related cabling.
4. Jacks: Comply with jack requirements specified for related cable category.
5. BAS applications: Comply with specifications for related cabling.
6. Performance specifications: Comply with specifications for related cabling.

D. Category 6 Multi-Pair Connectors for patch panel in IDF

1. General specifications: Connectors shall be double ended or single ended. Single-ended cable assemblies shall terminate directly onto back of modular patch panel. Connectors shall be keyed for compatibility with LAN equipment to prevent connection of category 3 cabling assemblies to LAN equipment requiring category 5 performance. Connectors shall meet FCC 47 CFR 68 F requirements and shall comply with following additional requirements:
 - a) Operating temperature: -10 to 60 degrees C (14 to 140 degrees F)
 - b) Contact plating: 0.762 micrometers (30 microinches) lubricated gold plating over 1.27 micrometers (50 microinches) nickel underplate
 - c) Contact force: 100 grams (3.53 ounces)

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- d) Insertion life: 200 insertions minimum
 - e) Direct and individual earthing connection upon insertion of jacks
2. Connector types shall be specified or indicated from following list:
- a) 90 degree plug
 - b) 90 degree jack
 - c) Angled plug
 - d) In-line plug
3. Comply with following standards:
- a) TIA/EIA 568-B.1
 - b) TIA/EIA-568-B.2
 - c) ISO/IEC 11801
4. Comply with following application standards:
- a) Voice, facsimile, modem, Switched 56, T-1, and ISDN
 - b) RS-232, RS-422, and RS-485
 - c) IEEE 802.3 1BASE5 and 10BASE-T
- E. Category 5 Multi-Pair Connectors and Cable Assemblies
1. General specifications: Category 5 multi-pair connectors and cable assemblies consist of 25-pair category 5 multi-pair cables connectorized with either one or two category 5 multi-pair connectors. Category 5 multi-pair connectors shall be compatible with industry standard 25-pair connectors while providing keyed category 5 connections with equipment using this feature. In addition, the connector design using crosstalk reduction techniques shall provide a 6 decibel margin to assure category 5 performances throughout systems that use multiple connectors. See following component requirements:
- a) Category 5 multi-pair cables: Comply with specifications in Category 5 Multi-Pair Solutions.
 - b) Category 5 multi-pair connectors:
 - (1) Comply with specifications above in Category 5 Multi-Pair Solutions.

(2) In-line (180 degree) connectors: Units shall connect to 100BaseT (50-pin category 5) modular patch panel.

(3) Unterminated cables: Unterminated ends of the cable assembly shall terminate directly onto the back of a modular patch panel.

Communications Optical Fiber Backbone Cabling

General Requirements

Special Requirements

50/125 Micron Multimode Optical Fiber Cables

A. General specifications: Cables shall be designed for Point To Point applications as well as mid-span access and shall provide a high level of protection for optical fiber installed in building environment and outside plant (OSP) applications. Higher optical fiber count cables shall utilize a sub-unitized design with color-coded subunits for easy identification.

B. Multimode Optical Fiber Specifications

The multimode fiber cable, patch cords and pigtails shall comply with the TIA TSB-172 and draft ISO/IEC 11801 OM4 specifications. In addition, the fiber cable shall comply with Tables 1 and 2.

Table 1: Multimode Fibre Cable Specifications		
Multimode Fibre Cable Specifications		
Parameters	850 nm	1300 nm
Cable Attenuation, dB/km	≤ 3.0	≤ 1.0
Overfill (OFL) Bandwidth, MHz.km	≥ 3500	≥ 500
Effective Modal Bandwidth (EMB), MHz.km	≥ 4700	≥ 500
Differential Mode Delay (DMD), ps/m	See Table 2	≤ 0.88

Table 2: Additional Multimode Fibre Cable Specifications		
DMD Templates, ps/m		DMD Interval Masks, ps/m
Inner mask for $R_{INNER} = 0 \mu\text{m}$, $R_{ROUTER} = 18 \mu\text{m}$	Outer mask for $R_{INNER} = 0 \mu\text{m}$, $R_{ROUTER} = 23 \mu\text{m}$	For radial intervals: 7 – 13 μm , 9 – 15 μm , 11 – 17 μm , 13 – 19 μm
≤ 0.14	≤ 0.14	≤ 0.11

C. Comply with following cable construction specifications by cable type:

1. Indoor LSZH tight-buffered: Tight buffer optical fibers, aramid strength yarn, and riser-rated outer jacket
2. Indoor LSZH tight-buffered: Tight buffer optical fibers, aramid strength yarn, and plenum-rated outer jacket
3. Indoor armored:
 - a) Interlocking armor spiraling around premises distribution cable, with an overall sheath jacket to provide additional protection and security
 - b) Aluminum armor
 - c) Available with Riser or Plenum-rated outer jacket
 - d) Sheath color-coded to optical fiber type and printed with relevant cable information on cable
4. OSP loose tube dielectric:
 - a) Design: Dielectric design with PE sheath jacket and no metallic elements to provide environmental protection
 - b) Buffer tubes and optical fibers:
 - (1) Industry standard buffer tubes stranded around a central strength member and compatible with standard hardware, cable routing, and fan-out kits
 - (2) Optical fibers shall be industry-standard color coded and separated into 12-fiber color-coded binder groups surrounded by plastic core tubes
 - c) Water blocking: Water-blocking compound shall be suitable for underground conduit, direct burial, and aerial applications
5. OSP loose tube metallic sheath:
 - a) Design:
 - (1) Metallic sheath design with PE sheath jacket to provide environmental protection
 - (2) Metallic armor of corrugated polymer coated steel tape to provide added crush protection

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- b) Buffer tubes and optical fibers:
 - (1) Industry standard buffer tubes stranded around a central strength member and compatible with standard hardware, cable routing, and fan-out kits
 - (2) Optical fibers shall be industry-standard color coded and separated into 12-fiber color-coded binder groups surrounded by plastic core tubes
 - c) Water blocking: Water-blocking compound shall be suitable for underground conduit, direct burial, and aerial applications
6. Indoor/outdoor tight-buffered:
- a) Design: Dielectric design with fluoropolymer thermoplastic outer sheath jacket and no metallic elements to provide petrochemical resistance, flame propagation, and reduced smoke generation properties
 - b) Optical fiber identification:
 - (1) Optical fibers shall be industry-standard color coded in accordance with ANSI/TIA-598-C
 - c) Water blocking: Dry water-blocking compound shall be suitable for underground conduit, direct burial, and aerial applications. Cable shall not contain gel, filling or flooding compound, grease or other flammable water blocking fluids. The aramid yarns shall be specially prepared with an agent that shall provide waterproof attribute of cable.
 - d) Fire rating: Cable shall be LSZH.
7. Indoor/outdoor loose tube:
- a) Design: Dielectric design with fluoropolymer thermoplastic outer sheath jacket and no metallic elements to provide petrochemical resistance, flame propagation, and reduced smoke generation properties
 - b) Buffer tubes and optical fibers:
 - (1) Industry standard 3 millimeter buffer tubes stranded around a central strength member for protection against thermal expansion and contraction at operational temperature extremes
 - (2) Compatible with standard hardware, cable routing, and fan-out kits
 - (3) Optical fibers shall be industry-standard color coded in accordance with ANSI/TIA-598-C and separated into 12-fiber color-coded binder groups surrounded by plastic core tubes
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- c) Water blocking: Dry water-blocking compound shall be suitable for underground conduit, direct burial, and aerial applications
 - d) Fire rating: Cable shall be LSZH.
8. OSP central tube dielectric:
- a) Design: Dielectric design with medium-density polyethylene (MDPE) sheath jacket with longitudinal polyester ripcords and no metallic elements to provide environmental protection
 - b) Buffer tubes and optical fibers
 - (1) Central tube of polybutylene terephthalate (PBT) material, containing all optical fibers, with 2 dielectric longitudinal outer strength members extending length of cable and industry-standard color coding
 - c) Water blocking: Water-blocking compound suitable for underground conduit, direct burial, and aerial applications
9. OSP central tube metallic sheath:
- a) Design:
 - (1) Metallic sheath design with MDPE sheath jacket to provide environmental protection
 - (2) Metallic armor of corrugated polymer coated steel tape to provide added crush protection
 - b) Buffer tubes and optical fibers: Central tube of PBT material, containing all optical fibers, with 2 metallic longitudinal outer strength members extending length of cable and industry-standard color coding
 - c) Water blocking: Water-blocking compound suitable for underground conduit, direct burial, and aerial applications
- D. Performance specifications: Refer to tables under Composite Multimode/Singlemode Optical Fiber Cable for physical, environmental, and performance specifications.
1. Comply with following standards:
- a) Bellcore, fiber distributed data interface (FDDI), and EIA standards
 - b) ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable

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- c) Telcordia's Generic Requirements for Optical Fiber and Optical Fiber Cable
 - d) Telcordia requirements for superior armored cable
 - e) TIA/EIA-568-B.1
 - f) TIA/EIA-568-C.3
 - g) ISO/IEC 11801
 - h) CENELEC EN-50173
2. The cable shall couple sufficient power from light emitting diode (LED) sources to support legacy applications such as Ethernet, token ring, FDDI, Fast Ethernet, and ATM. In addition, 50 micrometer core size shall be directly compatible with laser-based applications, as follows:
- a) Ethernet from 10 megabitsper second to 10 gigabits per second
 - b) Fiber channel from 1 to 10 gigabits per second
 - c) ATM/synchronous optical networking (SONET)/synchronous digital hierarchy (SDH) from OC-1 to OC-192

50 Micron Multimode Optical Fiber Cords and Pigtails

- A. General: To maintain channel integrity, optical fiber patch cords and pigtails shall be fabricated to meet the performance parameters corresponding to the optical fiber cable approved product type specified below. Patch cord and pigtail plug connectors shall be equipped with boots, and shall have same colors as related optical fiber backbone cables, unless specified or indicated otherwise.
- B. Basis for Design Specification: Multimode Patch Cord/Pigtail Assemblies
- C. Optical fiber patch cords and pigtails shall be available with the following options as specified or indicated:
 - 1. Termination types: LC, SC, or ST
 - 2. Connector/cable configuration: Simplex and duplex
 - 3. Fire ratings: Low Smoke Zero Halogen (LSZH)
 - 4. Patch cord outside diameters: 1.6 millimeters (0.063 inches) and 3.0 millimeters (0.118 inches)

5. Pigtails: Ruggedized and tight-buffered optical fiber, 0.9 millimeters (0.035 inches) outside diameter
6. Lengths: As specified or indicated

Composite Multimode/Single mode Optical Fiber Cable

- A. General specifications: Composite cables shall meet physical, performance, and standards compliance specifications for corresponding optical fiber cable types/configurations specified, along with jacket and sheath properties specified.
- B. See following table for performance specifications.

Optical fiber performance specifications										
Optical specifications		Units	Tolerance	Tight buffered		Loose tube		Tight buffered		Loose tube
				850 nm	1300nm	850 nm	1300nm	1310 nm	1550nm	1310 nm1550nm
550 mm	Attenuation/loss	dB/km	NA	3.00	1.00	3.00	1.00	NA	NA	NA
	Bandwidth (overfilled)	MHz-km	NA	3500	NA	3500	NA	NA	NA	NA
	Bandwidth (laser)	MHz-km	NA	4700	NA	4700	NA	NA	NA	NA
	1 Gb/s Ethernet	m	NA	1100	NA	1100	NA	NA	NA	NA
	10 Gb/s Ethernet	m	NA	NA	NA	NA	NA	NA	NA	NA
300 mm	Attenuation/loss	dB/km	NA	3.00	1.00	3.00	1.00	NA	NA	NA
	Bandwidth (overfilled)	MHz-km	NA	1500	NA	3500	NA	NA	NA	NA
	Bandwidth (laser)	MHz-km	NA	2000	NA	4700	NA	NA	NA	NA
	1 Gb/s Ethernet	m	NA	1000	NA	1000	NA	NA	NA	NA
	10 Gb/s Ethernet	m	NA	NA	NA	NA	NA	NA	NA	NA
150 MM	Attenuation/loss	dB/km	NA	3.00	1.00	3.00	1.00	NA	NA	NA
	Bandwidth (overfilled)	MHz-km	NA	NA	NA	3500	NA	NA	NA	NA
	Bandwidth (laser)	MHz-km	NA	NA	NA	4700	NA	NA	NA	NA
	1 Gb/s Ethernet	m	NA	NA	NA	NA	NA	NA	NA	NA
	10 Gb/s Ethernet	m	NA	NA	NA	NA	NA	NA	NA	NA
SM	Attenuation/loss	dB/km	NA	NA	NA	NA	NA	0.400	0.300	0.400 0.300
	Differential mode delay	ps/m	NA	NA	0.88	NA	0.88	NA	NA	NA
	Numerical aperture		+0.015-0.010	0.200	0.200	0.200	0.200	NA	NA	NA
	Point discontinuities	dB	NA	0.15	0.15	0.15	0.15	0.10	0.10	0.10
	Zero dispersion wavelength	nm	range	1297-1316				1302-1322		
	Zero dispersion slope	ps/nm ² -km	NA	0.101	0.101	0.101	0.101	0.090	0.090	0.090
	Effective group index of refraction	-	-	1.482	1.478	1.482	1.478	1.466	1.467	1.466
	Mode field diameter	um	± 0.3	NA	NA	NA	NA	NA	10.4	10.4
	Maximum dispersion @ 1285-1330 nm	ps/nm-km	NA	NA	NA	NA	NA	NA	18.0	18.0
	Polarization mode dispersion LDV	ps/(km)1/2	NA	NA	NA	NA	NA	0.06	0.06	0.06
	Physical specifications									
	Core non-circularity	%	NA	NA	NA	NA	NA	NA	NA	NA
	Core/cladding concentricity error	um	NA	NA	NA	NA	NA	NA	NA	NA
	Coating/cladding concentricity error	um	NA	NA	NA	NA	NA	12	12	12
	Macro bending—100 turns on 75 mm	dB	NA	NA	NA	NA	NA	NA	NA	NA
	Cladding non-circularity	%	NA	NA	NA	NA	NA	NA	NA	NA
	Core diameter	um	± 2.5	50	50	50	50	NA	NA	NA
	Cladding diameter	um	± 1	NA	NA	NA	NA	NA	NA	NA
	Coated fiber diameter—uncolored	um	± 10	NA	NA	NA	NA	NA	NA	NA
	Colored fiber diameter	um	± 7	NA	NA	NA	NA	NA	NA	NA
	Proof test levels	NA	NA	0.69	0.69	0.69	0.69	0.69	0.69	0.69
	Dymanic fatigue diameter	nd	NA	18	18	18	18	18	18	18
	Core/cladding offset	um	NA	NA	NA	NA	NA	NA	NA	NA
	Coating/cladding offset	um	NA	NA	NA	NA	NA	12	12	12
	Fiber curl	m	NA	NA	NA	NA	NA	4	4	4
	Macro bending—100 turns on 50 mm mandrel	dB	NA	0.50	0.50	0.50	0.50	0.05	0.05	0.05
	Macro bending— 1 turn on 32 mm mandrel	dB	NA	NA	NA	NA	NA	0.05	0.05	0.05
	Mechanical/environmental specifications									
	Bending radius—cable (installation)	diameter	NA	20	20	20	20	20.0	20.0	20.0
	Bending radius—buffered fiber	mm	NA	19	19	19	19	19.0	19.0	19.0
	Buffering	um	NA	NA	NA	NA	NA	NA	NA	NA
	pulling tension	kg	NA	90	90	90	90	90	90	90
	Storage temperature	degrees C	range	-40-70	-40-70	-40-70	-40-70	-40-75	-40-75	-40-75
	Operating temperature (test method FOTP-3)	degrees C	range	-40-70	-40-70	-40-70	-40-70	-40-70	-40-70	-40-70
	Installation temperature	degrees C	range	0-70	0-70	20-70	20-70	-30-60	-30-60	-30-60
	Crush resistance (test method FOTP-41)	N/mm	NA	10	10	44	44	10	10	44
	Impact resistance	NA	exceeds	20 @ 2.94	20 @ 2.94	FOTP-25	FOTP-25	NA	NA	FOTP-25
	Flexing	standard	exceeds	FOTP-104	FOTP-104	FOTP-104	FOTP-104	FOTP-104	FOTP-104	FOTP-104
	Twist bend	standard	exceeds	FOTP-85	FOTP-85	FOTP-85	FOTP-85	FOTP-85	FOTP-85	FOTP-85
	Coating strip force	N	range	1.3-8.9	1.3-8.9	1.3-8.9	1.3-8.9	1.3-8.9	1.3-8.9	1.3-8.9
	Temperature dependence (-60 -85 degrees C)	dB	NA	NA	NA	NA	NA	0.05	0.05	0.05
	Temperature/humidity cycling (-60-85 degrees C; 95% RH)	dB	NA	NA	NA	NA	NA	0.05	0.05	0.05
	Water immersion (23 degrees C)	dB	NA	NA	NA	NA	NA	0.05	0.05	0.05
	Heat aging (85 degrees C)	dB	NA	NA	NA	NA	NA	0.05	0.05	0.05
	Dynamic fatigue parameter	nd	NA	18	18	18	18	18	18	18

High-Density, Pre-terminated, Modular Optical Fiber Patching System (in main core switch room)

- A. General specifications: Provide high-density, factory terminated, factory tested, modular optical fiber connectivity system solution that allows quick connection of system components. Shelves and panels shall accommodate 50 micrometers laser-optimized multimode and singlemode optical fiber cabling. System shall consist of shelves and modules. General features shall be as follows:
 - 1. 16-fiber type multi-fiber push-on (MPO) connector-based modular design to simplify connections
 - 2. Modules constructed with 50 micrometer multimode or 9 micrometer singlemode high bandwidth optical fiber to provide headroom for future system upgrades
 - 3. Factory-terminated and tested modules for instant field connections and consistent quality and performance
 - 4. Each module shall have a dual footprint polarity labeling scheme to allow use of a single module for each end of optical fiber channel.
 - 5. Special or non-standard polarity components shall not be permitted.
 - 6. Automatic shutters for LC adapters
 - 7. System shall be UL listed and labeled
- B. Modules: Provide modules described as follows:
 - 1. 24 port LC-LS/SM Module: Includes 12 pre-installed duplex LC adapters at front routed to 2 pre-installed 12-fiber MPO adapters at back. Provide spring-loaded shutters for improved dust prevention and occupational safety.
 - 2. MPO Module: MPO module includes a panel that can handle up to 4 MPO adapters that allow for direct connections with MPO equipment for parallel applications.
 - 3. Blank cover: Provide for all unused module compartments
- C. Modular Shelf Specifications:
 - 4. High-capacity modular shelf: Modular shelf style assembly shall accommodate combinations of up to 4 DM2 modules in each 1U.
 - a) Trunk cable storage clips

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- b) Labels for network mapping
 - c) Universal shelf mounting brackets and hardware for 482.6 millimeters (19.0 inches), 584.2 millimeters (23.0 inches), or European Telecommunications Standards Institute (ETSI) frame mounting
 - d) Labels for network mapping
 - e) Following dimensions:
 - (1) Depth: 279 millimeters (11.0 inches)
 - (2) Overall height: 4 RU (178 millimeters [7.0 inches])
 - (3) Overall width: 482.6 millimeters (19.0 inches)
- D. Pre-terminated cables and cords: Pre-terminated trunk cables and equipment/cross-connect cords shall provide following configurations in 50 micrometer multimode and 8.3 micrometer singlemode, with appropriate lengths, features, and configurations. Provide pulling eyes for 12-fiber ribbon cables and for all types of round cables.
- 1. Comply with following specifications:
 - a) Trunk cables:
 - (1) Ribbon (IPR type): Construct from 12-fiber ribbons in flat sheaths and factory terminations on both ends with 12-fiber female MPO connectors. Cables shall be plenum-rated and available in 12- and 24-fiber versions.
 - (2) Round (IPD type): Construct from multiple 12-fiber subunits and factory terminations on both ends with 12-fiber female MPO connectors. Each 12-fiber subunit shall have protective oversheath, with lengths of breakout oversheaths having staggered construction for ease in handling. Maximum length breakout over-sheaths shall be 33 inches. Cables shall be plenum-rated and available in 12- 24-, 48-, 72-, 96-, and 144-fiber versions.
 - b) Equipment cords: Construct from 12-fiber ribbon cables, with a female MPO connector on one end (for connecting to transceiver) and a male MPO connector on other end (for connecting to trunk cable).
 - c) Cross-connect cords: Construct from 12-fiber ribbon cables, with male MPO connectors on both ends (to cross-connect trunk cables through MPO modules).

- d) Ruggedized fan-out cables: Construct from 12-fiber ribbon cables (IPR type) or round (IPD type) cables with multiple 12-fiber subunits. Cables shall be protected with aramid yarn and 2.0 millimeters furcation tubing. Provide MPO connector on one end (for connection to patch panel) and individual clipped duplex connectors (LT, SC, or ST as specified) on other end (for direct connection to equipment). Cables shall be LSZH and available in 12-, 24-, 48-, and 72-fiber versions.
 - e) Maximum pulling tension: 670 newtons (150 pounds) for ribbon IPR cable; 670 to 2670 newtons (150 to 600 pounds-force) for round IPD cable
 - f) Maximum pulling tension: 25 pounds
 - g) Operating temperature: 0 to 70 degrees C (32 to 158 degrees F)
 - h) Minimum bend radius: 20 times cable diameter during installation
 - i) MPO connector types: Trunk—female; equipment—female/male; cross-connect—male
 - j) Total termination insertion loss per cable: 1.45 decibels maximum
 - k) Mating durability by EIA 455-21A: <0.2 decibels change per 1,000 remates
 - l) Return loss: >20 decibels change per 1,000 remates for multimode; >55 decibels change per 1,000 remates for singlemode
2. Performance specifications: Refer to following table for performance specifications.

Optical fiber patch panel performance specifications—high-density, pre-terminated, modular fiber patching system

Optical specifications				
Component	50 μm multimode		8.3 μm singlemode	
	Insertion loss (max dB)	Return loss (min dB)	Insertion loss (max dB)	Return loss (min dB)
High-capacity and low-profile modular shelves				
LC modules	1.15	20	1.15	55
SC modules	1.3	20	1.3	55
ST modules	1.3	20	1.3	55
Low-profile high-density panel shelves				
LC panel shelf	1.15	20	1.15	55
SC panel shelf	1.3	20	1.3	56
LC DM module	1.15	20	1.15	57
SC DM module	1.3	20	1.3	58
Ruggedized Fanout Cable				
LC ruggedized fanout	1.15	20	1.15	55
SC ruggedized fanout	1.3	20	1.3	55
ST ruggedized fanout	1.3	20	1.3	55

Component	Attenuation (max dB/km)		Launch	Bandwidth (MHz·km) 50 μm multimode	
	50 μm multimode 150m	300m			
Pre-terminated cables and cords					
IPR ribbon type	3.5 @ 850 nm	3.5 @ 850 nm	0.5 @ 1310 nm	overfilled	
	1.5 @ 1300 nm	1.5 @ 1300 nm	0.5 @ 1385 nm	overfilled	700 @ 850 nm 1500 @ 850 nm
			0.5 @ 1550 nm	laser	500 @ 1300 nm 500 @ 1300 nm
				laser	950 @ 850 nm 2000 @ 850 nm
IPD round type	3.0 @ 850 nm	3.0 @ 850 nm	0.35 @ 1310 nm		500 @ 1300 nm 500 @ 1300 nm
	1.0 @ 1300 nm	1.0 @ 1300 nm	0.32 @ 1385 nm		
			0.24 @ 1550 nm		

3. Comply with following standards:

- a) TIA/EIA-568-B.1
- b) TIA/EIA-568-B.2
- c) ISO/IEC 11801
- d) CENELEC EN-50173

4. Comply with application standards specified for related cabling.

Fiber Optic Patch Panels inside IDF of floor distribution switch

- A. General specifications: Panel shelves shall be used for combination of splicing and termination of optical fiber building cable. Shelf shall be designed for use as termination shelf only (direct connector termination) or as splice and termination shelf. Fiber splice and termination capacities shall be as specified in this section.

- B. Optical fiber connector panel specifications: Provide connector types in simplex or duplex configurations. Panels shall accommodate 50 micrometer multimode, 100 micrometer multimode, and singlemode optical fiber cabling. Comply with following specifications:
1. Pre-populated panels with factory-installed adapters:
 - a) Duplex: 6 or 12 adapters accommodating LC or SC
 - b) Simplex: 6 or 12 adapters accommodating LC, SC, or ST connectors
 2. Unpopulated panels with field-installed adapters:
 - a) Duplex: 6 LC connectors; 3 or 6 SC connectors.
 - b) Simplex: 8 LC connectors; 6 or 8 SC connectors; 6 or 12 ST connectors
 3. Pre-terminated modules with pigtails: 12 LC, 6 SC, or 6 ST adapters for all optical fiber cable types:
 - a) LC modules shall contain 12 pigtails with colored 0.9 millimeters tight-buffered cordages, following color sequence as defined by TIA standard.
 - b) SC and ST modules shall contain 6 pigtails with colored 0.9 millimeters tight-buffered cordages, with following color sequence:
 - (1) Type A: blue, orange, green, brown, slate, and white
 - (2) Type B: red, black, yellow, violet, rose, and aqua
- C. Optical fiber termination module specifications: Modules shall support SC, ST and LC connectors and accommodate 50 micrometer multimode, 62.5 micrometer multimode, and singlemode optical fiber cabling. Modules shall be either unterminated or equipped with pigtails ready for splicing. Provide interchangeable multimedia outlet bezels where specified to accommodate 4 outlets for M-series jacks for multimedia applications. Configurations shall be as follows:
- a) Unterminated modules: 12 LC, 6 SC, or 6 ST adapters for all optical fiber cable types
 - b) Pre-terminated modules with pigtails: 12 LC, 6 SC, or 6 ST adapters for all optical fiber cable types:
 - (1) LC modules shall contain 12 pigtails with colored 0.9 millimeters tight-buffered cordages, following color sequence as defined by TIA standard.

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- (2) SC and ST modules shall contain 6 pigtails with colorized 0.9 millimeters tight-buffered cordages, with following color sequence:
- (a) Type A: blue, orange, green, brown, slate, and white
 - (b) Type B: red, black, yellow, violet, rose, and aqua
- c) Physical specifications:
- (1) High-capacity panel shelf
 - (a) Comply with following specifications:
 - (i) Fixed front faceplate panel shelf style assembly, configured for simplex or duplex optical fiber connectors. Design shall accommodate simplex and duplex configurations of LC, SC and ST connectors and combine both splicing and termination in a sliding format, with full front and rear access to all terminations. Panel interior shall have high reflectance white internal structure with improved visibility for installer. Capacities for connector panels, splices, and OSP cable provisions shall be as follows:
 - (a) Fixed connector panels: 12
 - (b) Splice trays: 6
 - (c) OSP cables: 4
 - (ii) Hinged front and rear doors constructed of black polycarbonate and equipped (rear door) with knockouts for optional lock mechanism
 - (iii) Universal shelf mounting brackets for 482.6 millimeters (19.0 inches), 584.2 millimeters (23.0 inches), or ETSI frame mounting.
 - (iv) Cable entry protectors for incoming building optical fibers
 - (v) Fiber jumper bend limiters
 - (vi) Blank labels for identifying optical fiber splices and terminations
 - (vii) Articulated splicing/termination panel that slides out and pivots for easy access
 - (viii) Dimensions

-
- (a) Overall height: 4 RU (177.8 millimeters [7.0 inches])
 - (b) Overall width (including mounting brackets): 432 millimeters (79.0 inches)
 - (c) Overall shelf depth (including trough): 355.6 millimeters (14 inches)
 - (ix) Splice/termination capacity for each connection type:
 - (a) Termination only: LC—288; SC—144; ST—144
 - (b) Termination plus fusion splicing: LC—192; SC—144; ST—144
 - (c) Termination plus mechanical splicing: LC—192; SC—144; ST—144
 - (2) High-capacity modular shelf
 - (a) Comply with following specifications:
 - (i) Modular shelf style assembly, with interchangeable optical fiber termination modules configured for connectors specified. Design shall accommodate simplex and duplex configurations of LC, SC and ST connectors, and shall combine both splicing and termination in a sliding format, with full front and rear access to all terminations. Panel interior shall have high reflectance white internal structure with improved visibility for installer. Capacities for connector panels, splices, and OSP cable provisions shall be as follows:
 - (a) Termination modules: 12
 - (b) Splice wallets: 2
 - (c) Splice trays: 6
 - (d) OSP cables: 4
 - (ii) Hinged front and rear doors constructed of black polycarbonate and equipped (rear door) with knockouts for optional lock mechanism
 - (iii) Universal shelf mounting brackets for 482.6 millimeters (19.0 inches), 584.2 millimeters (23.0 inches), or ETSI frame mounting
-

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- (iv) Cable entry protectors for incoming building optical fibers
 - (v) Fiber jumper bend limiters
 - (vi) Blank labels for identifying optical fiber splices and terminations
 - (vii) Articulated splicing/termination panel that slides out and pivots for easy access
 - (viii) Dimensions
 - (a) Tray depth: 254 millimeters (10.0 inches)
 - (b) Overall height: 4 RU (177.8 millimeters [7.0 inches])
 - (c) Overall width (including mounting brackets): 432 millimeters (79.0 inches)
 - (d) Overall shelf depth (including trough): 355.6 millimeters (14 inches)
 - (ix) Splice/termination capacity for each connection type:
 - (a) Termination only: LC144; SC72; ST72
 - (b) Termination plus fusion splicing: LC144; SC72; ST72
 - (c) Termination plus mechanical splicing: LC144; SC72; ST72
 - (x) Comply with performance specifications specified for related cabling.
 - (xi) Comply with following standards:
 - (a) TIA/EIA-568-B.1
 - (b) TIA/EIA-568-B.2
 - (c) ISO/IEC 11801
 - (d) CENELEC EN-50173
 - (xii) Patch panel and shelf assembly type shall support application standards specified for related cabling.
-

Fiber Connectors and Adapters

- A. General specifications: Optical fiber connector types shall be provided in patch panels, patch cords, and workstation outlets for termination of optical fiber cables. Connectors shall be compatible with 50 micrometer multimode, 62.5 micrometer multimode, and singlemode optical fiber cables. Connector colors shall be specified or selected by Owner's Representative from manufacturer's standard colors.
- B. Physical specifications:
 - 1. LC connector: Comply with following type LC connector physical specifications:
 - a) One half size (double density) of conventional ST and SC connectors
 - b) Insertion release mechanism similar to RJ45 type plug
 - c) Pull-proof to prevent momentary disconnect from axial loads
 - d) Anti-snag latch that facilitates routing of patch cords
 - e) Field-mountable with minimal polish
 - f) Polarized design
 - g) Operating temperature: –40 to 75 degrees C (–40 to 167 degrees F)
 - h) Mating durability for 500 reconnects insertion loss change: 0.2 decibels maximum
 - i) Temperature stability (–40°C to +75°C) insertion loss change: 0.3 decibels maximum
 - j) Cable retention: 0.91 kilograms (2 pounds) minimum for buffered fiber and 4.5 kilograms (10 pounds) for 1.6 mm jacketed cordage.
 - 2. SC connector: Comply with following type SC connector physical specifications:
 - a) Push-pull connection method
 - b) Crimped to outer hardware, to prevent momentary disconnect when axial load is placed on cable
 - c) Anti-snag latch that facilitates routing of patch cords
 - d) Provide fixed type or field-tunable type as specified

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- e) Operating temperature: –40 to 75 degrees C (–40 to 167 degrees F)
 - 3. STII connector: Comply with following type STII connector physical specifications:
 - a) Bayonet-type optical fiber connector
 - b) Ramped-latching keyed design
 - c) PC polish to ensure optical fiber-to-fiber physical contact for low loss and reflections
 - d) Operating temperature: –40 to 75 degrees C (–40 to 167 degrees F)
 - C. Average insertion losses shall be:
 - 1. LC: 0.10 decibels multimode; 0.10 decibels singlemode (Standard deviation of 0.1 dB)
 - 2. SC: 0.30 decibels multimode; 0.20 decibels singlemode-tuned; 0.30 decibels singlemode-untuned
 - 3. STII: 0.30 decibels multimode and single-mode
 - D. Comply with following standards:
 - 1. TIA/EIA-568-B.1
 - 2. TIA/EIA-568-C.3
 - 3. ISO/IEC 11801
 - 4. CENELEC EN-50173
 - E. Connectors shall support application standards specified for related cabling.

Communications Horizontal Cabling

General Requirements

- A. Horizontal (to desktop) cable shall consist of CAT 6 UTP for Voice applications.
- B. Horizontal cabling to typical data outlets shall consist of Category 6 cables serving each outlet.
- C. Outlets for wall-mounted or other “telephone only” installations shall consist of one Category 5 cable.
- D. Outlets for wireless access points (APs) shall consist of two Category 6 cables as a minimum.

Compliance

- A. All copper and fiber optic cabling shall comply with the latest applicable standards as listed in section 27 02 20.40.
- B. Contractor shall comply applicable codes as listed in 27 02 20.20 and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.

1.5.1 Outlets shall be duplex or triplex as indicated on drawings

Category 6/Class E Outlets

- A. General specifications: Telecommunications jacks shall be 8-position/8-conductor modular outlets accepting industry standard modular RJ45 type plugs and IDC terminations. Universal design shall support T568A and T568B wiring and shall have universal wiring labels, including color-coded insert identification labels to ensure accurate identification. Color shall be specified or selected by Owner's Representative from manufacturer's standard colors. Provide improved pair splitters and wider channel for enhanced conductor placement. Jack shall be backward compatible with lower category cords and cables. Low-profile wire cap shall protect against contamination and secure connection. Jacks shall be suitable for:
 - 1. Modular patching applications or as modular TO
 - 2. Installation without special faceplates at either 45- or a 90-degree angle in manufacturer's modular faceplates and frames, including those on surface-mounted boxes
- B. Basis for Design Specification: 3M VOL-OCK jack
- C. Comply with following physical specifications:
 - 1. Dimensions: 20 millimeters (0.8 inches) width by 20 millimeters (0.8 inches) height by 31 millimeters (1.2 inches) depth
 - 2. Material: High-impact, flame-retardant, UL-rated 94 V-0 thermoplastic
 - 3. Operating temperature: -10 to 60 degrees C (14 to 140 degrees F)
 - 4. Outlet wire contacts: Copper alloy with 1.27 micrometers (50 microinches) hard gold plating over 2.54 micrometers (100 microinches) nickel underplate

5. Connectors: Insulation Displacement Connections shall be industry-standard 110-style Connectors shall accept 0.51 to 0.64 millimeters (0.020 to 0.025 inches), 22 to 24 AWG, stranded conductors or 0.40 to 0.64 millimeters (0.016 to 0.025 inches) 26 to 22 AWG solid conductors with insulation size of 0.76 to 1.17 millimeters (0.030 to 0.046 inches)..
- D. Comply with following mechanical specifications:
 1. Plug/jack contact force: 100 grams (3.53 ounces) minimum per contact using FCC-approved plug
 2. Plug retention force: 133 newtons (30 pounds-force) minimum
 3. Plug insertion life: 750 insertions minimum
- E. Comply with following electrical specifications:
 1. Dielectric withstand voltage: 1000 volts alternating current root mean square, 60 hertz minimum, contact to contact
 2. Insulation resistance: 500 megaohms minimum
 3. Current rating: 1.5 amperes at 20 degrees C (68 degrees F) by IEC 60512-3-1-5b
- F. Comply with following standards:
 1. TIA/EIA-568-B.1
 2. TIA/EIA-568-B.2
 3. ISO/IEC 11801
 4. CENELEC EN-50173
- G. Application standards: Support application standards specified for related cabling.
- H. BAS applications: Comply with specifications for related cabling.
- I. Performance specifications: Comply with specifications for related cabling.

PART 3 - EXECUTION**3.1 GENERAL**

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

3.2 LABELS

- A. The labeling plan shall be developed by the Contractor. The Contractor will label all outlets following the detailed shop drawing design, using permanent/legibly typed or machine-engraved labels approved by the owner. The labeling information for patch panels will include the switch number and patch panel number. Outlets shall be labeled to match the corresponding label in the patch panel all copper/fiber terminations for riser/backbone cables shall be labeled with the patch panel number.
- B. A floor plan clearly labeled with all outlet jack numbers shall be included in the as-built drawings.
- C. All labels shall correspond to as-built and to final test reports.

3.3 STATION WIRING INSTALLATION (VOICE OR DATA STATION)

- A. The Certified Contractor shall supervise the installation of communications cable. All Category 3 (telephone), Category 6 (data) and fiber optic cable shall be installed by individuals trained in low voltage data cable system installations. All Category 3 (telephone), Category 6 (data) four-pair UTP cable must be handled with care during installation so as not to change performance specifications. The Contractor shall not over-tighten tie wraps or over-bend the UTP cable.
- B. Exposed station cable will only be run with owner approval. Approval will be granted only when no other option exists. When station cable must be run surface to a single outlet, surface raceway shall be used to cover the cable.
- C. All cabling and associated hardware shall be placed so as to make efficient use of available space in coordination with other uses. All cabling and associated hardware shall be placed so as not to impair the owner's efficient use of their full capacity.
- D. All cabling placed in ceiling areas must be tied or clamped. When cable is placed in ceiling areas or other non-exposed areas, fasteners shall be placed at intervals no greater than 150cm. Attaching cable to pipes or other mechanical items is not permitted. Communications cable shall be routed to avoid light fixtures (45cm minimum spacing), sources of heat (30cm minimum spacing), and power feeder conduits (30cm minimum spacing).

3.4 STATION HARDWARE

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

3.5 BACKBONE CABLING/EQUIPMENT RACK CONFIGURATION

- A. All cabling shall be routed so as to avoid interference with any other service or system, operation, or maintenance purposes such as access boxes, switches or electrical outlets, electrical panels, and lighting fixtures. Avoid crossing areas horizontally just above or below any riser conduit. Lay and dress cables to allow other cables to enter the conduit/riser without difficulty at a later time by maintaining a working distance from these openings. Use a minimum of 90cm for a service loop to the patch panel.
- B. Cable shall be routed as close as possible to the ceiling, floor, or other corners to ensure that adequate wall or backboard space is available to current and future equipment and for cable terminations. Cables shall not be tie-wrapped to existing electrical conduit or other equipment. The minimum bend radius shall be observed.
- C. Lay cables via the shortest route directly to the nearest edge of the backboard from the mounted equipment or block. Lace or tie-clamp all similarly routed cables together and attach by means of clamps screwed to the outside edge(s) of the backboard vertically and/or horizontally, then route via "square" corners over a path that will offer minimum obstruction to future installations of equipment, backboards, or other cables.
- D. Provide rack and jack panel hardware as required for all data station wiring.
- E. Do not over-tighten cable ties or binding on Category 6E and Category 6E station cable. Observe Category 6E and Category 6E cable bend radius.

3.6 INSTALLATION

System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with ANSI/TIA/EIA-606. Penetrations in fire-rated construction shall be fire stopped in accordance with Section 07840 FIRESTOPPING. Conduits, outlets and raceways shall be installed in accordance with SUB-SECTION 16415 ELECTRICAL WORK, INTERIOR. Wiring shall be installed in accordance with AINSI/TIA/EIA-568-A and as specified in SUB-SECTION 16415 ELECTRICAL WORK, INTERIOR. Wiring, and terminal blocks and outlets shall be marked in accordance with ANSI/TIA/EIA-606. Cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or wire ways shall be properly secured and neat in appearance and, if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

A. Horizontal Distribution Cable:

The rated cable pulling tension shall not be exceeded. Cable shall not be stressed such that twisting, stretching or kinking occurs. Cable shall not be spliced. Fiber optic cables shall be installed either in conduit or through type cable trays to prevent micro bending losses. Cable shall be routed in cable tray or conduit as shown on drawings. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 300 mm (12 inches) shall be maintained when such placement cannot be avoided. Cable shall be terminated; no cable shall contain un-terminated elements. Minimum bending radius shall not be exceeded during installation or once installed. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered.

B. Riser and Backbone Cable:

Vertical cable support intervals shall be in accordance with manufacturer's recommendations. Cable bend radius shall not be less than ten times the outside diameter of the cable during installation and once installed. Maximum tensile strength rating of the cable shall not be exceeded. Cable shall not be spliced.

C. Telecommunications Outlets:**1- Faceplates:**

As a minimum each jack shall be labeled as to its function and a unique number to identify cable link.

2- Cables:

Unshielded twisted pair and fiber optic cables shall have a minimum of 150 mm of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturers bend radius for each type of cable shall not be exceeded.

3- Pull Cords:

Pull cords shall be installed in all conduits serving telecommunications outlets, which do not initially have fiber optic cable installed.

D. Terminal Blocks:

Terminal blocks shall be mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Industry standard wire routing guides shall be utilized.

E. Unshielded Twisted Pair Patch Panel:

Patch panels shall be mounted in equipment racks with sufficient modular jacks to accommodate the installed cable plant plus 10 percent spares. Cable guides shall be provided above, below and between each panel.

F. Fiber Optic Patch Panel:

Patch panels shall be mounted in equipment racks with sufficient ports to accommodate the installed cable plant plus 10 percent spares. A slack loop of fiber shall be provided within each panel. Loop shall be 1000 mm in length. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

G. Equipment Racks:

Open frame equipment racks shall be bolted to the floor slab. Cable guides shall be bolted or screwed to racks. Racks shall be installed level. Ganged racks shall be bolted together. Ganged rack cabinets shall have adjacent side panels removed. Wall mounted racks shall be secured to the mounting surface to prevent fully loaded racks from the mounting surface.

H. Rack Mounted Equipment:

Equipment to be rack mounted shall be securely fastened to racks by means of the manufacturer's recommended fasteners.

3.7 TERMINATION

Cables and conductors shall sweep into termination areas; cables and conductors shall not bend at right angles. Manufacturer's minimum bending radius shall not be exceeded. When there are multiple system type drops to individual workstations, relative position for each system shall be maintained on each system termination block or patch panel.

A. Unshielded Twisted Pair Cable:

Each pair shall be terminated on appropriate outlets, terminal blocks or patch panels. No cable shall be un-terminated or contain un-terminated elements. Pairs shall remain twisted together to within the proper distance from the termination as specified in ANSI/TIA/EIA-568-A. Conductors shall not be damaged when removing insulation. Wire insulation shall not be damaged when removing outer jacketing.

B. Fiber Optic Cable:

Each fiber shall have connectors installed. The pull strength between the connector and the attached fiber shall be not less than 11.3 kg. The mated pair loss, without rotational optimization, shall not exceed 1.0 dB. Fiber optic connectors shall be installed per ANSI/TIA/EIA-568-A.

3.8 ADDITIONAL MATERIALS

The contractor shall provide the following additional materials required for facility startup:

- 1- 10 of each type outlet.
- 2- 10 of each type cover plate.
- 3- 1 of each type terminal block for each telecommunications closet.
- 4- 4 patch cords of 3 m for each telecommunications closet.
- 5- 1 set of any and all special tools required to establish a cross connect and to change and/or maintain a terminal block.

3.9 ADMINISTRATION AND LABELING

A. Labeling

1- Labels:

All labels shall be in accordance with ANSI/TIA/EIA-606.

2- Cable:

All cables will be labeled using color labels on both ends with encoded identifiers per ANSI/TIA/EIA-606.

- B. All workstation outlets and patch panels connections shall be labeled using color-coded labels with encoded identifiers per ANSI/TIA/EIA-606.

3.10 Workmanship

- Components of the SCS system shall be installed in a neat, workmanlike manner.
- Wiring color codes shall be strictly observed and terminations shall be uniform throughout the system.
- Identification markings and systems shall be uniform.
- TIA/EIA568-C wiring codes shall standardize all SCS wiring.

3.11 General description

- The wiring system components shall comply with all product specifications contained in Section two.
- The structured cabling system shall consist of the Work Area, Horizontal, Backbone – Riser, Backbone - Basement, Telecommunications Room (TR)

3.12 Work area

- Wiring and cords
- Contractor shall supply the wiring or cords that connect terminal devices to telecommunications outlets. This includes mounting cords and connectors, as well as extension cords.
- Transmission electronics

-
- Contractor shall supply the necessary transmission electronics equipment listed under "Requirements by Floor" in order to complete the system successfully.

3.13 Horizontal

Horizontal Cabling

- Contractor shall supply horizontal cables to connect each telecommunications outlet in apartment to the communication unit on the same floor.
- Unless otherwise noted on the floor plans or within this document, the type of horizontal cables used for each work location shall be 4-pair Shielded twisted pair (UTP)
- The 4-pair UTP cables shall be run using a star topology format from the (Telecommunications Closet) on each floor outlet of 3 floors to every individual Telecommunication patchpanel cabinet in apartment
- All cable routes to be approved by the consultant prior to installation of the cabling.
- The length of each individual run of horizontal cable from the administration subsystem (Telecommunications Closet) on floors to the Telecommunication communication unit shall not exceed 295 ft (90 m).
- Contractor shall observe the bending radius and pulling strength requirements of the 4-pair UTP cable during handling and installation.
- Each run of cable between the termination block and the telecommunications outlet shall be continuous without any joints or splices.
- In suspended ceiling and raised floor areas where cable trays or conduit are not available, the Contractor shall bundle station wiring with plastic cable ties at appropriate distances.
 - The cable bundling shall be supported via "J" hooks attached to the existing building structure and framework.
- Plenum cable will be used in all appropriate areas.
- If the interior of walls is not obstructed, the Contractor shall conceal horizontal distribution wiring internally within the walls. If such obstructions exist, Contractor shall secure approval by the consultant prior to the use of an alternate method.
- Every effort will be made to schedule the requirements under this Contract in such a manner so as to complete all above ceiling work prior to ceiling tile installation. In the event Contractor is required to remove ceiling tiles, such Work shall not break or disturb grid and must be coordinated with the General Contractor.
- The 4 pair UTP cable shall be Underwriter's Laboratories (UL) listed type MPR, MPP, CMR, or CMP as stated later in this section.
- Contractor shall provide detailed cable run diagrams for cable runs within raised floors detailing exact locations of cable for review and approval by the consultant after coordination with other contractors, architect and general contractor.
- Conduit runs installed by the contractor should not exceed 100 feet or contain more than two 90 degree bends without utilizing appropriately sized pull boxes.
- Station cables and tie cables installed within ceiling spaces shall be routed through these spaces at right angles to electrical power circuits.
- Work location telecommunications outlets
- Supply and install outlets as shown on drawings and as directed by the consultant.

3.14 Riser backbone

Riser Backbone

- Contractor shall supply and install the transmission media and terminating hardware to provide interconnection between the main communication and each floor Telephone closet or closet in a star topology.
- All cable routes to be approved by the consultant prior to installation.
- All fibers will be run in innerduct and terminated in the telephone room or closet with ST or SC type connectors in wall or panel mounted Distribution Shelves equipped with sufficient panels, couplers and jumper storage shelves to terminate and secure all fibers.
- Adequate riser sleeve/slot space is available and/or re-enterable in all TRs such that no drilling of additional sleeves is necessary.
- Contractor shall run the riser cables in a star topology, terminated in the equipment room at one end and in the administration subsystem at the other end.
- Riser and tie cables shall be extended between TRs utilizing the interfloor conduit sleeves.
- The cable shall support voice and data applications.
- Contractor shall observe the bending radius and pulling strength requirements of all backbone cables during handling and installation.

3.15 Telecom Equipment room (Basement)

Terminations

Contractor shall connect the trunk cross-connect and the distribution cross-connect to the common equipment such as PABX or host computer in the equipment room as applicable. Contractor shall be responsible to coordinate with Solidere and Ogero requirements.

Electrical Protection

- Contractor shall supply lightning protectors and wires used to ground the equipment.
- The electrical protection devices supplied by the contractor shall be in multi-pair form.
- For small pair count applications, contractor shall supply electrical protection devices, which consist of a mounting panel for a series of solid-state, or gas-tube protector units and a wiring block. The wiring block shall be used for input and output cable terminations. Insertion of the protector units into the mounting block will complete the circuit.
- The protection devices shall be available in 4, 6, 25, 50 and 100 pair sizes.
- If the electrical protection circuit is separated from the cross-connect field, contractor shall supply protector units consisting of a metal housing containing mountings for a series of solid-state or gas-tube protector units. The protector shall include a 25 foot, 26 AWG stub cable that serves as a fusible link, a 24 AWG terminating cable, and two connectors for external ground connections.

3.16 Administration

The administration subsystem shall consist of wiring blocks and patch panels for termination of balanced twisted pair cables or interconnection units and shelves for the termination of optical fibers.

- All wall field layouts to be approved by the consultant prior to installation.
- Fields
 - Separate termination fields shall be created for voice and data applications.
- Termination blocks
 - Termination blocks that require rotation after connection of horizontal/vertical wiring shall not be allowed.
- Cross-connect wire, patch cords
 - Contractor shall supply cross-connect wire, balanced twisted pair and fiber patch cords for cross-connection and inter-connection of termination blocks, patch panels, fiber shelves and interconnection units.

3.17 Installation

All installation shall be done in conformance with ANSITIA-568-C standards, federal and local standards and Vendor Design and Installation guidelines.

- The Contractor shall ensure that the maximum pulling tensions of the specified distribution cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines will require the Contractor to provide in a timely fashion the additional material and labor necessary to properly rectify the situation. This shall also apply to any and all damages sustained to the cables by the Contractor during the implementation.

3.18 Firestop systems

A firestop system is comprised of: the item or items penetrating the fire rated structure; the opening in the structure and the materials and assembly of the materials used to seal the penetrated structure. Fire stop systems comprise an effective block for fire, heat, vapor and pressurized water stream.

All penetrations through fire rated building structures (walls and floors) shall be sealed with an appropriate fire stop system. This requirement applies to through penetrations (complete penetration) and membrane penetrations (through one side of a hollow fire rated structure). Any penetrating items i.e., riser slots and sleeves, cables, conduit, cable tray, and raceways, etc... shall be properly fire stopped.

3.19 Grounding and bonding**A. Product Specifications:**

All racks, metallic backboards, cable sheaths, metallic strength members, splice cases, cable trays, etc. entering or residing in the Telecom closet shall be grounded to the respective TGB or TMGB using a minimum 25mm² stranded copper bonding conductor and compression connectors. Where metallic panels attached to the rack do not have sufficient metal to metal contact to provide an adequate path to ground, they shall be bonded to the rack using a minimum 4mm² AWG copper conductor. The copper conductor size shall be upgraded based on the largest power conductor feeding any rack mount equipment. The conductor shall be continuous; attaching all isolated components in a daisy chain fashion from top to bottom and bonded to the rack using an appropriate compression connector.

All wires used for telecommunications grounding purposes shall be identified with a green insulation. Non-insulated wires shall be identified at each termination point with a wrap of green tape. All cables and bus bars shall be identified and labeled in accordance with the System Documentation Section of this specification.

B. Ground System Installation:

The TBB shall be designed and/or approved by a qualified PE, licensed (actual or reciprocal) in the state that the work is to be performed. The TBB shall adhere to the recommendations of the TIA/EIA-607 standard, and shall be installed in accordance with best industry practices. Installation and termination of the main bonding conductor to the building service entrance ground, at a minimum, shall be performed by a licensed electrical contractor.

3.20 Main Telecommunications Room

The telecommunication room shall house racks, voice termination fields and required cable routing hardware. Racks shall be placed in a manner that will allow a minimum of 3 feet of clearance from the front and rear mounting surfaces and on one side. If one mounting rail of the rack is placed against a wall, the mounting rail shall be no closer than 6" to the wall to allow room for vertical management. Where there is more than one rack, the racks shall be ganged with vertical management hardware to provide interbay management. Ganged rack frames will be placed in a manner that will allow a minimum of 3 feet of clearance from the front and rear mounting surfaces and on one side of the ganged assembly.

Backbone termination fields shall be mounted to the left of the horizontal voice fields. Conduits a minimum of 4" in diameter shall be used in all closets. Conduits for data backbone shall be located adjacent to the racks and conduits for voice shall be located adjacent to the voice termination fields. The contractor shall provide Inner duct for all backbone fiber runs. Contractor shall provide required ladder and wall mount management rings to properly support and dress cables from conduits to racks and frames.

A. Installation Specifications:

Racks shall be installed in the following manner:

- Racks shall be securely attached to the concrete floor using 3/8” hardware
- All racks shall be grounded to the telecommunications ground bus bar in accordance with Section 9.0 of this document.
- Rack mount screws (#12-24) not used for installing fiber panels and other hardware shall be bagged and left with the rack upon completion of the installation.

Power Separation

The cabling vendor shall provide power separation guideline documentation for the Contractor.

Miscellaneous Equipment

The Contractor shall provide any necessary screws, anchors, clamps, tie wraps, distribution rings, wire molding (MC & TR locations), miscellaneous grounding and support hardware, etc., necessary to facilitate the installation of the System.

Special Equipment and Tools

It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the System.

- Tools shall include, but are not limited to:
 - tools for terminating cables,
 - testing and splicing equipment for balanced twisted pair/fiber cables,
 - communication devices,
 - jack stands for cable reels,
 - Cable wenchers.

Labeling

- The Contractor shall be responsible for printed labels for all cables and cords, distribution frames, and outlet locations, according to specifications i.e., 2N-001-V, 2N-001-D1, 2N-001-D2 at the time of delivery.
- Labels shall not be written by hand.

Cable Storage

The Contractor shall not roll or store cable reels without an appropriate underlay and the prior approval of the consultant, or it's General Contractor.

Cable Records

The Contractor shall maintain conductor polarity (tip and ring) identification at the main equipment room (switch room), risers, and station connecting blocks in accordance with industry practices, but only in locations authorized by Company's General Contractor, Consultant Company, and Architect.

Engineering

Planning meetings and schedule

- An initial planning meeting will be held with the successful bidder to:
 - Clarify all requirements (systems, services, distribution methods, etc.),
 - Identify responsibilities,
 - Schedule the events that will transpire during the implementation of the project.
- Within two (2) weeks of the initial meeting, the contractor shall provide a written report and project schedule to clearly document the events and responsibilities associated with the project.

Drawings and review

In order to start the initial engineering phase, the consultant shall provide the Contractor with one (1) clearly readable, up-to-date scale copy of all architectural, electrical, and mechanical drawings, two (2) weeks prior to the commencement of any engineering design activities. This will allow for a one (1) week review of the diagrams by the Contractor, and allow one (1) week for the customer to answer any queries pertaining to the Contractor's review. In reviewing such drawings Contractor shall be obligated to make an on-site inspection with the customer and its General Contractor for on-site verification of access routes for cabling and other matters.

Proposed wiring solution

- Upon completion of the initial engineering stage, the Contractor shall provide two (2) draft copies of engineering documentation for approval by the consultant. Consultant will review the engineering documentation within a two (2) week period.
- This documentation will include, but is not limited to the following:
 - a detailed drawing of the MC,
 - a drawing of each IC
 - and a drawing of each TR.
- If no revisions are required, the documentation shall be formally accepted in writing by the consultant.
- Any revisions shall be completed by the contractor within a two (2) week time period and resubmitted for review.

Drawings and diagrams

Upon completion of final engineering and incorporation of the consultant review comments, Contractor shall provide to consultant for its records the following:

- Detailed drawings / diagrams which shall include:
 - cable routing
 - position of all components and
 - detailed layout of the wall field

-
- labeling plan.
 - Work Area Floor Plans which shall Include:
 - detailed cable routes
 - approved labeling plan for all work areas.
 - Cross Connect Documentation which shall include:
 - cross connect records for all voice, and data devices.
 - Riser Distribution Plan
 - Cable Tray, Conduit, and Raceway Plans
 - Campus Distribution Plan (if applicable)
 - Documentation shall be in the following format:
 - four (4) copies and one reproducible sepia of all diagrams and drawings in "D" size (24" x 36") or "E" size (30" x 42") as appropriate,
 - two (2) copies of all cross connect documentation in printed form

As Built Documentation

- Upon completion of the project, Contractor is to prepare "As Built" documentation showing actual site conditions and installation as constructed.
- Provide copies of such documentation to consultant as mentioned above.

Additional Records

- In addition to the engineering diagrams, the following items shall be provided by the contractor:
 - Cable Records and Assignments

3.21 Damages

The Contractor shall be liable for any and all damages to portions of the building caused by it, its employees or subcontractors; including but not limited to:

- Damage to any portion of the building caused by the movement of tools, materials or equipment.
- Damage to any component of the construction of spaces "turned over" to the Contractor.
- Damage to the electrical distribution system and/or other space "turned over" to the Contractor.
- Damage to the electrical, mechanical and/or life safety or other systems caused by inappropriate operation or connections made by the Contractor or other actions of Contractor.
- Other damage to the materials, tools and/or equipment of the customer, its consultants, General Contractor, subcontractors, Architect, other contractors, agents and lessees.

3.22 Penetrations of walls, floors and ceilings

Prior consent

The Contractor shall make no penetration of floors, walls or ceiling without the prior consent of the Architect and General Contractor.

Sealing penetrations

- Where penetrations through acoustical walls or other walls for cableways have been provided for the Contractor or made by the Contractor, such penetrations shall be sealed by the Contractor in compliance with applicable code requirements and as directed by customer's Architect or General Contractor.
- Where penetrations through fire-rated walls for cableways have been provided for the Contractor or made by the Contractor, such penetrations shall be sealed by the Contractor as required by code and as directed by the Architect or General Contractor.
- Contractor shall, prior to the commencement of on-site activities, submit to the consultant for review by its Architect, details of any special systems to be used.

3.23 On site move day support

Technical Support

- Contractor will provide technical support on a per/hour basis at such levels and at such times as the customer deems necessary during the physical move to the site.
- The personnel providing technical support will:
 - Have intimate knowledge of the System and Materials that were used
 - Be skilled in all use of equipment and materials used under the Contract.
 - Be competent to troubleshoot and fix problems associated with Contractor provided materials.

3.24 Project direction

Single Point of Contact

- Contractor will provide a single point of contact, i.e., Project Manager, to speak for the Contractor and to provide the following functions:
- Initiate and coordinate tasks with the consultant, General Contractor, Architect, and others as specified by the customer.
- Provide day-to-day direction and on-site supervision of Contractor personnel:
- Ensure conformance with all Contract provisions.

3.25 Completion of work

- At the completion of the System, the Contractor shall restore to its former condition, all aspects of the project site and on a daily basis, shall remove all waste and excess materials, rubbish debris, tools and equipment resulting from or used in the services provided under this Contract.
- All clean up, restoration, and removal noted above will be by the Contractor and at no cost to the customer.
- If the Contractor fails in its duties under this paragraph, the customer may upon notice to the Contractor perform the necessary clean up and deduct the costs thereof from any amounts due or to become due to the Contractor.
- The consultant, through the General Contractor will provide a dumpster for the use of the Contractor.
- It shall be the Contractor's responsibility to remove trash from the areas it is working in and bring trash and debris to the dumpster.
- The Contractor shall not use the General Contractor's dumpsters or trash disposal without prior approval of the General Contractor.

3.26 Training

- The SCS Contractor shall provide one (1) technician for one (1) week beginning with the first scheduled move-in date.
- This technician will also assist the owner in cross connecting the voice and data services throughout the building during the move-in period. It is at this time that all Owner provided connectivity schedules for voice and data services will be provided to the Contractor.
- Patching (cross connection) of the station assignments between the Owners service demarcation shall also be considered part of this Contractors work.

3.27 Inspection

- On-going inspections shall be performed during construction by the Project Manager and/or the SCS System Manager. All work shall be performed in a high quality manner and the overall appearance shall be clean, neat and orderly.
- The following shall be examined and shall comply satisfactorily in all instances.
 - Is the design documentation complete?
 - Are all cables properly labeled, from end-to-end?
 - Have all terminated cables been properly tested in accordance with the specifications for the specific category as well as tested for opens, shorts, polarity reversals, transposition and presence of AC and/or DC voltage?
 - Is the cable type suitable for its pathway?
 - Are the cables bundled in parallel?
 - Have the pathway manufacturer's guidelines been followed?
 - Are all cable penetrations installed properly and fire stopped according to local code?
 - Have the Contractors avoided excessive cable bending?
 - Have potential EMI and RFI sources been considered?

-
- Is Cable Fill capacity Correct?
 - Are hanging supports within 1.5 meters (5 feet)?
 - Does hanging cable exhibit some sag?
 - Are telecommunications room terminations compatible with applications equipment?
 - Have Patch Panel instructions been followed?
 - jacket removal point
 - termination positions
 - all pair terminations tight with minimal pair distortions
 - twists maintained up to Index Strip
 - Have Modular Panel instructions been followed?
 - cable dressing first
 - jackets remain up to the Connecting Block
 - all pair terminations tight and undistorted
 - twists maintained up to the Connecting Block
 - Are connectors properly turned right side up in the Jack Panels without cables wrapped or twisted around the Mounting Collars?
 - Have the correct outlet connectors been used
 - Have outlets been wired correctly? (T568A or T568B)
 - Is the cable jacket maintained up to the?
 - Are identification markings uniform, permanent and readable?

3.28 Systems Testing and Documentation

- General Requirements:
 - Provide installation testing of equipment where required by manufacturer's installation instructions.
 - Provide complete end to end testing for all copper and fiber optic systems/channels based on latest applicable standards. Document all testing and submit with final as-built submittal package
 - For all controls and operating equipment, submit equipment/systems to at least three complete operational sequences, in which all equipment operations are tested, observed, and verified.
 - Prior to substantial completion and project acceptance inspection, submit test reports to indicated scope of startup and operational tests, with results of testing for each specified operation.

3.29 Copper Cabling System Testing

- General: Copper cabling shall be tested and certified after installation as follows and as required for cable manufacturer's warranty. Twisted-pair copper cable channels shall be tested for continuity as specified below, presence of ac/dc voltage, and performance. All cabling shall be tested for conformance to horizontal cable specifications as outlined herein, and shall be tested according to test set manufacturers instructions utilizing latest firmware and software. Testing shall include all of electrical parameters as specified under Product.

All cables and termination hardware shall be 100 percent tested by installation contractor for defects in installation and to verify cable performance under installed conditions. All conductors of each installed cable shall be verified useable by Contractor prior to system acceptance. All cables shall be tested according to contract documents, manufacturer's warranty provisions, and best industry practices. If any of these are in conflict, Contractor shall comply with most stringent requirements. All defects in cabling system installation shall be repaired or replaced in order to ensure 100 percent useable conductors in all cables installed, at no additional cost to Owner.

- Continuity: Each pair of each installed cable shall be tested using a test unit that shows opens, shorts, polarity and pair-reversals, crossed pairs and split pairs. The test shall be recorded as pass/fail as indicated by test unit according to manufacturers' recommended procedures, and referenced to appropriate cable identification number and circuit or pair number. Any faults in wiring shall be corrected and cable re-tested prior to final acceptance.
- Length: Each installed cable link shall be tested for installed length using a TDR type device. The cables shall be tested from patch panel to patch panel, block to block, patch panel to outlet or block to outlet as appropriate. The cable length shall conform to maximum distances set forth in TIA/EIA-568-B standards. Cable lengths shall be recorded, referencing cable identification number and circuit or pair number. For multi-pair cables, shortest pair length shall be recorded as length for cable.
- Factory testing: Every reel of cable shall be tested by cable manufacturer for all characteristics specified for cable type in this section. This testing shall be performed using a sweep test method and include frequencies specified for cable. A test report shall be available electronically, at no additional cost, for a minimum of five (5) years from the date of manufacture. The test report shall include the reel number, the date of the test, the Lot number, and test results for Return Loss (RL), Insertion Loss (Attenuation), Pair-to-Pair NEXT, and Power Sum NEXT Pair-to-Pair ELFEXT and Power Sum ELFEXT. The test report shall show the "Worst Case Margin" for the listed transmission characteristics.
- Test results: Test results shall be automatically evaluated by equipment, using most up-to-date criteria from TIA/EIA-568-B standards and all other applicable standards and result shown as pass/fail. Test results shall be printed directly from test unit or from a download file using an application from test equipment manufacturer. The printed test results shall include all tests performed, expected test result and actual test result achieved.
- Test reports: Test reports for all factory testing and field test reports for copper cabling installation shall be submitted to the Owner's Representative and manufacturer prior to commissioning voice and data system and final contract payment. Refer to Submittals in this Section.

3.30 Optical Fiber Cable Testing

- General: Optical fiber cabling shall be tested and certified after installation as described below and as required for cable manufacturer's warranty. Fiber testing shall be performed on all fibers in completed end to end system. Testing shall consist of a bi-directional end to end test in accordance with applicable standards in 27 02 20.20, or a bi-directional end to end test performed by EIA/TIA-455-53A and all other applicable standards in 27 02 20.20. The system loss measurements shall be provided at 850 and 1300 nanometers for multimode type glass and 1310 and 1550 nanometers for single-mode type glass. These tests shall also include continuity checking of each fiber. For spans greater than 90 meters, each tested span must test to a value less than or equal to value determined by calculating a link loss budget. For horizontal spans less than or equal to 90 meters, each tested span must be less than or equal to 2.0 decibels. The insertion loss for each mated optical fiber connector pair shall not exceed 0.40 decibels.
- Pre-installation testing: Test all optical fiber cable for all fibers prior to installation of cable.
- Performance testing: Where links are combined to complete a circuit between devices, Contractor shall test each link from end to end to ensure performance of system. Only a basic link test is required. Contractor can optionally install patch cords to complete circuit and then test entire channel. The test method shall be same used for test described above. The values for calculating loss shall be those defined in applicable TIA/EIA standards in Appendix 1: Codes, Standards, and Informative References.
- Attenuation testing: Attenuation testing shall be performed with a stable launch condition using two-meter jumpers to attach test equipment to cable plant. The light source shall be left in place after calibration and power meter moved to far end to take measurements.
- Loss budget: Fiber links shall have a maximum loss of:
- $(\text{Allowable cable loss by kilometer}) \times (\text{kilometers of fiber in link}) + (0.2 \text{ decibels}) \times (\text{number of connectors}) = \text{maximum allowable loss}$ or $(\text{Allowable cable loss per kilometer}) \times (\text{length of cable in kilometers}) + (0.4 \text{ dB} \times \text{number of mated connectors}) + (0.3 \text{ dB} \times \text{number of splices}) = \text{maximum allowable loss}$
- Link loss: A mated connector to connector interface shall be considered a single connector. Loss numbers for installed link shall be calculated by taking sum of bi-directional measurements and dividing that sum by two. All links not meeting requirements of standard shall be brought into compliance by Contractor, at no additional cost to Owner.
- Documentation: Following final documentation shall be submitted to the owner's representative prior to commissioning data system and final contract payment according to Submittals in this section.

- Test results: Test results shall be automatically evaluated by equipment, using most up-to-date criteria from all applicable standards specified in 27 02 20.20 and result shown as pass/fail. Test results shall be printed directly from test unit or from a download file using an application from test equipment manufacturer. The printed test results shall include all tests performed, expected test result and actual test result achieved.
- End-to-end loss data
- As installed diagrams

3.31 Test Documentation

- Provide test documentation in 3-ring binders within 2 weeks after completion of project testing. Binders shall be clearly marked on outside front cover and spine with words Test Results, project name, and date of completion (month and year). Major heading tabs, Horizontal and Backbone, shall divide binder. Each major heading shall be further sectioned by test type. Within horizontal and backbone sections, divide by tabs scanner test results by category, optical fiber attenuation test results, and continuity test results. Present test data within each section in sequence listed in administration records. Provide test equipment by name, manufacturer, model number and last calibration date at the end of document. Unless manufacturer specifies more frequent calibration cycle, annual calibration cycle shall be required on all test equipment used for this installation. Test document shall detail test method used and specific settings of equipment during test. Scanner tests shall be printed on 8 1/2 by 11 inches. Hand written test results (attenuation results and continuity results) shall be documented on a suitable test form. When repairs and re-tests are performed, note problem found and corrective action taken, and collocate in binder both failed and passed test data.

3.32 SOURCE QUALITY CONTROL

A. Manufacturer's Test

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

B. Inspection

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

C. Verification of Performance

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

3.33 EXAMINATION**A. Verification of Conditions**

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

B. Protection

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

3.34 INSTALLATION

- A. All cables, connectors, distribution frames, etc. that comprises this system shall be installed as per manufacturers' recommendations, unless otherwise noted.
- B. The Contractor shall purchase installation guides from vendors, and become familiar with the installation requirements prior to commencement of the work. Any discrepancies between plans, specifications and the manufacturers' recommendations shall be brought to the attention of the Engineer.
- C. The plans and specifications indicate the general arrangement and scope of work. To facilitate the installation and coordination with other trades, the Contractor may deviate from this general arrangement so long as the scope does not change. All such changes shall be submitted to the duly authorized Engineer. All such changes shall be made with no additional cost to the Employer.
- D. Refer to installation details on contract drawings for equipment rack, switches and patch panel configurations.
- E. Cables shall be continuous, with no factory or field splices, or intermediate couplings.
- F. Contractor shall require where necessary cable support bridges over obstructions i.e. under floor conduit, pipes, supports, etc.
- G. Contractor shall install cable supports and fasteners for horizontal cable.
 - Used to keep cable off of black iron, ceiling stringers and ceiling tile.
 - Hangers or straps permanently attached to the underside of concrete deck.
 - Contractor to bundle cables in groups not to exceed 10 units.
 - Straps installed every three feet along a respective cable run.
 - Contractor to submit manufacturer's cut sheets and proposed installation method prior to starting work.

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- H. Contractor shall provide sufficient slack at all termination locations to allow for proper termination. The Contractor shall not coil cable in ceiling, telephone closets and the main telephone room so as to avoid unnecessarily adding to cable lengths, unless specified.
 - I. Contractor shall install fire stopping material, filling the interstices between the cable in conduit or floor ceiling assemblies, used to give comparable thermal conductance to the barrier itself in addition to resisting the fire and restricting the passage of hot gases for the required fire rated time.

3.35 LABELING

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

3.36 ADJUSTING

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

3.37 DEMONSTRATION

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

3.38 PROTECTION

- A. After installation, protect from damage during subsequent construction and other normal activities.
- B. Protect existing work may be affected.

3.39 Electro-Magnetic Interference (EMI)

- A. Equipment links must be protected against interference by:

-
- Providing the different items of equipment with the appropriate grounding connection.
 - Using cable ducts in steel of the type close or semi-close.
 - The wired steel ducts shall be used considering the specifications here below.
 - All the steel ducts will be connected together.
 - Fitting the data cables at least at 30 cm from any source of Electro Magnetic Interference like TL lamps. If there is no practical possibility to keep these minimum distances, the metallic ducts will be covered with metal covers.
 - Isolating low-current equipment away from power circuits.
 - The lay of the cable will be executed keeping the following minimum distances (in mm) between the cables and the data cables. The power to be considered is the total power of all the cables.

Power less than 2 kVA:

Type of Ducts	Type of Cables*	
	UTP	FTP
Common duct without metal separator	127	50
Common duct with metal separator	64	30
Separated Ducts	0	0

Power between 2 kVA and 5 kVA:

Type of Ducts	Type of Cables*	
	UTP	FTP
Common duct without metal separator	305	130
Common duct with metal separator	152	65
Separated Ducts	76	40

Power above 5 kVA:

Type of Ducts	Type of Cables*	
	UTP	FTP
Common duct without metal separator	610	300
Common duct with metal separator	305	150
Separated Ducts	152	80

All dimensions are in mm

Particular Precautions:

If the power supplies existing in the building are 1000 Volts in alternative current, the vendor shall use fiber optic links or must lay earthing cable in parallel with the copper data links.

If the local norms exist, the most stringent to be adopted.

The data cables or the bundle of these cables may be laid close to the feeding cables if:

- The total power remains under 1 kVA.
- These kinds of transfer cables are not mixed.
- The power cable and the data cable are laid in parallel on the entire length and are connected on the same work place.

If the data cables or the bundles of these cables may be laid close to the power cables if:

- The total power remains under 1 kVA.
- The link is screened from one side to the other (using cords blocking the low frequencies and allowing the pass through of the high frequencies).
- These kinds of transfer cables are not mixed.

The non-screened and the screened cables can be laid in parallel side by side of the power cables, if the power of these last cables doesn't exceed 100 VA (ISDN, data cable, CATV).

Installation Limitations Precautions:

The vendor shall respect the minimum-bending radius, the installation notices of the connectorisation and of the cabinets and the way of setting the earthing and the grounding.

The cables shall be correctly aligned in the ducts. They will be grouped per 20 maximum and tied to the ducts every 5 meters at least.

The twist of the wires shall be kept as far as possible with a minimum of 13 mm.

The tension of the tie raps should not be too high to avoid the NEXT problems.

All fixed metal pieces shall be earthed.

3.40 Horizontal Distances

The maximum horizontal distance shall not exceed 90 meters (295 ft) from the information outlet to the Telecommunications Closet.

In establishing maximum distance, an allowance is made for 3 additional meters (9.8 ft) from the I/O to the workstation.

END OF SECTION

SECTION 16721 – FIRE ALARM AND VOICE EVACUATION

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 fire alarm systems.
- B. Related Sections include the following:
 - 1. Division 8 Section "Door Hardware" for door closers and holders with associated smoke detectors, electric door locks, and release devices that interface with the fire alarm system.

1.3 DEFINITIONS

- A. FACP: Fire alarm control panel.
- B. LED: Light-emitting diode.
- C. NICET: National Institute for Certification in Engineering Technologies.
- D. Definitions in NFPA 72 apply to fire alarm terms used in this Section.
- E. IDC (Initiating Device Circuits), NAC (Notification Appliance Circuits), SLC (Signaling Line Circuit).

1.4 SYSTEM DESCRIPTION

- A. Noncoded, analog-addressable system; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only.
- B. The Firemen (Fire Fighters Phone two way communication between the main fire alarm control panel and emergency phone jack(s) and voice evacuation system (manual voice paging)

1.5 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 72 and NFPA 101 or BSEN54 (instead of NFPA), and latest requirements of local civil authorities.
- B. Premises protection includes all floors.

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- C. Fire alarm signal initiation shall be by one or more of the following devices:
1. Manual stations.
 2. Heat detectors.
 3. Smoke detectors.
 4. Addressable input / output module
 5. Verified automatic alarm operation of smoke detectors.
- D. Fire alarm signal shall initiate the following actions as applicable:
1. Alarm notification appliances shall operate continuously.
 2. Identify alarm at the FACP.
 3. De-energize electromagnetic door holders.
 4. Transmit an alarm signal to the remote alarm receiving station.
 5. Unlock electric door locks in designated egress paths.
 6. Release fire and smoke doors held open by magnetic door holders (as applicable).
 7. Switch, ventilating, and equipment controls to fire alarm mode.
 8. Close smoke dampers in air ducts of system serving zone where alarm was initiated.
 9. Record events in the system memory.
 10. Record events by the system printer.
- E. System trouble signal initiation shall be by one or more of the following devices or actions:
1. Open circuits, shorts and grounds of wiring for initiating device, signaling line, and notification-appliance circuit.
 2. Opening, tampering, or removal of alarm-initiating and supervisory signal-initiating devices.
 3. Loss of primary power at the FACP.
 4. Ground or a single break in FACP internal circuits.
 5. Abnormal ac voltage at the FACP.
 6. A break in standby battery circuitry.
 7. Failure of battery charging.
 8. Abnormal position of any switch at the FACP or annunciator.
 9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
- F. System Trouble and Supervisory Signal Actions: Ring trouble bell and annunciate at the FACP. Record the event on system printer.

1.6 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
1. Shop Drawings shall be prepared by persons with the following qualifications and shall be approved by Fire Brigade Authorities:

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- a. Trained and certified by manufacturer in fire alarm system design.
 - b. Fire alarm certified by NICET, minimum Level III.
 2. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
 3. Device Address List: Coordinate with final system programming.
 4. System riser diagram with device addresses, conduit sizes, and cable and wire types and sizes.
 5. Wiring Diagrams: Power, signal, and control wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Show wiring color code.
 6. Batteries: Size calculations.
 7. Duct Smoke Detectors: Performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 8. Ductwork Coordination Drawings: Plans, sections, and elevations of ducts, drawn to scale and coordinating the installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, the detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
- C. Qualification Data: For Installer.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For fire alarm system to include in emergency, operation, and maintenance manuals. Comply with NFPA 72, Appendix A, recommendations for Owner's manual. Include abbreviated operating instructions for mounting at the FACP.
- F. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals specified in Division 1 Section "Submittals," make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.

G. Documentation:

1. Approval and Acceptance: Provide the "Record of Completion" form according to NFPA 72 to Owner, Architect, and authorities having jurisdiction.
2. Record of Completion Documents: Provide the "Permanent Records" according to NFPA 72 to Owner, Architect, and authorities having jurisdiction. Format of the written sequence of operation shall be the optional input/output matrix.
 - a. Hard copies on paper to Owner, Architect, and authorities having jurisdiction.
 - b. Electronic media may be provided to Architect and authorities having jurisdiction.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Work of this Section be performed by a UL-listed company.
- C. Installer Qualifications: Personnel certified by NICET as Fire Alarm Level II, III.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, or BS EN 54 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Fire Alarm Service: Do not interrupt fire alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
 1. Notify Owner no fewer than two days in advance of proposed interruption of fire alarm service.
 2. Do not proceed with interruption of fire alarm service without Owner's written permission.

1.9 EXTRA MATERIALS

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

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but not less than 1 unit.
2. Smoke, Fire, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but not less than 1 unit of each type.
3. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but not less than 1 unit of each type.
4. Keys and Tools: One extra set for access to locked and tamperproofed components.
5. Audible and Visual Notification Appliances: One of each type installed.
6. Fuses: Two of each type installed in the system.

PRODUCT 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:
 1. FACP and Equipment:
 - a. Edwards Systems Technology Inc.
 - b. Esser / Honeywell
 - c. Siemens Building Technologies, Inc.; a Cerberus Division.
 - d. Simplex; a Tyco International Company.
 - e. Gent
 - f. Notifier
 2. Wire and Cable:

They shall be fire rated FP200

2.2 FIRE ALARM SYSTEM

- A. Fire alarm system shall provide early detection, accurate location of zone and point of origin of fire and automatic control for the ventilation and air conditioning system.
- B. The fire alarm system shall provide visual and audible warning on main annunciator panel for supervisory signals such as:

1. Failure or disconnection of power supply to main control panel
2. Failure of fuse or protective device.
3. Removal of detector head on any initiating circuit.
4. Break or short circuit in wiring of any initiating or alarm circuit.
5. Valve tamper at fire pumps.
6. Fire pumps running.
7. Fire pumps power loss.
8. Fire pumps phase reversal.

2.3 FACP

A. General Description:

1. Modular, power-limited design with electronic modules, UL 864 listed.
2. Minimum Capacity: 3000 devices.
3. Addressable initiation devices that communicate device identity and status.
 - a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at the FACP.
 - b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
4. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACP and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands; and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:

1. Signaling Line Circuits: NFPA 72, Class A, Style 2.
2. Signaling Line Circuits: NFPA 72, Class B, Style 0.5
 - a. System Layout: Install no more than 50 addressable devices on each signaling line circuit.
3. Notification-Appliance Circuits: NFPA 72, Class A, Style Z.

4. Notification-Appliance Circuits: NFPA 72, Class B, Style W.
 5. Actuation of alarm notification appliances, emergency voice communications, annunciation, smoke control, elevator recall, and actuation of suppression systems shall occur within 15 seconds after the activation of an initiating device.
 6. Electrical monitoring for the integrity of wiring external to the FACP for mechanical equipment shutdown and magnetic door-holding circuits is not required, provided a break in the circuit will cause doors to close and mechanical equipment to shut down.
- D. Smoke-Alarm Verification:
1. Initiate audible and visible indication of an "alarm verification" signal at the FACP.
 2. Activate a listed and approved "alarm verification" sequence at the FACP and the detector.
 3. Record events by the system printer.
 4. Sound general alarm if the alarm is verified.
 5. Cancel FACP indication and system reset if the alarm is not verified.
- E. Notification-Appliance Circuit: Operation shall sound in a temporal pattern, complying with ANSI S3.41, 60 beats per minute, march-time pattern.
- F. Elevator Controls: Heat detector operation shuts down elevator power by operating a shunt trip in a circuit breaker feeding the elevator.
- G. Elevator Controls: Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shuts down elevators associated with the location without time delay.
1. A field-mounted relay actuated by the fire detector or the FACP closes the shunt trip circuit and operates building notification appliances and annunciator.
- H. Power Supply for Supervision Equipment: Supply for audible and visual equipment for supervision of the ac power shall be from a dedicated dc power supply, and power for the dc component shall be from the ac supply.
- I. Alarm Silencing, Trouble, and Supervisory Alarm Reset: Manual reset at the FACP after initiating devices are restored to normal.

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1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
 2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
 3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.
- J. Walk Test: A test mode to allow one person to test alarm and supervisory features of initiating devices. Enabling of this mode shall require the entry of a password. The FACP and annunciators shall display a test indication while the test is underway. If testing ceases while in walk-test mode, after a preset delay, the system shall automatically return to normal.
- K. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and control of changes in those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and make a print-out of the final adjusted values on the system printer.
- L. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, trouble, and supervisory signals to a remote alarm station through a digital alarm communicator transmitter and telephone lines.
1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones, or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall be UL 1711 listed.
 - a. Allow the application of and evacuation signal to indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
 - b. Programmable tone and message sequence selection.
 - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
 - d. Generate tones to be sequenced with audio messages of the type recommended by NFPA 72 and that are compatible with tone patterns of the notification-appliance circuits of the FACP.
 2. Notification-Appliance Circuits: NFPA 72, Class A.
 3. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
 4. Preamplifiers, amplifiers, and tone generators shall automatically transfer to back-up units, on primary equipment failure.

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- M. Service Modem: Ports shall be RS-232 for system printer and for connection to a dial-in terminal unit.
1. The dial-in port shall allow remote access to the FACP for programming changes and system diagnostic routines. Access by a remote terminal shall be by encrypted password algorithm.
- N. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including the same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- O. Primary Power: 24-V dc obtained from 220-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signal, [supervisory and digital alarm communicator transmitter shall be powered by the 24-V dc source.
1. The alarm current draw of the entire fire alarm system shall not exceed 80 percent of the power-supply module rating.
 2. Power supply shall have a dedicated safety switch for this connection at the building service distribution panel. Paint the switch box red and identify it with "FIRE ALARM SYSTEM POWER."
- P. Secondary Power: 24-V dc supply system with batteries and automatic battery charger and an automatic transfer switch.
Batteries shall be provided and shall be the dry sealed lead-acid type. The batteries shall have ample capacity. With primary power disconnected, to operate the firm alarm system for a period of 48 hours. Following this period of operation via batteries. The batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a minimum period of 30 minutes.
- Q. Surge Protection:
1. Install surge protection on normal ac power for the FACP and its accessories.
 2. Surge protectors shall be as recommended by FACP manufacturer.
- R. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 CONTROL RELAY MODULE

Control relay module shall provide four Form-C auxiliary relay circuits rated at 5 amperes, 28 VDC. An expansion circuit board shall allow expansion to eight Form-C relays per module.

Relay circuit shall be capable of being activated (change in state) by any initiating device or from any combination of initiating devices.

Provide relay module with 8 green ON/OFF LEDs and 8 yellow LEDs (indicates disabled status of the relay).

Provide a momentary switch per relay circuit that may be used to manually turn the relay ON/OFF or to disable the relay.

Relay circuit shall include a custom label inserted to identify its location. Labels shall be created using a standard typewriter or word processor.

Provide control relay module with removable wiring terminal blocks. Terminal blocks shall be UL listed for use with up to 12 AWG wire.

2.5 ENCLOSURE OF ALL CONTROL PANELS

Control panel shall be housed in an UL-listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.

Back box and door shall be constructed of 0.060 steel with provisions for electrical conduit connections into the sides and top.

Door shall provide a key lock and include a glass or other transparent opening for viewing indicators. Door may be site configured for either right or left hand hinging.

2.6 POWER SUPPLY:

Power supply shall continuously monitor all field wires for earth ground conditions, and have the following LED indicators:

Ground Fault LED

AC Power Fail LED

NAC on LED (4)

Main power supply shall operate on 220 VAC, 50 Hz, and provide necessary power for the FACP.

Circuits shall be power-limited, per UL864 requirements.

2.7 ALPHANUMERIC LCD TYPE ANNUNCIATOR: (next to FACP)

The alphanumeric display annunciator shall be a supervised, remotely located back-lit LCD display containing a minimum of eighty (80) characters for alarm annunciation in clear English text.

LCD annunciator shall display system alarm and trouble conditions.

Audible indication of alarm shall be integral to alphanumeric display.

The display shall be UL listed for fire alarm application.

It shall be possible to connect up to 32 LCD displays and be capable of wiring distances up to 6,000 feet from the control panel.

The annunciator shall connect to a separate, dedicated "terminal mode" EIA-485 interface. This is a two-wire loop connection and shall be capable of distances to 6,000 feet. Each terminal mode LCD display shall mimic the main control panel.

System shall allow a minimum of 32 terminal mode LCD annunciators. Up to 10 LCD annunciators shall be capable of the following system functions: Acknowledge, Signal Silence and Reset, which shall be protected from unauthorized use by a keyswitch or password.

The LED annunciator shall offer an interface to a graphic style annunciator and provide each of the features listed above.

2.8 LOCAL PRINTER

Printer shall provide hard-copy printout of all changes in status of the system and time-stamp such printouts with the current time-of-day and date. Printer shall be standard carriage with 80-characters per line and use standard pin-feed paper. Enclose printer in a separate cabinet suitable for placement on a desktop or table. Communication with the control panel shall utilize an interface complying with Electrical Industries Association standard EIA-232D. Power to the printer shall be 220 VAC @ 50 Hz.

System shall have a strip printer capable of being mounted directly in the main FACP enclosure. Alarms shall be printed in red, other messages, such as a trouble, shall be printed in black. Printer shall receive power from the system power supply and operate via battery back-up if AC mains are lost. Strip printer shall be UL 864 listed.

2.9 ADDRESSABLE DEVICES

Addressable Devices - General

Addressable devices shall use simple to install and maintain decade, decimal address switches. Devices shall be capable of being set to an address in a range of 001 to 159. Addressable devices, which use a binary-coded address setting method, such as a DIP-switch, are not an allowable substitute due to increased risk of error and special knowledge required for maintenance.

Detectors shall be intelligent (analog) and addressable, and shall connect with two wires to the fire alarm control panel Signaling Line Circuits.

Addressable smoke and thermal detectors shall provide dual alarm and power/polling LEDs. LEDs shall flash green under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady red illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.

The fire alarm control panel shall permit detector sensitivity adjustment through field programming of the system. The panel on a time-of-day basis shall automatically adjust sensitivity.

Using software in the FACP, detectors shall compensate for dust accumulation and other slow environmental changes that affect their performance. Detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter 10 (2002).

The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature. Bases shall include a sounder base with a built-in (local) sounder rated at 85 DBA minimum, a relay base and an isolator base designed for Style 7 applications.

The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.

Detectors shall store an internal identifying type code that the control panel shall use to identify the type of device (photo, thermal).

Detectors will operate in an analog fashion, where the detector simply measures its designed environment variable and transmits an analog value to the FACP based on real-time measured values. FACP software, not the detector, shall make the alarm/normal decision, permitting the sensitivity of each detector to be set in the FACP program and allowing the system operator to view the current analog value of each detector.

A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100% of the alarm threshold.

Addressable modules shall mount in a 4-inch square (101.6 mm square), 2-1/8 inch (54 mm) deep electrical box. An optional surface mount Lexan enclosure shall be available.

A. General Description:

1. UL 268 listed, operating at 24-V dc, nominal.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
3. Multipurpose type, containing the following:
 - a. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
 - b. Piezoelectric sounder rated at 88 dBA at 10 feet (3 m) according to UL 464.
 - c. Heat sensor, combination rate-of-rise and fixed temperature.

4. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection of building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
 - a. Rate-of-rise temperature characteristic shall be selectable at the FACP for (8 deg C) per minute.
 - b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at the FACP to operate at (57 deg C).
 - c. Provide multiple levels of detection sensitivity for each sensor.

B. Manual Call Point, Analog Addressable (Alternative 1)

1. Physical and electronic characteristics:

The alarm shall be activated by breaking the glass without the need of an additional instrument (e.g. hammer).

The glass plate shall be designed in a way to prevent injuries when struck by the operator.

The manual call point shall be capable of being connected along with other intelligent interactive devices, such as smoke detectors, to a common fire detector loop.

The manual call point shall be able to isolate short circuits on the detection-line bus in order not to disrupt the proper function of the rest of the detectors connected on the detection-line bus. The isolating function shall be restored upon request by the control unit, when the short circuit condition is removed.

The manual call point shall be controlled by a custom designed application specific integrated circuit (custom-ASIC) in order to guarantee a maximum reliability of the electronic circuit.

The call point shall have a digital communication with the control unit on the basis of error recognizing protocol with multiple transmission of information.

The call point shall have a built in LED which will be illuminated upon actuation of the manual call point.

It shall be possible to test the manual call point without destroying the covering window.

Unauthorized removal of the call point's cover must release an alarm.

The manual call point shall comply with standard pr EN 54-11.

2. Mechanical characteristics:

The call point shall fit on a surface mounting box which contains at least three terminals for the connection of the field wiring.

It shall be possible to mount the part containing the sensitive electronic circuit separately just before commissioning, thus preventing any possible damage due to inappropriate installation work.

2.10 INTELLIGENT PHOTOELECTRIC SMOKE DETECTOR

The detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

The intelligent photo smoke detector shall be a spot type detector that focuses the light beam to a very small volume near a receiving photo sensor. The scattering of smoke particles shall activate the photo sensor.

The detector shall have conductive plastic so that dust accumulation is reduced significantly.

The intelligent photo detector shall have nine sensitivity levels and be sensitive to a minimum obscuration of 0.03 percent per foot.

The intelligent photo detector shall support standard, relay, isolator and sounder detector bases.

Photo detector shall not require cleaning requirements other than those listed in NFPA 72. Replacement, refurbishment or specialized cleaning of the detector head shall not be required.

Photo detector shall include two bicolor LEDs that flash green in normal operation and turn on steady red in alarm.

2.11 INTELLIGENT THERMAL DETECTORS:

Thermal detectors shall be intelligent addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. It shall connect via two wires to the fire alarm control panel signaling line circuit.

2.12 INTELLIGENT DUCT SMOKE DETECTOR

Smoke detector housing shall accommodate either an intelligent ionization detector or an intelligent photoelectric detector that provides continuous analog monitoring and alarm verification from the panel.

When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.

2.13 INPUT MODULE AND OUTPUT MODULES

A. Input Module, Analog Addressable

1. Physical and electronic characteristics:

The analogue addressable input module shall be designed to be capable of being connected along with other analogue addressable elements on a loop. The devices shall interface a stub line for simple dry contacts (switch) to the analogue addressable loop.

The stub line shall be supervised with an end-of-line resistor.

Programmable normally open or normally closed contacts shall be usable.

The analogue addressable input module shall receive all its power requirements through the analogue addressable detection loop.

The analogue addressable input module shall be equipped with a line separator /isolator function, the operation of which shall not impair the function of the device when connected in loop mode.

The built-in LED shall indicate an alarm when the connected contact is in alarm condition.

The analogue addressable input module shall be equipped with a built-in push button for assigning its address during commissioning. An additional built-in LED shall indicate the functionality of the device. Both LED and button shall only be accessible with case.

It shall be possible to exchange the electronic parts without removing the housing or the wiring.

The analogue addressable input module shall be capable of operating in both dry and wet rooms according to IP56 protection category.

The housing shall be able to be equipped with 6 PG16 cable glands.

The analogue addressable input module shall be equipped with screw less terminals with built-in strain relief mechanism.

The box with wiring terminals and the electronic parts shall be available separately in order to carry out the wiring before inserting the electronic device and/or to fit the electronics into any other standard installation box of suitable size.

For environmental protection purposes, the detector shall:

- Have no disposable parts like caps or packing
- Have recyclable packing
- Be easy to maintain
- Be easy to dismantle and to separate different material types
- Have markings on plastic by engraving (not ink)

B. Output Module, Analog Addressable

1. Physical and electronic characteristics:

The analogue addressable output module shall be designed to be placed somewhere along the other analogue addressable devices on a detector loop. The device shall provide an interface as a control output of the fire alarm panel to equipment such as fire doors, smoke vents, smoke curtains etc.

The output contact of the analogue addressable output module shall be rated to 230VAC/2A.

The output control device should be controllable by any detector connected to the same fire detection control unit.

The analogue addressable output module shall be disconnectable also by key code from the fire control unit / terminal.

No additional power supply shall be required to activate the relay output.

The analogue addressable output module shall be connected to the control unit via the normal 2-wire analogue addressable loop.

The analogue addressable output module shall be microprocessor based and have its own factory set identification number.

The analogue addressable output module shall be equipped with line separator/ isolator function without losing its control and confirmation function. The analogue addressable output control device shall resume its normal status automatically after a short circuit.

The analogue addressable output module shall be equipped with a built-in push button to activate the device for testing and for assigning its address during commissioning. An internal LED shall indicate the functionality of the device. Both LED and button shall only be accessible with open case.

2. Mechanical characteristics:

The analogue addressable output module shall be capable of operating in both dry and wet rooms according to IP56 protection category.

It shall be possible to exchange the electronic parts without removing the housing or the wiring.

The housing shall be able to be equipped with 6 PG16 cable glands.

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

The wiring terminals and the electronic parts shall be available separately in order to carry out the wiring before inserting the electronic device and/or to fit the electronics into any other standard installation box of suitable size.

For environmental protection purposes, the detector shall:

- Have no disposable parts like caps or packing
- Have recyclable packing
- Be easy to maintain
- Easy to dismantle and to separate different material types
- Have markings on plastic by ingraining (not ink)

2.14 ADDRESSABLE RELAY MODULE

Addressable Relay Modules shall be available for HVAC control and other building functions. The relay shall be form C and rated for a minimum of 2.0 Amps resistive or 1.0 Amps inductive. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.

2.15 ISOLATOR MODULE

Isolator modules (one per maximum six elements) shall be provided to automatically isolate wire-to-wire short circuits on an SLC (Signalling Line Circuit) Class A or Class B branch. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC loop segment or branch. At least one isolator module shall be provided for each floor or protected zone of the building.

If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC. When the short circuit condition is corrected, the isolator module shall reconnect the isolated section.

The isolator module shall not require address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.

One isolator shall be provided per apartment. One isolator shall be provided for a maximum of six devices in non-apartment areas.

The isolator module shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

2.16 AUDIBLE ALARM DEVICES

A. General

The fire detection system shall include the following coordinated and complementary audible signaling devices:

1. Alarm buzzer
2. Alarm bells
3. Strobes
4. Voice Alarm Speakers-Ceiling Mounted/Wall Mounted

All alarm devices shall be electronic types suitable for low voltage and low power consumption, up to max. 15W.

It shall be possible to switch alarm devices installed in areas covered by automatic extinguishing systems to various sound patterns. Sound patterns shall be watched remotely from the fire alarm control unit alarm devices applied in open air or in areas with an explosion hazard, shall be available with the appropriate protection category or approval respective.

Alarm devices connected in parallel shall be electrically synchronized.

The range of audible alarm equipment shall include device suitable for spoken messages as well as alarm signals.

The sound intensity of the horns shall be approximately 10 dB above the room (environmental) background noise.

The manufacturer shall provide exact technical data concerning the sound output of the alarm devices he proposes to install.

B. Alarm Bells

The alarm bells shall have under dome gongs, red in color 6" diameter.

Bells shall be surface mounted.

Technical Data

1. Operating Voltage	: 18 to 24 VDC
2. Power consumption approx.	: 1.5 VA
3. Sound intensity at 3m distance	: 90 dB
4. Ambient temperature	: -20 °C to + 40°C
	: -4 °C to + 104°C
5. Protection category IEC 529	: IP 20

Alarm horn shall be acceptable.

2.17 BATTERIES

The battery shall have sufficient capacity to power the fire alarm system for not less than forty eight hours plus 5 minutes (15 minutes for Audio Systems) of alarm upon a normal AC power failure.

The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills, and leakage shall not be required.

If necessary to meet standby requirements, external battery and charger systems may be used if they are UL Listed with the system.

The system shall provide a means of monitoring the battery voltages from the front panel display for the local batteries.

2.18 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door plate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.19 WIRE AND CABLE

All cables associated with Fire Alarm installation shall be of fire resistant (minimum 3 hours) 2 core 1.5sq.mm twisted pair. Cables shall comply with BS 6207 Part 1. The cable for use on the Fire Alarm loop shall be of the following type and specification. The cable is to BS 6207. Part 1 having, Typically no more than 2 cores, A maximum of 190pF/m intercore capacitance, A maximum of 220 pF/m core to screen capacitance, A maximum of 18 ohms per core, Each core having 1.5 sq.mm cross sectional area.

A read cover sheath (preferred for alarm applications), having continuous metal sheath encapsulation, Fire resistant tested to BS6387.

PART 3-EXECUTION**3.1 EQUIPMENT INSTALLATION**

- A. Connecting to Existing Equipment: Verify that existing fire alarm system is operational before making changes or connections.
1. Connect new equipment to the existing control panel in the existing part of the building.
 2. Connect new equipment to the existing monitoring equipment at the Supervising Station.
 3. Expand, modify, and supplement the existing control monitoring equipment as necessary to extend the existing control monitoring functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
- B. Smoke or Heat Detector Spacing:
1. Smooth ceiling spacing shall not exceed (9 m).
 2. Spacing of heat detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas, shall be determined according to Appendix A in NFPA 72.
 3. Spacing of heat detectors shall be determined based on guidelines and recommendations in NFPA 72.
- C. HVAC: Locate detectors not closer than (1 m) from air-supply diffuser or return-air opening.
- D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of the duct.
- E. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
- F. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
- G. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
- H. Audible Alarm-Indicating Devices: Install not less than (150 mm) below the ceiling. Install chimes and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

- I. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- J. FACP: Surface mount with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
- K. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.
- L. In parking spaces open area a master addressable with a minimum of five conventional detectors shall be provided.
- M. The total number of input / output addressable elements shall be determined during bidding stage – no varieties order shall be accepted a fire contract award.

3.2 WIRING INSTALLATION

- A. Install wiring according to the following:
 - 1. NECA 1.
 - 2. TIA/EIA 568-A.
- B. Wiring Method: Install wiring in metal raceway according to Division 16 Section "Raceways and Boxes."
 - 1. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
- C. Wiring Method:
 - 1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 - 2. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.
- D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

- G. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- H. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum 1-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
- I. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the FACP and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."
- B. Install instructions frame in a location visible from the FACP.
- C. Paint power-supply disconnect switch red and label "FIRE ALARM."

3.4 GROUNDING

- A. Ground the FACP and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACP.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
 - 1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in NFPA 72.

2. Perform each electrical test and visual and mechanical inspection listed in NFPA 72. Certify compliance with test parameters. The mother company of the fire alarm system shall confirm that all tests shall be conducted under the direct supervision of a NICET technician certified under the Fire Alarm Systems program at Level III or approved equal in Europe.
 - a. Include the existing system in tests and inspections.
3. Visual Inspection: Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or nonfunctional equipment, and correct before beginning tests.
4. Testing: Follow procedure and record results complying with requirements in NFPA 72.
 - a. Detectors that are outside their marked sensitivity range shall be replaced.
5. Test and Inspection Records: Prepare according to NFPA 72, including demonstration of sequences of operation by using the matrix-style form in Appendix A in NFPA 70.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.
- B. Follow-Up Tests and Inspections: After date of Substantial Completion, test the fire alarm system complying with testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for three monthly, and one quarterly, periods.
- C. Semiannual Test and Inspection: Six months after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- D. Annual Test and Inspection: One year after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for monthly, quarterly, semiannual, and annual periods. Use forms developed for initial tests and inspections.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the fire alarm system, appliances, and devices. Refer to Division 1.

END OF SECTION

SECTION 16726**PUBLIC ADDRESS AND MUSIC SYSTEMS (EMERGENCY EVACUATION)****PART 1 – GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

The Contractor shall supply, install and connect the public address system distribution as shown on the Drawings and as here in specified. The system shall have all the necessary fire proof characteristics for operating as an emergency evacuation system. The system shall include public address main management facility controller, remote loudspeakers, microphones, conduits and wiring complete as specified and as on the Drawings to the approval of the Engineer.

All basic equipment shall be that of a single reputable manufacturer with an accepted reputation for engineering achievement and development of quality electronic products.

All components shall comply with IEC 268, and the entire system shall conform to IEC 268-15 and quality assurance ISO 9001. The specified technical data listed hereinafter are provided as guideline only and it shall be the entire responsibility of the Contractor to seek the assistance of a specialist supplier of international reputation to provide satisfactory performance of public address system.

Both 100 V and distributed amplification line system shall be accepted for sound system distribution in the project. The Contractor shall be responsible to select all his equipment's in a consistent way so that they suit the elected system.

The Contractor shall seek the assistance of sound specialists for proper distribution and choice of equipment and shall modify the specified equipment to provide an acceptable sound distribution, to the approval of the Engineer.

The Contractor shall abide strictly by the two following installation requirements.

Loudspeakers in permanent exhibition area shall be suspended from an aluminium track or stainless steel track running along the adjacent lighting track but totally independent from the lighting track. The track shall be used only as a suspension support structure and a wiring channel for flame retardant shielded twisted pair screen / aluminium foiled cable with minimum 1.5mm.sq cross section. Loudspeaker shall be supported to track with approved accessories (stainless steel) swivel brackets for suspension mounting on ceiling track and wall surface mounting with necessary loading capacity and adequate mounting kits.

1.3 DEFINITIONS

- A. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
- B. Zone: Separate group of loud speakers and associated supply wiring that may be arranged for selective switching between different channels.
- C. VU: Volume unit.

1.4 SYSTEM DESCRIPTION

The project shall be fitted with a central main sound processing system that would serve to distribute back-ground music into the museum, as well to distribute paged announcement and emergency evacuation information with overriding facility of paging system on music distribution.

Zoned loudspeakers will be provided as required by Museum Owner (the present zoning indicated on plan is a suggestion only) throughout the project to fulfill the above objective. The description and function area allocation of zones shall be as indicated on riser schematics drawings.

The public address system generally comprises the following:

- 1. Desk and wireless microphones.
- 2. Central rack in the central control room including:

COMPONENTS:

The system comprises the following:

- * Paging desks
- * 19" rack cabinets including:
 - * Two AM/FM Tuner
 - * Two dual auto reverse K7 rec/play
 - * Three five rotating CD player
 - * One Digital routing system
 - * Software
 - * Control panel
 - * Power supplies
 - * Power Amplifiers (at least one per zone)
 - * Spare Power Amplifiers (one in each rack cabinet) to replace automatically a damaged Amplifier
- 3. Loudspeakers: Recessed ceiling, wall mounted speakers and track suspended speakers as indicated on plans.

The wiring of the public address system shall be done with flame rated shielded aluminium foiled cable through separate heavy gauge embedded PVC conduits or surface mounted fire resistant cable.

All connection shall be with ceramic input connector and thermal fuse.

The central equipment would be installed at the main CCTV control room in 1st floor. Premises would be divided as proposed into sound processing zones as shown on plans. Each floor or functional space would be set as an independent zone.

In each zone would be directly connected to the system however Contractor shall be responsible to coordinate with Owner to verify if in specific activities area should be fitted with volume potentiometers, including an off position. A dc overriding relay would be fitted into the volume potentiometers so as, in emergencies, and even if the volume potentiometer is set to the off position, the overriding relay would switch it back to a preset emergency volume level. Volume potential meter shall be priced separately by Contractor assume 30W rating. No variation order shall be authorized.

The system should operate out of 220V/50Hz outlets, but should be backed-up by a rechargeable battery for dc operation during power failures, **(24 hours autonomy)** and distribute the sound signals as a 100 V system or 70volts.

The system should incorporate a 20 KHZ tone generator, and together with relevant accessories, it should detect defects in amplifiers and in zone lines up to the furthest loudspeaker of the zone, and should indicate it at the control room. When a defect is detected in an amplifier the system should automatically switch to a spare amplifier.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Preamplifiers.
2. Power amplifiers.
3. Transfer to standby amplifier.
4. Microphone.
5. Volume limiter / compressor.
6. Control console.
7. Telephone paging adapter.
8. Tone generator.
9. Equipment cabinet and rack.
10. Monitor panel.
11. Loudspeakers.
12. Noise-operated gain controller.
13. Microphone and headphone outlets.
14. Battery backup power unit.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Design Calculations: Calculate requirements for selecting seismic restraints for central control cabinets.
2. Equipment Details: Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components and location of each filed connection.

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3. Console layouts.
 4. Control panels.
 5. Rack arrangements.
 6. Wiring Diagrams: Power, signal and control wiring. Include the following:
 - a. Identify terminals to facilitate installation, operation, and maintenance.
 - b. Single-line diagram showing interconnection of components.
 - c. Cabling diagram showing cable routing.
- C. Calculations: For sizing backup battery.
- D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Qualification Data: For installer and testing agency.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: for public address and music equipment to include in emergency, operation and maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this project.
1. Maintenance Proximity: Not more than 2 hours normal travel time from installer's place of business to Project site.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain public address and music equipment through a single source authorized by manufacturer to distribute each product.

- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70.
- F. Comply with UL 50.

1.07 COORDINATION

Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system and partition assemblies.

1.08 EXTRA MATERIALS

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

- 1. Microphone: One.
- 2. Desk Stands: One.

PART 2- PRODUCTS

2.1 MANUFACTURER

- A. Available Manufacturer: Subject to compliance with requirements, manufactures 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:
 - 1. Toa (Japan).
 - 2. Philips Bosch (Holland).
 - 3. Dynacord (Germany)
 - 4. Uniton Switzerland.
 - 5. Or approved equal.

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. System Functions: include the following:
 - 1. Selectively connecting separate zones to different signal channels.
 - 2. Selectively amplifying sound among various microphone outlets and other inputs.
 - 3. Communicating simultaneously to all zones regardless of zone or channel switch settings.

4. Paging, by dialing an extension from any local telephone instrument and speaking into the telephone.
5. Producing a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
6. Reproducing high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off, and output free of non-uniform coverage of amplified sound.

2.3 EQUIPMENT AND MATERIALS

- A. Coordinate features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- B. Equipment: Modular type using solid-state components, fully rated for continuous duty, unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 220 to 230V, 50 Hz.
- C. Waterproof Equipment: Listed and labeled for duty outdoors or in damp locations.

2.4 MAIN PUBLIC ADDRESS MANAGEMENT CONTROLLER

The public address main management facility controller shall be of a modular design to enable sound reinforcement systems to be plugged into the centre according to the requirement of the system.

The management controller shall integrate in a central housing all the necessary input and output modules with their interface circuitry.

The control centre shall house the various printed circuit boards and plug in modules.

The interconnection board shall include necessary slots in which the plug-in modules can be fitted.

The connections between the control center and the corresponding input and output equipment shall be made by using standard plugs and screw connector blocks.

All the interconnections between the plug-in modules shall take place automatically when they are installed. Each module shall have its own place in the cabinet and the misuse in other slots will not cause damage to any part of the system.

The control center shall be 19 inch rack mounted.

The system shall have a pilot tone signal generator and shall be used for the surveillance of power amplifiers and their output devices. Signal tone generator shall produce more than 40 chime, attention and alarm signals. These signals shall be programmed to precede a call or pre-recorded message, or to be activated independently if required.

The system shall be controlled by a microprocessor and shall be programmed by using the programmed keys and the LCD display on the front panel.

The control center shall comprise the following plug-in modules, but shall not be necessarily limited to:

ROUTING SYSTEM

- * 16 audio inputs
- * 32 audio outputs
- * Total access matrix
- * Monitor bus input for system monitoring (low & high level signals, 100v or 70V signals)
- * Audio record input/audio play output
- * Digital recording-playback for messages and alert-tones
- * 9 pre-recorded tones
- * Opto inputs/outputs on relay programmable for digital commutations
- * Rs 232 port (nr.1)
- * Rs 485 port (nr.3)
- * Printer output for printing configuration and diagnostics
- * 20khz amplifier/line diagnosis
- * Cpu Pentium based
- * Digitals consoles direct connection
- * Back-amplifier boards direct connection (amp/line diagnosis)
- * Built-in puss for cpu, input/output audio boards and digital commutation in/out boards digital
- * External power supply 24 vdc (to feed consoles and/or back-amplifier boards) **including NICd batteries for 24 hours operation.**
- * To include standards software together with the system:
 - configuration by supervisor (password needed)
 - clock - timer - printer configuration
 - digital console configuration (priority, push-buttons etc.)
 - input configuration (input levels, tones)
 - output configuration (output levels)
 - digital i/o controls (events, priority, timers)
 - amplifier configuration (main / spar units)
 - full audio monitoring (manual & autoscan)
 - alarm messages (by monitor, display, printer, digital consoles etc.)
 - digital recording - playback for messages and alert-tones
- * graphic software (mouse operating) to be used with external p.c. Linked via RS 232

Mainframe 19" rack type (at least one for cpu + one for in/out boards)

- * Connectors and guides boards standard DIN 41612
- * All in/out connections on rear panel by removable screw terminals
- * Nr. 2 power supply units
- * Cpu, hard-disk and digital audio board

- * Serial communication board fully equipped for future extensions
- * Monitor speaker
- * Front panel with set-up and configurations buttons
- * Alphanumeric LCD display (back-light) 4x40

Inputs:

- * 16 input (expandable to 32)
- * 16 inputs balanced 20 K ohm .
- * Trimmers for tone controls for each input (they can be switched on/off by software)
- * Input level control by software
- * Input dynamics + 16 db
- * Input monitor function selectable by software
- * Self -configuration of the boards installed
- * Configuration set-up stored on E2prom for a quick system re-start.

Outputs

- * 32 outputs (expandable to 64)
- * Low impedance outputs
- * Output level control by software
- * Output level up to + 16 db
- * Self - configuration of the boards installed
- * Configuration set-up stored on **EPROM** for a quick system re-start

I/O digital board: (to interface with other system)

- * 32 opto-isolated inputs and 48 relay outputs completely programmable:

Useful to use the system with standard mike consoles (no digital) for simple operation or local paging, or to use the router for driving external devices such as lights, alarm systems etc. Or to interface the router with other systems which work by closing contacts. Please note that digital interface is required (RS 232 or RS 485) by software.

2.5 RACK CONTROL PANEL

A Vu meter & speaker to control the low level signal of the audio sources ,or the signal at the speaker output of a power amplifier.

Centralized switch on/off of all the equipment installed in the rack cabinets

A digital volt -ammeter to check the mains voltage & the total current absorbed from the equipment's connected.

Digital console unit (paging desk)

- * Back-lighted Icd alphanumeric display 16 x 1 for busy status and alarm messages

- * 16 buttons programmable for zones or groups selection
- * All-call button
- * Emergency button
- * 3 buttons completed programmable for other functions
- * Possibility to record a message when system busy. Automatic diffusion when system free.
- * Built-in chime
- * Electret microphone on gooseneck with red light ring
- * Configuration set-up stored on **EPROM**
- * Audio output balanced by transformer, level adj.
- * Agc
- * Buzzer and led(s) indicators
- * Connections for audio, **RJ 485** and power supply

Analogic console unit (paging desk)

- * 4 buttons programmable for zones and group selection
- * All-call button
- * Emergency button
- * Built- in chime
- * Electret microphone on gooseneck with red light ring
- * Audio output balanced by transformer, level adj.
- * Agc
- * Led(s) indicators
- * Audio and power supply connections (to be used linked to i/o board)

The control centre shall have, at least, the following characteristics:

- 1) Microprocess or Hardware
EEPROM data storage time : more than 10 years.
- 2) Main Supply
 - Mains voltage selection range : 220-230V
 - Maximum voltage deviation : +6/-10%
 - Main frequency : 50 Hz
- 3) Emergency Supply
 - DC voltage : 48V
 - Polarity protection against reverse connection.
- 4) Environmental requirements
 - Ambient temperature : -10 to 45 °C
 - Relative humidity : 15 - 90%

5) Recorded Message Module

- Data retention : >30 days
- Audio bandwidth : 320 - 6000 Hz
- Max. total recording time : 30 seconds
- Max. number of messages : 4
- Microphone phantom power supply voltage : 12 VDC

6) Audio Outputs

- Music Input to Music Output gain: Control range : >60 dB (2 dB steps)
- input level : >150 mV
- Output level symmetrical nominal : 0 dBV
- maximum : +12 dBV
- Amplifier output distortion at nominal level : 0.1 %
- at max. output : 0.3 %
- Amplifier output at nominal level : >80 dB (flat)

7) Call Station or Microphone Input to Call Output

- Output level symmetrical: nominal : 0 dB
- maximum : + 12 dBV
- Microphone Input Module: input level : > 1.mV
- frequency response : 50 -15000 Hz (+/-2 dB)
- signal-to-noise ratio : 68 dB (flat)
- Call Station: input level : 84 dB
- frequency response : 440 - 12500 Hz (-3 dB)
- signal-to-noise ratio : 58 dB (flat)
- Amplifier output distortion at nominal level : 0.1 %
- at max. output : 0.3 %

8) Music and Call Output Impedance

- at 1 KHz : < 50 Ohms

2.6 POWER AMPLIFIER

Power amplifier shall be used to power the system in combinations of anything from 120 watt or 240 watt(as per drawings). The amplifier shall be complete with built-in output transformers, enable a choice of three-line output voltages (50, 70 and 100 V) sufficient to drive large groups of loudspeakers connected over long distances.

Power amplifier shall be a 19 inch rack mounted and shall incorporate two balanced audio-line level inputs: 1 "Music" input and a "Priority call" input.

The amplifier module shall comprise the power supply section, the output matching transformer and the main printed circuit board which shall contain the power amplifier, a limiter circuit and all necessary mutual connections and logic that shall be required by the system.

The amplifier shall have the following characteristics as a minimum requirement:

Mains supply	: 220 - 230 V at 50 Hz.
Emergency Battery Supply	: +48 V polarity protected

2.7 POWER AMPLIFIERS (at least one per zone)

Power amplifier is to be 19" rack mountable specifically for the transmission of microphone announcements and/or musical programmers in all PA systems.

The amplifier must incorporate the following features:

- 2 balanced inputs
- 1 unbalanced input
- High pass & Low pass filters
- Input level control
- Bass & Treble controls

The amplifier must be protected against any incorrect speaker connections, Thermal, overload & short circuit.

The amplifier must be fitted with a diagnosis board (if the amp. is damaged it will be replaced by a spare one).

Output power nominal	as shown on the drawings
Frequency response	60Hz to 15000Hz
Input	sensitivity 0dB / -20dB
Outputs/Voltage - impedance	25 V- 50 v - 100 V - 4 ohm
Signal / noise ratio	≥ 85 dB
Distortion	≥ 1 %
Tone controls	Bass - Treble
Volume control	Master
Protection	Thermal - Overload - Short circuit
Indicators	LEDs for signal, Overload, Peak

Technical Characteristics of Inputs**Audio ('music') Input Balanced**

- Input sensitivity : 0.5-10 Volt (adjustable)
- Input impedance : 10 k Ohms

Priority ('call') input Balanced

- Input sensitivity : 1 Volt
- Input impedance : 10 k Ohms

Surveillance ('test') Input Unbalanced

- Input sensitivity : 500 mV (20 Hz) for rated output - 20 dB
- Input impedance : 4.7 Kohms at 20 KHZ
- Signal-to-noise ratio : >90 dBA
- Cross talk damping : > 70 dB at 5 kHz
- Frequency response (- 10 dB) : 50 to 20,000 Hz (-3dB)
- Distortion : < 0.5 % at rated power at 1 kHz
- Interference : 50 dB for field of 3 V/m
- Power Bandwidth : 50 - 20,000 Hz.
- Monitor output : Headphone impedance 8-600 Ohms

2.8 CALL STATION

Call Station shall be a desktop unit which presents the operator with a logical, comprehensive, and easy to use method of routing and transmitting calls, alarms, announcements, and music.

Call station shall includes:

Microphone

Phantom powered cardioid electret condenser microphone with a built-in bass rolloff filter giving a clear voice reproduction.

Numeric Keypad

Allowing individual selection of up to 18 loudspeaker zones by typing in the zone number. Each zone shall have a Zone Selection Indicator LED.

Function Keys

With a Function Key a call shall be routed to a pre-programmed selection of zones.

Each function key shall be programmed for different tasks as:

- routing a low priority call, preceded by an attention tone, to several frequently used loudspeaker zones.
- routing and alarm tone, followed by a pre-recorded evacuation message, to all loudspeaker zones.
- toggling a control relay on and off which switches a warning lamp, etc.
- selecting a music source, turning the music volume up/down, and muting the music.

Whenever a function key is pressed, the relevant Function Key LED shall be illuminates.

Busy LED

LEDs shall be provided to advise the operator whether a call may be activated or the call is accepted.

Loudspeaker Zone Template

A paper template shall be provided, onto which the names of the loudspeaker zones can be written.

The call station shall have the following characteristics as a minimum requirements:

- Phantom Power supply (IEC268-15A)	: 11 - 52V
- Frequency range (IEC268-4)	: 100 - 16000 Hz
- Sensitivity (IEC 268-4)	: 2 mV/Pa +/- 3dB
- Rated output impedance	: < 200 Ohm
- Load impedance	: > 600 Ohm
- Equivalent input noise level	: 24 dB (A)
- Ambient temperature range	: - 20 °C to +55 °C
- Ambient relative humidity	: 80% at 20 °C

Call station shall be similar to Philips LBB 9568/30 or approved equal.

2.9 HAND-HELD MICROPHONE

The hand-held microphone shall be with frequency independent cardioid directivity and shall have an on/off slide switch and 3 pole XLR plug and supplied with a quick-release clamp for use on floor or table-stands. A stand adaptor shall be provided for mounting on 3/8", and 5/8" without screw fittings.

The hand-held microphone shall have the following characteristics as minimum requirements:

- Phantom power supply : 11 - 52V
- Frequency range : 100 - 16000 Hz
- Transducer type : Condenser
- Sensitivity : 2 mV/Pa $\pm$ 3dB
- Rated output impedance : < 200 Ohm
- Load impedance : > 600 Ohm
- Equivalent input noise level : 24 dB (A)
- Ambient temperature range : -20 °C to +55 °C
- Ambient relative humidity : 80% at 20 °C

Hand-held microphone shall be similar to Philips LBB 9510/20 or approved equal.

2.10 EXTENSION UNIT

The Extension unit shall be intended to function as an amplifier surveillance unit with spare amplifier switching, as an audio monitoring facility and as a volume override relay supply unit.

The unit shall be provided with breakdown switchover, including monitoring electronics for the required number of power amplifiers and stand-by amplifier, and automatic switching circuitry and illuminated push buttons for breakdown signaling and function checks. the pilot-tone generator shall create an inaudible 20 KHZ put by evaluation logic circuitry. In case of breakdown, the stand-by amplifier shall be immediately energized to substitute for the defective amplifier, and a visual signal (amber LED) shall indicate the failure of a specific amplifier and a green LED shall indicate the correct functioning of an amplifier.

An automatic lock-out circuit shall prevent the stand-by amplifier from overloading, in case more power amplifiers do fail. The function of the unit shall be checkable at any time through a push button.

A fault relay shall be provided to activate when all output detectors located at amplifiers output indicate the presence of the test signal.

If one detector indicates a fault, the fault relay shall be deactivated.

Two separate 24 VDC supply sources shall be provided to power external volume override relays.

A push-button and a rotary switch shall be available for the monitoring of the external amplifier inputs and their outputs.

The Extension unit shall be operated on the mains supply. An emergency DC-supply connector shall be provided to operate the unit on 48 VDC.

The Extension Unit shall be designed for 19" rack mounting.

The extension unit shall have the following characteristics according to IEC 65 and BS 415.

Mains supply

- mains voltage : 220 V.
- Frequency : 50 Hz

External DC supply

- Voltage : +48V -6/+10V

Override Relay supply

- DC voltage : +24 V + 25/-10 %

INPUTS

- symmetrical inputs :
- signal level : 500 - 1000 mV
- load impedance : > 3 Kohm

Output relays

- contacts : 2-pole make and break
- effective audio current : 2A
- effective audio signal level : 100 V

Pilot generator

- frequency : 20 kHz +/- 3/5
- signal level : 500 mV +/- 1 dB
- source impedance unbalanced : < 50 Ohm

Cross talk

- attenuation at 5 kHz
between separate channels : > 75 dB

Environmental Conditions

- Ambient temperature range : -10 to + 55 °C
- Ambient relative humidity : 15 to 95%

Extension unit shall be similar to Philips LBB 1290 or approved equal.

2.11 AM/FM TUNER

It shall be a compact radio receiver with built-in AFC having an AM medium wave channel and an FM channel and shall be mounted on 19 inch rack and suitable to be placed in the cabinet of the public address center.

Each channel shall be selected by means of a push button switch (1 for AM and 4 for FM) each with a built-in cat's eye tell-tale indicator and tuned to a station by means of a screw driver control adjacent to the channel switch.

AM/FM tuner module shall be provided with a sliding volume control so that the tuner's audio output level can be adjusted to match the output level of the other modules.

A noise muting circuit shall be provided to prevent any disturbing inter-channel white noise being distributed by the loudspeaker system when switching from one station to another.

The AM/FM tuner module shall have the following characteristics as a minimum requirement:

2.12 AM/FM TUNER (Rack Type)

AM/EM Tuner must offer stable disturbance free reception, and has the following features:

- 16 storable FM stations
- 8 storable AM stations
- FM stereo reception
- manual or automatic tuning
- back-lighted liquid crystal display
- digital clock
- DNR (Dynamic Noise Reduction) circuit
- timer for tuner switch - on/off
- adjustable output level
- possibility for remote control of the tuner functions
- mono and stereo outputs on RCA connectors

Specifications

FM tuner

- tuning range	: 87.5 - 108 MHz
- intermediate frequency	: 10.7 Mhz
- sensitivity (S/N 30db)	: $\leq 10 \mu V$
- selectivity (+ 400 Khz)	: 60dB
- AM rejection	: $\geq 40 \text{ dB}$
- intermediate rejection	: $\geq 80 \text{ dB}$

- image rejection : ≥ 25 dB
- stereo separation (1 KHz) : ≥ 30 dB
- Frequency response : 20 - 15000 Hz
- distortion (1mV-dev.40 KHz) : $\leq 1\%$
- signal/noise ratio (1 mV) : ≥ 50 dB
- automatic tuning sensitivity : ≥ 50 mV
- LF output voltage : 500mV

AM tuner

- tuning range : 522 - 1611 MHz
- intermediate frequency : 450 KHz
- sensitivity (S/N 20 dB) : ≤ 1 mV
- sensitivity (± 9 KHz) : 50 dB
- intermediate rejection : ≥ 45 dB
- image rejection : ≥ 30 dB
- distortion (5mV) : $\leq 2\%$
- signal/noise ratio (5mV) : ≥ 35 dB
- automatic gain control : ≥ 45 dB
- automatic tuning sensitivity : ≤ 2 mV
- EF output voltage : 300 mV

CD PLAYER (RACK TYPE)

- Five disc carousel changer
- Drawer - type loading disc
- Disc can be exchanged while player is in play mode
- Full repeat for continuous prolonged playing
- D/A converter : two
- : 16 - BIT
- Frequency response : 50 Hz - 20kHz + 1 dB
- Signal to noise ratio : > 96 dB
- Output : 2 Vrms

2.13 19 INCH FRAME CABINETS 36U + FRONT DOOR WITH PLEXICLASS + WHEEL SET

Panels shall comply with IEC 297 and shall be totally enclosed, side and rear panels shall be removable, cable entrance shall be at the rear, top or bottom side.

Front door steel frame shall have same finishes rack enclosure holding a transparent panel in lexan equipped with key lock.

If required, a module mounting frame with hinges shall be provided. The surface finish shall be of epoxy powder high temperature stove enameled resistant to scratching and atmospheric agent. The frame shall be of anodized aluminium sections. Each frame shall be basically provided with a ventilation rack including an electric-driven tangential fan with a thermostat control energizing the fan at an

Inside cabinet temperature of +40 °C. Suitable ventilation opening shall be provided in compliance with IEC 297-2 standards.

The rack shall be mounted on floor with swivel wheels + fixed wheels with min. 250 Kg. Applicable Load.

2.14 MATCHING TRANSFORMERS

Matching transformers shall be suitable for 70 V or 100 V line system (as selected by Electrical Contractor).

Transformers shall be specified with an input voltage of 100 V, and each has taps on the primary winding for connecting for full-power, half-power or quarter-power operation for matching to the amplifier output.

The 6, 12, 24 and 36 watts transformers shall have taps on the secondary winding for loudspeaker impedance matching.

The frequency response shall be within a 3 dB envelope from 50 to 12,000 Hz induced distortion less than 1k and insertion loss not more than 1 dB at 1 kHz.

The transformer shall be provided with two mounting holes. External connections shall be to 7" colour coded leads. Transformer finish shall be cadmium plated.

2.15 CEILING RECESSED LOUDSPEAKER

Loudspeakers (wide band double cone type) shall be specially intended for flush-mounting in walls and ceilings, and shall be suitable for speech as well as music reproduction.

Loudspeaker shall have a flame retardant white plastic body in accordance with US Standard UL 945 VA.

Loud speakers shall be voice evacuation compliant (EVAC) according to BS5839 part 8 and IEC 60849 with ceramic terminal block, thermal fuse and heat resistant, high temperature wiring to ensure that in case of fire, damage to loudspeaker doesn't result in failure of the circuit to which it is connected.

Loudspeaker assembly shall consist of a 6 watts, high quality loudspeaker with 100 V matching transformer, front grille and a mounting plate with locking clamps.

The loudspeaker shall be protected by rear fire metal dome and shall be fastened by springs in the fire dome.

Transformer taps are, 6-3- 1.5 watt.

Output power of the transformer shall be stepped down to half or to quarter the rated power by changing the connections at the taps that shall be provided at the transformer primary.

Loudspeaker shall be protected by a dustproof cloth. The front grille shall be coated with a primer colour to be ready for finishing in any colour as required by the Engineer.

The loudspeaker shall have the following characteristics:

- Power handling capacity : 6 w continuous pink noise (above 50Hz)
- Rated voltage : 100V
- Rated impedance : 1667 Ohm
- effective frequency range : 40 - 18 Hz
- Sound pressure level at 1 KHZ octave,
1m, 1W, according to IEC : 93 dB
- Opening angle at 4 KHZ : 90 deg.
- Ambient temperature range : -15 to +50 deg. C

The loudspeaker shall be similar to Dynacord DL 70 SH or RCF PL 80 A.

Ceiling recess loudspeakers in corridors and lobbies shall be tapped at 1.5 watt (or as per calculations).

2.18 CEILING SUSPENDED /WALL MOUNTED SPEAKER

Combination of woofer (5" cone) and tweeter (1"dome) made of ABS resin enclosure and steel mesh grille with the following characteristics:

- Speaker Components : 4.72" cone woofer and 1" dome tweeter.
 - Impedance/power tap: 10 W or 12W – 100V line, (as per calculation results)
 - Sensitivity (1W, 1m) 90 dB SPL
 - Power Handling : 30W (100 V line)
 - Frequency : 80-20,000 Hz
 - Cross over frequency : 2 KHz.
- Similar to TOA F-1300BT

2.19 CABLES

All cables shall be fire retardant type: flame retardant as per UL1666

- 1- Core shielded (100% Aluminium foiled wrap) similar to West PENN FPLR No.14AWG as per calculation results for surface mounted speaker cables

- 2- Cable type (C) for Analog Microphone

4 pairs twisted equivalent to West PENN 653.

1 pairs shielded equivalent to Belden 9452.

1 pair DC supply minimum section 0.82 mm² equivalent to West PENN 224.

3- Cable type (D) for Digital Microphone

1 pairs twisted equivalent to west PENN 220.

1 pair shielded equivalent to Belden 9452.

1 pair DC supply minimum section 0.82 mm² equivalent to west PENN 224.

4- Distance in Cable Tray between Speakers Cable and Microphone Cable not less than 10 cm.

5- Microphone cables and speaker cables must be in 2 independant conduits.

6. Cable between volume control and speaker, is similar to cable type (A) west PENN PL 1991.

PART 3-EXECUTION

3.1 INSTALLATION

- A. Wiring Method: Install wiring in raceways except within consoles, desks, and counters. Conceal cables and raceways except in unfinished spaces.
- B. Wiring Method: Install wiring in raceways 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 plenum cable in environmental air spaces including plenum ceilings. Conceal cables and raceways except in unfinished spaces.
- C. Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings so designed and installed to avoid damage to cables. Secure cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, or fittings.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets.
- E. Control-Circuit Wiring: Install number and size of conductors as recommended by system manufacturer for control functions indicated.
- F. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.
- G. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

- H. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- I. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
- J. Wall-Mounting Outlets: Flush mounted.
- K. Floor-Mounting Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.
- L. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.
- M. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
- N. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.
- O. Connect wiring according to Division 16 Section "Conductors and Cables."

3.2 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
- C. Install grounding electrodes as specified in Division 16 Section "Grounding and Bonding."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connection, and to assist in field testing. Report results in writing.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:

1. Schedule tests with at least seven days' advance notice of test performance.
2. After installing public address and music equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
4. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
 - b. Repeat test for each separately controlled zone of loudspeakers.
 - c. Minimum acceptance ratio is 50 dB.
5. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
6. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in the same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
7. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
8. Signal Ground Test: Measure and report ground' resistance at public address equipment signal ground. Comply with testing requirements specified in Division 16 Section "Grounding and Bonding."
- E. Retesting: Correct deficiencies, revising tap settings of speaker-line matching transformers where necessary to optimize volume and uniformity of sound levels, and retest. Prepare a written record of tests.
- F. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

3.4 **STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
- C. Complete installation and startup checks according to manufacturer's written instructions.

3.5 **ADJUSTING**

- A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
- B. Occupancy Adjustments: When requested within 12 months of date of Submittal Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.6 **DEMONSTATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain public address and music equipment. Refer to Division 1 Section "Demonstration and Training".

END OF SECTION

SECTION 16750**TELEPHONE SYSTEMS (PABX)****PART 1 – GENERAL****1.1 SUMMARY**

- A. Provide labor, materials, equipment and services, and perform operations required for the installations of telephone systems as indicated on the drawings or specified herein.
- B. Telephone boxes should be cabinet type made up of a load-bearing aluminum framework, with vertical rails on to which the connection modules clip, with doors and locks, wire guide rings, cable guides with clamps and earthing terminal.
- C. The PABX shall:
1. Support SIP Protocol
 2. Be Hybrid IP-PBX
 3. Be Compatible to be mounted in 19" rack for integration with structured cabling system.
 4. Have facilities expansion without the need to replace existing equipment
 5. The exchange must be able to function correctly when connected to trunk circuits with a loop resistance up to 2000 ohms.
 6. Environmental Conditions: The PABX shall be able to work under the following environmental conditions:
Operational Temperature : 0 to 45 Deg. C
Operational Humidity : 95%
 7. Copy of ISO 9001 Quality Approval Certificate of the supplier manufacturing facility of all the offered products shall be provided.
 8. Be equipped with necessary power supply unit.
 9. Over-Voltages Caused by Lightning

The switching equipment must withstand the over voltage stated below without degradation of any component.

This requirement shall also be fulfilled if one of the wires in the exchange is connected to earth. The over-voltage may be positive or negative.

Peak voltage 1000 volts

Rise time 10 μ s

Time to half value 100 μ s (Pulse decay time)

10. Ringing Current

Accidental connection between the ringing source and the electronic devices in the extension line circuits and trunk line circuits shall not destroy any components.

11. Electrical Network

Over-voltages, cause by direct connection of an extension line to power lines, 220V, 60Hz, shall not destroy more than the individual line equipment and shall not cause fire.

D. Numbering Plan:

The PABX shall have a flexible numbering plan.

It shall be possible to use 1 to 5 digit codes concurrently for the functions within the PABX, e.g. mix 3 and 4 digit extension numbers.

The allocation of extension numbers to multiple positions shall be variable by programming.

Group hunting numbers must not be related to the extension numbers for the individuals in the group.

1.2 QUALITY ASSURANCE

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

1.3 DELIVERY, STORAGE AND HANDLING

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

1.4 EQUIPMENT

The Contractor shall submit to the Engineer for approval a complete list, in triplicate, of materials and equipment to be incorporated in the work. This list shall include catalogue numbers, cuts and such other descriptive data as may be required. No consideration will be given to partial lists submitted from time to time.

Approval of material will be based on manufacturer's published data submitted with the list; approval of materials and equipment will be tentative subject to submission of complete shop drawings indicating compliance with the Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

Approved suppliers: Panasonic (Japan)
Northern Telecom
Siemens Germany
Alcatel (France)
Lucent (USA)
Or approved equal

2.2 MATERIALS

A. System Features:

1. Call ID
2. Call forward transfer
3. Call pickup
4. Call waiting
5. Auto attendant
6. Voice Mail
7. Automatic Route Selection
8. Line Hunt Group
9. Extension Ring Group

B. Operator Console General Features:

1. Transfer of incoming call

Operator is to be able to connect any internal station or outside trunk line with any other internal station with or without announcement of the call to the recipient extension.

2. Calling number display

Visual display of the station seeking attendant service the station dialed by the operator.

3. 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.

C. TELEPHONE HANDSETS**I. Operator Console**

The PABX Operator console shall be equipped with a display that can show:

- Call type
- Called and Calling ex-numbers
- Trunk line number and route number

Sets (Digital)

Digital telephone Sets will be with LCD display. They are to address and simplify the features offered by the system. Sixteen function keys will be provided, hands free operation, redial, hold, mute, transfer, volume control.

Telephone Hand Set (Analog)

Analog telephone set shall be providing for a minimum of 10 speed dial buttons, and with redial, transfer, and volume control buttons.

D. DC POWER SUPPLY:

The DC Power equipment shall consist of a system of rectifier and batteries to provide the necessary standby DC requirement of the PABX.

The rectifier-charger unit will be used for initial charging and subsequent charge maintenance of the batteries. When the mains supply is present, the unit is fed by the 220 VAC and provides the 48 VDC to the system. Meanwhile, it maintains the batteries full charged. On failure of the mains supply, the batteries automatically take over the supply of power to the load circuit. When the mains supply is resumed, the rectifier-charger unit is to automatically recharge the batteries to its full charge. Thus, the rectifier output voltage will be intrinsically regulated to one of two levels: the floating level, under normal operating conditions where the mains supply is available and the batteries are in stand-by situation; and the equalization level (charge level) whereby a higher voltage is provided in order to recharge the batteries to their full capacity. After the batteries are fully recharged, the rectifier-charger unit is to resume the floating level.

The rectifier-charger unit is to be solid state type, with sufficient capacity to supply the required power to the PABX and maintain batteries fully charged, with circuit breakers and fuses, voltage and current meters, battery voltage monitoring, protection and alarm indication system.

Batteries will be lead acid heavy duty type, maintenance free located on load side of rectifier and kept continuously fully charged. The battery pack will have autonomy of not less than eight hours, that is to say their capacity will provide a minimum of eight hours of continuous telephone system operation without loss of functions or reduction in performance after mains power supply failure and before the PABX can be automatically disconnected.

E. MAIN DISTRIBUTION FRAME

The MDF will be wall or floor mounted, space saving, on-site assembled, flexible design, of modular sections, single sided or double sided, with numbering plates and labeling strips for all terminal blocks.

Each terminal block will be composed of a set of horizontal connection modules. Connections are to be performed by quick-clip IDC (Insulation Displacement Contact) connectors, no soldering will be allowed.

Over voltage protection devices will be provided for the trunks in the MDF.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. All lightning arrestors cables, connectors, etc. that comprise this system shall be supplied and installed as per manufacturer's recommendations, unless otherwise noted.
- B. The plans and specifications indicate the general arrangement and scope of work. To facilitate the installation and coordination with other trades, the contractor may deviate from this general arrangement so long as the scope does not change. All such changes shall be submitted to the duly authorized Engineer drawings. All such changes shall be made with no additional cost to the Employer.
- C. Over-voltages caused by lightning

The switching equipment must withstand the over voltage stated below without degradation of any component.

This requirement shall also be fulfilled if one of the wires in the exchange is connected to earth. The over-voltage may be positive or negative.

Peak voltage 1000Volts.

Rise time 10 us.

Time to half value 1000 us (Pulse decay time)

3.2 PROTECTION

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

3.3 WORKMANSHIP

All materials and equipment shall be installed in accordance with the recommendations of the manufacturer as approved by the Engineer. The installation shall be accomplished by workmen skilled in this type of work. System connections shall be made by approved connectors. Wiring shall be neatly cabled, trained, fanned and secured in each cabinet and junction box, with each cable permanently tagged to identify the area or function served.

3.4 OPERATION AND MAINTENANCE

A. General

The following principles shall be employed:

Remote operation and maintenance shall be possible.

All common equipment shall be continuously served by a built-in supervisory system.

If faults occur, measures to limit the effects shall be undertaken automatically.

There shall be no need for preventive maintenance and manual testing during operation of the system.

Fault localization down to printed circuit board level shall normally be made automatically with the built-in supervisory system.

At least two different classes of alarm issued by supervisory functions shall be indicated in the exchange room and on the PABX operator consoles. Detailed information shall be available from the I/O terminal.

Information about faults shall be stored in an alarm log containing information about time and date for the various faults together with information about the faulty units, position.

Disturbances in one module must not spread to other modules in the system.

The contractor shall propose adequate training programs for operation and maintenance of the PABX

B. I/O Functions

It shall be possible to connect up to 6 input/output (I/O) units of standard type (Printer or display terminals) concurrently to the system via standard CCITT V.24 interfaces, directly or remotely via standard modems.

The Man-machine Language shall be simple to use and menu supported.

3.5 Tests

Prior to system hand-over, it is to be demonstrated to the satisfaction of the Engineer that installed equipment meet the requirements of the specification and is ready for hand-over. Test calls are to be made from stations selected at random, and AC power is to be disconnected to test reliability of emergency power system.

System is to be tested also under actual operating conditions for 15 days prior to acceptance. Tests are to demonstrate to the satisfaction of the Engineer that system is fully operational and compatible with the Specifications.

END OF SECTION

SECTION - 16950

ELECTRICAL TESTING AND COMMISSIONING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Electrical Testing and Commissioning of the electrical systems and equipment including, but not limited to, the following:
1. Testing phases and sequence.
 2. Switchgear / Panel board testing.
 3. Earth resistance testing.
 4. Fire detection and alarm system testing,.
 5. Low current systems testing.
 6. Miscellaneous testing.
 7. Safety tagging procedures.

1.02 RELATED SECTIONS

- A. Submittals.
- B. Materials and Equipment.
- C. Starting of Systems.
- D. Contract Closeout.
- E. Operation and Maintenance Data.
- F. Basic Mechanical Requirements.
- G. Basic Electrical Requirements.
- H. Electrical Identification.

1.03 GENERAL REQUIREMENTS

- A. Access shall be afforded at all times to the Engineer to enable him to inspect all the electrical equipment.
- B. Upon completion of the electrical equipment installation or part of the installation, carry out and be responsible for testing and commissioning, in stages if required, to ensure that it is in proper working order and capable of performing all of its functions in accordance with the Specification and to the satisfaction of the Engineer. Any electrical equipment damaged in commissioning shall be replaced and retested by the Contractor at his own expense to the satisfaction of the Engineer.
- C. All testing shall be carried out according to the requirements of the relevant standards and regulations as may be stated or implied in the Specification or otherwise agreed by the Engineer in writing.
- D. Submit for Engineer's approval, no later than 6 weeks prior to the commencement of testing and commissioning, a schedule of all electrical equipment tests and commissioning procedures to be carried out to prove that the electrical equipment complies with the requirements of the Specification together with proposed programmed for such testing and commissioning.
- E. Tests shall not commence before the schedule of tests has been approved and such other tests as may be required by the Engineer shall be included within the schedule of tests.
- F. Give to the Engineer in writing at least ten days' notice of the date by which he will be ready to make the specified tests on completion of installation. Unless otherwise agreed the tests shall take place within seven days after the said date on such day or days as the Engineer shall in writing notify the Contractor.
- G. The tests shall as far as possible be carried out under normal working conditions to the satisfaction of the Engineer and shall extend over such periods as he may direct.
- H. Provide all skilled labor, supervision, consumables, apparatus and instruments required for commissioning and testing and within a reasonable time thereafter furnish to the Engineer a total of six certificates of all tests performed and accepted, signed by the Contractor, or an authorized person acting on his behalf, as prescribed in the appropriate regulations and specifications.
- I. When any part of the electrical equipment fails to pass the specified tests, further tests shall be repeated, if required by the Engineer. The Contractor shall, without delay, put in hand such modifications as are necessary to meet the requirements as described in the Contract and any expense which the Owner may have incurred by reason of such further tests may be deducted from the Contract price.

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- J. Acceptance shall not in any way absolve the Contractor of his responsibility for the performance of the electrical equipment after erection as a complete working system in all respects.
 - K. Each completed system within the installation shall be tested as a whole under normal site operating conditions to ensure that each component functions correctly in conjunction with the rest of the system.
 - L. Comply with the requirements given in Sections 01300, 01600, 01700, 01730 and other related sections of the Specifications.

PART 2 TESTING AND COMMISSIONING

2.01 GENERAL

- A. Programme, oversee, co-ordinate and record all the testing and commissioning of the electrical systems in co-ordination with those elements undertaken by the mechanical services Contractor. The main Contractor and the Electrical sub-contractor, as the case may be, shall allow for liaising and attendance and providing all necessary test and general data information at the correct times.
- B. For remote monitoring/controls, comply with the requirements as given in Section 15180.
- C. All the electrical systems, whether mentioned in this section or not, shall be subject to testing and commissioning.
- D. All electrical equipment and integral systems shall be commissioned in accordance with the relevant standards and regulations given in the Specification and to the recommendations of specialist suppliers and Manufacturers (e.g. Switchboards, Cables, etc.).
- E. Full operational tests shall be carried out on all systems to demonstrate that they operate in accordance with the requirements of the Specification.
- F. All tests listed under the heading of "Field Quality Control" in various sections of Division-16 of these Specifications shall be conducted in the presence of and performed up to the full satisfaction of the Engineer. All the results/test reports shall be submitted in bound form for Engineer's approval.
- G. Comply with the requirements given in Section 01039, 01650, 01700, 01730 and other related sections of these Specifications

2.02 TESTING PHASES AND SEQUENCE

- A. All the electrical systems and equipment shall undergo following phases of testing and commissioning, in accordance with the actual site requirements and as approved by the Engineer:
1. Phase 1 : Works testing and quality assurance of elements.
 2. Phase 2 : Site installation, wiring, checks, performance and operational tests for all elements.
 3. Phase 3 : Sub system group operational tests/performance tests.
 4. Phase 4 : Complete system operational and performance tests on Dummy loads.
 5. Phase 5 : Complete system operational and performance tests on actual loads.
- B. Testing of all the electrical installations shall be carried out in the following sequence as applicable and approved by the Engineer:
1. Ring-main continuity.
 2. Protective conductor continuity, including main and supplementary equip-potential bonding.
 3. Earth electrode resistance.
 4. Measurement of insulation resistance including site built assemblies and distribution cables.
 5. Check of protection by electrical separation, barriers and enclosures.
 6. Measurement of the insulation on non-conducting floors and walls.
 7. Check of phase rotation.
 8. Verification of polarity.
 9. Measurement of earth fault loop impedance.
 10. Test of operation of residual current devices.
 11. All external distribution cables, both medium and low voltage in accordance with the relevant standard(s).

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12. Fault simulation on protective devices or control systems of stand-by generators, power distribution boards, motor control centers, etc., as applicable.
 13. Load test on sub-station, power distribution boards, panelboards, etc., as applicable.
 14. All cables and equipment shall be pressure tested. Submit a method statement for the test procedure, voltage levels and safety precautions.
 15. Complete testing of lighting control system.
 16. Complete testing of central battery system.

2.03 SWITCHGEAR / PANEL BOARD TESTING

- A. Provide type test results of rated continuous current, short circuit current and enclosure dielectric strength for the power distribution boards, switchboards, motor control centers, panel boards and all other LV switchgear, when required by the Engineer.
- B. Perform all routine production tests in the factory including dielectric strength, mechanical operation, grounding, control wiring, electrical operation, etc., for each LV switchgear and submit test results with the delivery of equipment on site.
- C. Prior to energization of main and sub-main LV power distribution boards, panel boards and all other LV switchgear on site, carry out field tests including, but not limited to, the following:
 1. Testing of all accessible bolted connections to Manufacturer's torque specifications.
 2. Testing of phase-to-phase and phase-to earth insulation resistance.
 3. Testing of electrical continuity / short circuits of the circuits.
 4. Current injection testing of all circuit breakers and protective devices.
 5. Ratio tests of all current transformers.
- D. Subsequent to wire and cable hook-ups, energize the LV power distribution boards, panel boards, etc. and demonstrate functioning in accordance with the requirements. Check whether all outgoings are connected as per load schedules. Record changes in the schedule for final as-built, when acceptable to the Engineer.

2.04 EARTH RESITANCE TESTING

- A. Carry out earth resistance tests after installation of the individual Earthing Systems in accordance with Section 713-11 of the IEE Wiring Regulation 16th edition.
- B. Prior to connection of earth rods to the Earthing System, measure the earth resistance of individual earth rod by using an approved type of earth resistance tester.
- C. After completion of all the connections of Earthing System, measure the earth resistance from the earthing, test point in presence of the Engineer.
- D. Record all the readings obtained duly witnessed by all parties and submits the earth resistance test reports for Engineer's approval.
- E. Similarly carry out earth resistance tests after installation of the Lightning Protection System in accordance with IEE Wiring Regulations, 16th edition and BS 6651.

2.05 MISCELLANIOUS TESTING

- A. All tests listed under the heading of "Field Quality Control" and any where else in the miscellaneous sections of Division-16 of these Specifications shall be conducted in the presence of and performed up to the full satisfaction of the Engineer. All the results/test reports shall be submitted in bound form for Engineer's approval.
- B. Carry out electrical testing of all the electric-operated equipment provided under other divisions of the Specifications such as elevators, trash compactors, motorized doors / blinds, arm barriers, water features, swimming pool, etc. in accordance with the applicable
- C. Develop and submit for Engineer's approval prior to implementation, a safety tagging procedure for use when working on energized systems or to identify systems that have been turned over to operations.
- D. Provide plastic tags of minimum dimensions 300 x 200 x 3 mm with appropriate internationally recognized pictorial symbols and statements in Arabic and English languages for use as safety tag. The tags shall be coloured red with white letters or coloured yellow with black letters as approved by the Engineer. The letters shall be at least 20 mm high or more as required. The safety tag shall be provided with fire resistant rope for suspension at suitable locations.
- E. Type of safety tags shall include, but not limited to, the following:
 - 1. Refer to the equipment instructions/manual for important information before proceeding.
 - 2. This unit must be accessed only by qualified personnel.

3. Do not switch ON. Work is in progress on other end.
 4. Danger - Hazardous AC (or DC) voltage.
 5. Danger - AC mains voltage.
 6. Danger - Hot surface. Do not touch without taking care.
 7. Risk of injury due to high current.
 8. Avoid contacting conductors with un-insulated metal objects. Follow safety precautions. Make sure the power is disconnected.
 9. Danger - Arcing/Sparking may happen. Risk of eye injury. Always wear safety glasses.
 10. Make sure the equipment is grounded before switching ON power.
- F. The installation and removal of safety tagging shall be carried out with the permission of an authorized Client's or Engineer's representative.

Approved type of pad locks shall be provided to lock out any circuit breaker, isolator, switch fuse or a piece of equipment to prevent accidental turn ON or turn OFF. The keys shall be in the custody of an authorized Client's or Engineer's representative.

END OF SECTION