

CENTRAL

NEW CAIRO

100% TENDER DEVELOPMENT STAGE

TECHNICAL SPECIFICATION

REV.00 | DEC. 2023

ELECTRICAL SPECIFICATIONS

CONTENTS

INDEX

DIVISION 11: PARKING EQUIPMENT

SECTION 111200 PARKING CONTROL SYSTEM

DIVISION 14: CONVEYING SYSTEM

SECTION 142100 ELECTRIC TRACTION ELEVATORS

SECTION 143100 ESCLATORS

DIVISION 26: ELECTRICAL

SECTION 26 05 00 BASIC ELECTRICAL MATERIALS AND METHODS

SECTION 26 05 13 MEDIUM- VOLTAGE CABLES

SECTION 26 05 19 LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

SECTION 26 05 26 GROUNDING AND BONDING

SECTION 26 05 33 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

SECTION 26 05 36 CABLE TRAYS

SECTION 26 05 39 UNDERFLOOR RACEWAY

SECTION 26 09 23 LIGHTING CONTROL DEVICES

SECTION 26 12 16 MEDIUM VOLTAGE TRANSFORMERS

SECTION 26 13 00 MEDIUM-VOLTAGE SWITCHGEAR

SECTION 26 24 13 SWITCHBOARDS

SECTION 26 24 16 PANELBOARDS

SECTION 26 24 19 MOTOR CONTROL CENTERS

SECTION 26 25 00 LOW VOLTAGE ENCLOSED BUS ASSEMBLIES

SECTION 26 27 26 WIRING DEVICES

SECTION 26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

SECTION 26 32 13 DIESEL-ENGINE-DRIVEN GENERATOR SETS

SECTION 26 33 53 STATIC UNINTERRUPTIBLE POWER SUPPLY

SECTION 26 35 33 POWER FACTOR CORRECTION EQUIPMENT

SECTION 26 36 23 ENCLOSED TRANSFER SWITCHES

SECTION 26 41 00	LIGHTNING PROTECTION SYSTEM
SECTION 26 51 00	INTERIOR LIGHTING
SECTION 26 56 00	EXTERIOR LIGHTING

DIVISION 27: COMMUNICATION

SECTION 27 10 00	STRUCTURED CABLING SYSTEM
SECTION 27 20 00	DATA COMMUNICATION AND NETWORK EQUIPMENT
SECTION 27 30 00	VOICE COMMUNICATION
SECTION 27 41 00	IP TELEVISION SYSTEM
SECTION 27 51 16	PUBLIC ADDRESS SYSTEM

DIVISION 28: ELECTRONIC SAFETY AND SECURITY

SECTION 28 13 00	IP ACCESS CONTROL SYSTEM
SECTION 28 13 55	DISABLE TOILET ALARM SYSTEM
SECTION 28 23 00	IP SURVEILLANCE CCTV
SECTION 28 31 00	FIRE DETECTION AND ALARM

DIVISION 33: UTILITIES

SECTION 33 71 19	UNDERGROUND DUCTS AND UTILITY
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END OF INDEX

SECTION 111200 PARKING CONTROL SYSTEM

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 SYSTEM FUNCTIONS AND COMPONENTS - GENERAL

A. Summary

1. The car park system shall cover the Parking areas at the basement floor.
2. For the tenants parking areas, automatic rising barriers associated with proximity card readers shall be provided. Barriers manual Control shall also be provided.

B. This Section includes the following:

1. Automatic barrier gates.
2. Vehicle loop detectors.
3. Parking facility management software.
4. Auto tag
5. All wiring (network loops), control cabling, conduit, boxes, weather-proof enclosures, contactors and accessories and ancillary work, whether described in the Specification or not, required for a complete and fully operational system.

C. Related Sections include the following:

1. Division 2 Section "Hot-Mix Asphalt Paving" for asphalt driveway and approach paving.
2. Division 2 Section "Cement Concrete Pavement" for concrete driveway and approach paving.
3. Division 3 Section "Cast-in-Place Concrete" for concrete islands and curbing.
4. Division 3 Section "Cement Based Screeds" for concrete islands and curbing.
5. Division 5 Section "Metal Fabrications" for pipe bollards to protect parking access equipment.
6. Division 10 Section "Signs, Post and Panel Signs" for exterior parking-related signs.
7. Division 28 Section "Fire Alarm" for integrating parking access equipment with fire alarm system.
8. Division, Section "Building Management System (BMS), Instrumentation and Controls.

1.3 PERFORMANCE REQUIREMENTS

- A. Thermal Movements: Provide parking access equipment that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 57 deg C, ambient; 100 deg C, material surfaces.
- B. Waterproof Equipment: Listed and labeled for duty outdoors or in damp locations, with a minimum Ingress Protection rating of IP54.
- C. Software integration with other systems shall be carried out through a standard protocol.
- D. Integrate the system with the Fire Alarm System for the following purpose:
 - 1. Fire Alarm: for opening the barriers and display message at the entry gates in case of fire.
- E. BMS interface: hard wire interface to provide healthy status and power failure conditions.
- F. ISOP interface: hard wire interface to provide healthy status and power failure conditions.
- G. Access Control interface: both car parking system and access control system to be interfaced and to have their software and controlling via same computer.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Product data submittal shall include the following as minimum:
 - 1. Schedule of equipment proposed, with catalogue reference number.
 - 2. Name and address of the manufacturer and country of origin of the product.
 - 3. Compliance statement to specification, with necessary supporting documents.
 - 4. Catalogue pages of proposed equipment.
 - 5. Name and address of the authorized local representative/dealer.
 - 6. System architecture and schematic diagram.
- C. Shop Drawings: Include plans, elevations, details, and interface to other work. Detail equipment assemblies and indicate dimensions, required clearances, and method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Samples: Provide samples of parking access equipment subject to the Engineer's approval

for color/finish.

- D. 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 the Engineer.

- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For parking access to include in emergency, operation, and maintenance manuals. Include the following:
 - 1. As-Built layouts and schematics.
 - 2. System operation.
 - 3. Maintenance schedule.
 - 4. System software documentation
 - 5. Power supply schedule.
 - 6. Integration and interfaces with other systems documentations.
- G. Record (As-Built) Drawings: At Project close-out, submit Record (As-Built) Drawings of all system components and peripherals in accordance with the requirements of the Specification, Division 1.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who is an authorized representative of the parking access equipment manufacturer for both installation and maintenance of the type of units required for Project, and whose installations have resulted in construction with a record of successful in-service performance of projects of similar complexity.
- B. Local Representative: Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy the Engineer may disqualify a manufacturer.
 - 1. Maintenance Proximity: Not more than one hours' normal travel time from Installer's place of business to Project site.
- C. Source Limitations: Obtain parking main control equipment through one source from a single manufacturer.
- D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.6 COORDINATION

- A. Coordinate installation of anchorages for parking access equipment. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

- B. The contractor shall be responsible for coordination with the Access Control contractor in order to integrate the proximity card reader to the rising barrier.
- C. Electrical System Roughing-in: Coordinate layout and installation of parking access equipment with connections to power supplies.
- D. The Contractor shall be responsible for coordination with various systems under this Contract

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. Gate Arms: 20% breakaway gate arms, but not less than 1, for the total number of gates installed, complete with accessory components.
 - 2. Manufacturer's recommended spare parts for a minimum of 5 years' operation.

1.8 POWER SUPPLY

- A. Provided from the building uninterruptible Power Supply (UPS) at 220 V, 50 Hz in the security room to serve all the car park management system equipment including motors of arm barriers. All required power supply equipment and cabling from this source is to be provided under this section of work.

1.9 AVAILABILITY OF SPARE PARTS AND FORWARD COMPATIBILITY.

- A. The Contractor has to obtain and submit a written undertaking from the manufacturer that the spare parts of the system to be installed shall be made available upon request for at least 10 years from the date of substantial completion.

1.10 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the project environmental conditions specified under Division 16 Section 16050 without mechanical or electrical damage or degradation of operating capability.

PART 2 - PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

2.2 APPROVED MANUFACTURERS

- A. Obtain parking access system from one of the following:

As approved vendor list

2.3 MATERIALS

- A. Aluminum: Alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated, and as follows:
1. Sheet: ASTM B 209M.
 2. Extruded Shapes: ASTM B 221M.
- B. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.
- C. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, commercial quality, with Z180 coating designation; mill phosphatized.
- D. Stainless-Steel Sheet: ASTM A 666, Type 304.
- E. Anchorages: Anchor bolts; hot-dip galvanized according to ASTM A 153/A 153M.

2.4 AUTOMATIC BARRIER GATES

- A. General: Provide a parking access device consisting of operator and controller housed in cabinet enclosure with gate arm. Device shall be activated by a signal from access control device. Fabricate unit with gate arm height in down position of not more than 889 mm to prevent even small vehicles from passing under gate arm.
1. Controller: Factory-sealed, solid-state, plug-in type, with galvanized steel box for wiring connections. Equip unit with the following features:
 - a. Capable of storing successive inputs and sequentially processing each one.
 - b. Automatic instant-reversing mechanism that stops downward motion of gate arm if arm strikes an object and that immediately returns arm to upward position. Include a 0- to 60-second variable-time reset device.
 - c. On-off power supply switch.
 - d. Automatic-manual switch.
 - e. Directional arming logic.

- f. RS-485 communication port.
 - g. Broken gate-arm monitoring.
 - h. Programmable automatic timer.
 - i. Internal resettable counters.
 - j. Thermal-overload protection with manual reset.
 - k. Thermostatically controlled heater with on-off-auto switch.
 - l. Diagnostic mode for on-site testing, with LEDs for inputs and outputs.
 - m. Automatic and continuous testing of inputs and outputs.
 - n. Switch to test motor and limit switches or raise gate arm manually.
 - o. Single, 230-V ac grounded power receptacle.
- B. Cabinets: Fabricated from metal sheet with seams welded and ground smooth; approximately 400 mm square by 1100 mm tall. Provide single, gasket access door for each cabinet with flush-mounted locks. Furnish two keys for each lock, all locks keyed alike. Fabricate cabinet with internal reinforcing and four mounting holes accessible only from inside cabinet.
- 1. Material: 2.8-mm- thick, stainless-steel sheet.
 - a. Finish cabinet exterior with No. 4 finish.
 - b. Finish cabinet, interior and exterior, with manufacturer's standard yellow baked-enamel finish over primer.
- C. Straight Gate Arm: Aluminum, with enamel coated or paint finish and red stripes on traffic-side face. Provide mounting flange with breakaway feature to ensure clean break if arm is struck by vehicle.
- 1. Length: to cover the entire (endurances/exits) lane width. Attention and consideration shall also be given to the clear height inside the car park, and accordingly proper type of arm selected, whether straight gate arm or folding type, as suitable and fit for proper operation and function.
 - 2. Tip supports shall be specified for arm lengths more than 4000mm.
- D. Operator: 1/2 hp, 230V AC, 50 Hz, single-phase, instant-reversing, continuous-duty motor for operating gate arm. Transmit power to gate-arm drive shaft through speed reducer to harmonic-acting crank and connecting rod. Fabricate crank, rod, and drive shaft of galvanized solid bar steel. Provide an operable cam for adjusting arm travel.
- E. Accessories:
- 1. Low-voltage red warning lights that illuminate when gate is in down position.
 - 2. Gate-arm tip support.

2.5 VEHICLE LOOP DETECTORS AND DIFFERENTIAL COUNTERS

- A. Vehicle Loop Detector System: Provide self-tuning electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire. Provide number of loops consisting

of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.

1. Field-Assembled Loop: Wire, in size indicated for field assembly, and sealant; style for pave-over installation.
2. System Performance: Capable of the following:
 - a. Recognize vehicle direction by detecting vehicle.
 - b. Differentiate vehicle direction by detecting vehicle moving from one loop to another, reporting to server, which display on the VMS the parking spaces status per zone.
 - c. Generate reverse count if vehicle backs up after generating directional count in forward direction.
 - d. Continuous diagnostic monitoring for intermittently operating and failed loops.
 - e. Crosstalk test between adjacent loops.

2.6 ACCESS CONTROL UNITS

- A. Card Reader Access Unit: Access control system that activates barrier gates and functions only when authorized card/auto tag is presented. Fabricate housing from welded cold-rolled steel sheet with weatherproof front access panel equipped with flush-mounted lock and two keys. Finish units with manufacturer's standard baked-enamel coating system. Provide face-lighted unit fully visible at night.
 1. System: System shall be coordinated with the Access System contractor.
 2. Operation: On-line communication to remote parking access system computer.
 3. Features: Capable of monitoring and auditing barrier-gate activity.
 4. Cards: access control system cards /auto tags carried by tenants to access their dedicated zones are to be used to access the dedicated parking areas inside the parking as well, and at main entrances.

2.7 PARKING FACILITY MANAGEMENT SOFTWARE

- A. General: Manufacturer's standard software that provides automatic facility monitoring, supervision, and remote control of parking access equipment from one or more locations.
 1. System Performance: Capable of the following:
 - a. Collect data for access and space control.
 - b. Communication between park access system equipment and work stations.
 - c. Program parking access equipment.
 - d. Accuracy: System accuracy of 95 percent with tolerance +/- 2 percent.
- B. System software shall use industry standard protocols such as LON, LAN, Ethernet, TCP/IP protocols, subject to system supplier.

2.8 CABLING

A. RS 485 Cables

1. RS-485 communications require 2 twisted pairs, with a distance limitation of 1220 m.
2. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.

3. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket.
 - a. NFPA 70, Type CMP or equivalent.
 - b. Flame Resistance: NFPA 262 Flame Test.

2.9 FINISHES

- A. Comply with internationally recognized standards.
- B. Stainless-Steel Finishes: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
 1. Bright, Directional Polish: No. 4 finish.
 2. When polishing is completed, passivity and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, critical dimensions, and other conditions affecting performance.
 1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- B. Examine roughing-in for electrical systems to verify actual locations of connections before parking access equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide templates for anchor bolts and other items encased in concrete or below finished surfaces so as not to delay the Work.

3.3 INSTALLATION

- A. Automatic Barrier Gates: Anchor cabinets to concrete bases with anchor bolts or expansion anchors and mount barrier-gate arms.

- B. Vehicle Loop Detectors: Bury and seal wire loop at locations indicated on Drawings according to manufacturer's written instructions. Connect to parking access equipment operated by detector.
- C. Ground equipment according to Division 16 Section "Grounding and Bonding."
- D. Connect wiring according to Division 16 Section "LV Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized and trained 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. Perform the following field tests and inspections and prepare test reports:
 - 1. Each electrical test and visual and mechanical inspection shall be stated in NETA ATS, Section 7.15 and compliance with test parameters shall be certified.
 - 2. Operational Test: After electrical circuitry has been energized, units shall be started to confirm proper motor rotation and unit operation.
 - 3. Controls and safeties shall be tested and adjusted. Report any damaged and malfunctioning controls and equipment.
- C. Remove and replace parking access equipment where test results indicate that it does not comply with specified requirements.
- D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- E. Experimental period for all systems shall be three months, before provisional taking over.

3.5 ADJUSTING AND CLEANING

- A. Adjust parking access equipment to operate smoothly, easily, and properly. Confirm that locks engage accurately and securely without forcing or bending.
- B. Lubricate hardware, gate operators, and other moving parts.
- C. After completing installation of exposed, factory-finished parking access equipment, inspect exposed finishes and repair damaged finishes.
- D. Remove barrier-gate arms during the construction period to prevent damage, and install them immediately before Substantial Completion.

3.6 DEMONSTRATION

- A. Engage a factory-authorized and trained service representative to train Owner's maintenance personnel to adjust, operate, and maintain parking access equipment. Refer to Division 1 Section "Closeout Procedures, Demonstration and Training."
 - 1. Train personnel on procedures to follow if operation fails or malfunctions.

3.7 TESTS ON SITE

- A. Equipment and Labor: Provide all testing equipment and specialists for testing system.
- B. Tests are to include insulation resistance, continuity, loop characteristics, signal measurements and analysis, logic routines etc. in accordance with manufacturer's test plan, to be submitted two months before testing, and fully cover performance of components.
- C. Operational tests are to be carried out on system for one week, to test performance of system as if fully operational at peak periods, with all normal and abnormal functions checked and analyzed. Trained staff is to be stationed at various positions to carry out operations and report results. Operations are to include, without limitation, actual vehicular movement over detector loops, performance of counters, central control unit and the like, card reader operation and consequent operations etc. as well as auditing and management functions.

END OF SECTION 11120

SECTION 14210 - ELECTRIC TRACTION ELEVATORS

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. Electric traction passenger elevators number, type and capacity as per design package and report.
 2. Electric traction service elevators, type and capacity as per design package and report.
- B. Related Sections include the following:
1. Division 03 Section "Cast-in-Place Concrete" for setting sleeves, inserts, and anchoring devices in concrete.
 2. Division 04 Section "Unit Masonry" for setting sleeves, inserts, and anchoring devices in masonry.
 3. Division 05 Section "Structural Steel" for attachment plates, angle brackets, and other preparation of structural steel for fastening guide-rail brackets.
 4. Division 05 Section "Metal Fabrications" for attachment plates, angle brackets, divider beams, and other steel framing for supporting guide-rail brackets.
 5. Division 05 Section "Structural Steel" for hot-rolled steel subsills and entrance frames that are a part of steel frame.
 6. Division 05 Section "Metal Fabrications" for hot-rolled steel subsills and entrance frames.
 7. Division 05 Section "Metal Fabrications" for pit ladders.
 8. Division 05 Section "Ornamental Metalwork" for combination hall push-button stations.
 9. Division 09 Section "High Performance Coating" for epoxy / polyurethane painting.
 10. Division 09 Sections for finish flooring in elevator cars.
 11. Division 23 Sections for ventilating hoistways.
 12. Division 26 Section "Basic Electrical Materials and Methods".
 13. Division 26 Sections for electrical service to elevators, including fused disconnect switches, standby power source, and transfer switch.
 14. Division 28 Sections for security card access equipment used to restrict elevator use.
 15. For seismic parameters, PGA and building category, refer to structural drawings/documents
- C. Allowances: Provide finished elevator cars under the Elevator Car Allowance specified in Division 1 Section "Allowances." Allowance includes furnishing and installing wall, floor and ceiling finishes; car door finishes; light fixtures; handrails; and trim. Allowance also includes cutouts and other provisions for installing elevator signal equipment in cars.

1.3 DEFINITIONS

- A. The following terms used on Drawings and in the Specification are synonymous and may be used interchangeably:

1. "Elevator" and "Lift".

- B. Electric Traction Elevators: Elevators in which cars are hoisted by wire ropes using electrically driven traction sheaves and are defined to include driving machines; cars; hoistway doors; guide rails; guide-rail brackets; roping; buffers; counterweights; signals; control systems; electrical wiring within elevator system; and devices for operations, safety, security, required performance at rated speed and capacity, and for complete elevator installation.
- C. Defective Elevator Work: Operation or control system failures; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; the need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

1.4 SUBMITTALS

- A. Product Data: For each elevator. Include capacities, sizes, performances, operations, safety features, finishes, and similar information.
 - 1. Sample Warranty: Copy of manufacturer's proposed warranty, stating obligations, remedies, limitations, and exclusions.
- B. Country of origin of the Elevator shall be indicated in addition to the country of origin of main components including drive ,motor ,controller,...etc. complete documentation for factory manufacturing the equipment shall be submitted including but not limited to local and international experience, quality certificates, quality assurance plan, and organization.
- C. Shop Drawings: For each elevator. Show plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction and locations of equipment and signals. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.
- D. Samples: For exposed finishes of cars, hoistway doors and frames, and signal equipment; 75 mm square samples of sheet materials; and 100 mm lengths of running trim members.
- E. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, overhead and machine room layout and dimensions, as shown on Drawings, and electrical service, including emergency generator, as shown and specified, are adequate for elevator system being provided.
- F. 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.
- G. Maintenance Manuals: For each different electric traction elevator, including operation and maintenance instructions, parts listing with sources indicated, recommended parts inventory listing, emergency instructions, and similar information. Include all diagnostic and repair information available to manufacturer's and Installer's maintenance personnel. Submit for Employer's information at project closeout as specified in Division 1.
- H. Warranties: Warranties specified in this Section.
- I. Inspection and acceptance certificates and operating permits as required by governing authorities for normal, unrestricted elevator use.

- J. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 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.
- K. Type test reports shall be submitted for the following:
1. Landing door fire test to EN 81-58 and EN 1363 as required in clause 2.6.B.2.
 2. Speed governor.
 3. Safety gear.
 4. Buffer.
 5. Brake (main and auxiliary) system.
 6. Traction Ropes.
 7. Swing / Service elevator loading class.

In case, recent type test reports, within 5 years are not available for any of the above components, new type test shall be carried out on the relevant components.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Elevator manufacturer or an experienced Installer approved by the elevator manufacturer who has completed elevator installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance for not less than 10 years.
1. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoist way, pit, and control closet layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator system being provided.
- C. Regulatory Requirements: In addition to local governing regulations, comply with the latest applicable provisions of the following standards, referred to as the "Code", in order of priority:
1. Egyptian local codes.
 2. BS EN 81-50: Safety rules for the construction and installation of lifts. Examinations and tests. Design rules, calculations, examinations and tests of lift components.
 3. BS EN 81-20: Safety rules for the construction and installation of lifts. Lifts for the transport of persons and goods. Passenger and goods passenger lifts.
 4. BS EN 81-28: Safety rules for the construction and installation of lifts. Remote alarm on passenger and goods passenger lifts.
 5. BS EN 81-70: Safety rules for the construction and installation of lifts. Particular applications for passenger and goods passenger lifts. Accessibility to lifts for persons including persons with disability.
 6. BS EN 81-71: Safety rules for the construction and installation of lifts. Particular applications to passenger lifts and goods passenger lifts. Vandal resistant lifts.
 7. BS EN 81-72: Safety rules for the construction and installation of lifts. Particular applications for passenger and goods passenger lifts. Firefighters lifts.

8. BS EN 81-77: Safety rules for the construction and installations of lifts. Particular applications for passenger and goods passenger lifts. Lifts subject to seismic conditions.
9. BS EN 5655-6: Lifts and service lifts. Code of practice for the selection, installation and location of new lifts.
10. BS 7671: Requirements for Electrical Installations.
11. BS ISO 4190-1: Lift (Elevator) installation. Class I, II, III and VI lifts.
12. NFPA 101: Life safety code.
13. BS EN 81-58: Safety rules for the construction and installation of lifts. Examination and tests. Landing doors fire resistance test.
14. NFPA 252: Standard Methods of Fire Tests of Door Assemblies

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging. Store materials, components, and equipment off of ground, under cover, and in a dry location

1.7 COORDINATION

- A. Coordinate installation of sleeves, block outs, elevator equipment with integral anchors, and other items that are embedded in concrete or masonry for elevator equipment. Furnish templates, sleeves, elevator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.
- B. Coordinate locations and dimensions of other work relating to electric traction elevators including pit ladders, sumps, and floor drains in pits; entrance sub-sills; and electrical service, electrical outlets, lights, and switches in pits and machine rooms.

1.8 WARRANTY

- A. Manufacturer's Warranty: Provide a written warranty signed by elevator manufacturer agreeing to repair, restore, or replace defective elevator work within the specified warranty period.
 1. Warranty Period: 18 months from date of Substantial Completion.
 2. At the time of commissioning the installations, the Contractor shall make the available staff required to give all necessary explanations for the operation and maintenance of all the installations and they shall remain until the Employer states in writing that he is entirely satisfied.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 18 months' full maintenance service by skilled, competent employees of the elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Use parts and supplies as used in the manufacture and installation of original equipment.
 1. Include 24-hour-per-day, 7-day-per-week emergency callback service.
 - a. Response Time: 2 hours or less.

- B. Continuing Maintenance Proposal: Provide a continuing maintenance proposal from Installer to Owner in the form of a standard yearly maintenance agreement starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal as per Project's Vendor list:

1. Mitsubishi (Japan).
2. Otis Elevator Co. (USA/France).
3. Schindler Elevator Corp. (Switzerland/Germany).
4. ThyssenKrupp (Germany/Spain).
5. Kone (Finland/Italy)

2.2 MATERIALS AND COMPONENTS

- A. General: Provide manufacturer's standard elevator systems. Where components are not otherwise indicated, provide standard components, published by manufacturer as included in standard pre-engineered elevator systems and as required for a complete system.
- B. Passenger/Service Elevator Machines: [provide variable-voltage, variable frequency ac-type hoisting machines]. Provide solid-state power converters.
1. Provide regenerative system.
 2. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.
 3. Provide means for absorbing regenerated power when elevator system is operating on standby power.
 4. Provide line filters or chokes to prevent electrical peaks or spikes from feeding back into building power system.
- C. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Specification Section.
- D. Machine Beams: Provide framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Division 5 Section "Metal Fabrications" for materials and fabrication.
- E. Roller Guides: Provide roller guides at top and bottom of car and counterweight frames.
- F. Car Frame and Platform: Welded steel units.
1. For service elevators, provide special heavy-duty units where indicated for power truck loading, designed to withstand impacts and wheel loadings indicated.

2.3 MACHINE AND DRIVE

- A. Gearless Machine-Drive: To have traction sheave and brake.
- B. Gearless Machine-Motor: Enclosed, ventilated type, with top speed not exceeding 2.5 m/s.
- C. Gearless Machine-Bearings: Sleeve or anti-friction type, properly lubricated, of ample capacity to sustain heavy loads supported by machine, and rigidly mounted in proper alignment. Sleeve bearings are to have automatic lubrication. Sound isolation pads shall be provided to reduce vibration and noise transmission to building structure.
- D. Gearless Machine-Brake: dual independent brake units are to be provided on the machine and is to noiseless spring applied, magnetically released, self-cooling and capable of holding car securely under maximum speed and load conditions. Brake is to be designed for automatic and instantaneous application immediately after power is interrupted on motor. Brake springs are to work in compression.
- E. Gearless Machine-Manual Brake Release: Provide means for manual release of brakes, to allow manual winding of unit in emergencies. Emergency levers and handles are to be handed to the Employer, with instructions for use. Brake emergency release is to be self-resetting.
- F. Variable Speed A.C. Motor: Induction type, 3-phase, reversible, with electronically controlled speed, using controlled semi-conductor power rectifiers (thyristors) in main circuit and solid-state electronically computed acceleration and deceleration equipment in control circuits. Speed measurement and feedback control shall be through a tachogenerator mounted on the machine, measuring actual revolutions of drive and comparing with programmed reference level. Deceleration shall be electronically controlled by eddy-current braking, feeding motor winding with thyristor controlled d.c. current. Acceleration and deceleration shall not exceed 1 m/s/s.
- G. Motors shall be rated at a minimum of 180 starts per hour for elevators with speeds exceeding 1 m/sec and a minimum of 150 starts per hour for speeds 1 m/sec and less and for machine room less elevators.
- H. Machine Motor Assembly: Motor, traction sheaves, brake, gearbox and bearings shall be one unit assembly mounted on common bed plate. Assembly shall be adequately isolated from main building structure by cork or other approved material, to prevent transmission of noise and vibration.
- I. Lifting Tackle: Provide and fix steel joists and hand-operated winch of adequate strength in each hoistway for lifting and moving each assembly
- J. Motor Acceleration and Jerk: Motors shall produce an average acceleration of not less than 0.6 m/sec² over the total accelerating period except in machine room-less-lifts, service lifts where lower acceleration rates are acceptable. Acceleration shall not exceed 1.5 m/sec² on acceleration peak. The rate of acceleration shall be adjustable after installation is made and the final adjustment shall not produce any objectionable physiological effects on the passengers. Jerk rate shall not be less than 1.2 m/sec³ and shall not exceed 2 m/sec³.
- K. Traction and Deflection Sheaves: Traction sheave shall be fine grained cast iron of suitable hardness, accurately grooved for number and size of hoisting ropes, and shall give constant traction and long rope life. Bearings for sheaves shall be approved type. Diameter of sheave shall be not less than forty times overall diameter of ropes. Deflection and secondary sheaves shall be of same material and grooved similarly to traction sheave, and shall be protected by guards extending below machine level, when required.
- L. Chains: Duplicate heavy duty high tensile multiple leaf chains, with safety factor of at least 10.

- M. Cylinder: Place in a suitable casing of iron or steel. Cylinder casing shall be 100 mm larger in diameter than cylinder. Whole assembly shall be mounted on lowest slab or pit surface and shall not penetrate into ground.
- N. Packing: Provide special type packing to eliminate leakage under widely variable load conditions.
- O. Provisions shall be made on each hoisting machine such that the lift car can be raised or lowered during emergency by manual operation. Direction of winding corresponding to raising or lowering must be clearly indicated, the hand winding apparatus where detachable shall be mounted in an accessible position inside the hoist way. A notice shall be provided stating the details of the process step by step and indicating that this shall be done only by authorized person.
- P. Automatic Leveling: Maximum tolerance ± 5 mm for variable speed elevators. Accuracy is to be maintained regardless of change of load or rope stretch.
- Q. Power Regenerative Converter: a means shall be provided for removing regenerated power from the drive system. This power shall be dissipated in resistors or return to the three-phase A.C. power supply system. Failure of the system to remove the regenerated power shall cause the drive output to be removed from the hoist motor. The energy generated during the inverter braking for regeneration shall be performed through the following method:
 - 1. For lifts where the product of load times speed is less than 3500 kg.m/s, combined brake unit and discharging resistors or a power converter shall be used according to the manufacturer's recommendations.
- R. Noise Level: the level of noise as measured inside the machine room is not to exceed 80 dB (A) when all cars are in operation. Coordinate with building contractor to carry out as part of the civil works all necessary acoustic treatment of walls and doors of the machine rooms adjacent to residential spaces according to spectrum characteristics of machine noise, which are to be provided by the machine manufacturer to achieve a maximum noise level of 40 dB(A) at one meter in any direction outside the room.
- S. Machine Room-Less Lifts: all machine-room-less lifts shall be powered by gearless machines with permanent magnet synchronous motors mounted in the overhead inside the lift shaft. Neither machines nor controllers are allowed to be placed in the pit. Provide variable voltage variable frequency drives built into the control panel and located inside the shaft next to the machine. A machine access panel shall be built in either the landing door frame or the adjacent wall at the last served floor to facilitate maintenance, and emergency applications.

2.4 CAR

- A. Construction: Structural steel frame members suitably braced and fastened together, and clad internally and externally with sheet metal at least 1.5 mm thick, which is not to drum during normal operation. Materials are to be fire resisting.
- B. Reinforce roof to sustain 150-kg load on any 0.2 m², and 50 kg at any point. Provide trap door, at least 500 x 600 mm, opening outward and capable of being opened from car top with a handle is to be provided for all lifts with 8 passenger capacity and above. Trap doors of fire fighter lifts are to be opened from both sides. A key is to be used for opening from the inside. Opening of trap door is to activate electrical interlock preventing operation of elevator.
- C. Platform: Fill frame with timber sub-floor and provide specified top floor finish. Protect underside of platform with sheet steel covering, at least 1.5 mm thick. Sill is to be anti-slip, with provision for car doors.

- D. Load Weighing Device: is to be provided for all lifts.
- E. Isolating Cushion: Rubber pads supported on auxiliary steel frame fastened to car frame are to form isolating cushion between car and car frame.
- F. Guide Devices: Adjustable and renewable, and fastened to top and bottom of car frame.
- G. Guard rails and kick-plates fitted to car are to be not less than 75 mm and 150 mm wide respectively.
- H. Ventilation and Lighting: Provide each car with necessary lighting and adequately rated, silent running, properly padded and rigidly fixed exhaust fan of approved type and manufacture. Fan and lights are to switch on automatically when car is called or when landing doors are opened, remain switched on whilst car is in operation, and switch off by time relay 30 - 60 seconds after car has stopped. Lighting level is to be minimum 200 lux. LED lighting is to be rapid start or instant start type, Fan is to be provided to bring air into car through the ventilation slots near the wall base and to exhaust through the ceiling. Fan shall be 2 speed to provide at least 1 air change a minute at low speed and 1.5 air change a minute at high speed. A screen grill over the fan is to be provided for mechanical protection of fan. Lighting arrangement is subject to Engineer's approval. Battery shall be provided to operate the car fan and the car lighting fixtures for at least 1 hour.
- I. Natural ventilation is to be provided for each car irrespective of provision of forced ventilation.
- J. Inspection lamp sockets are to be provided inside, on roof and below car.
- K. Indicators and control stations are to be provided in each car according to "Signal Equipment Article". Provide small cabinet with lockable cover for telephone/intercom set.
- L. Padded Covers: Provide one set with each type of service elevator, to protect car finishes from damage at times elevator is used to carry freight. Provide hooks for hanging padded covers.
- M. Noise Level inside the car shall not exceed the following values:
 - 1. 50dBA at full speed in both directions with fan off.
 - 2. 55dBA at full speed in both directions with fan at high speed.
- N. Noise level outside the car shall not exceed 55dBA at one meter in front of the car entrance during full door open and close cycle and reversal cycle, in addition to a lift travelling at full speed inside the shaft.
- O. Car horizontal Acceleration: Lateral quaking, peak to peak shall not exceed 15 milli-g.
- P. Car inspection station is to be provided on top of the car to include the following:
 - 1. A two-position (auto/inspection) switch.
 - 2. A run button, to be pressed in conjunction with up and down direction buttons. This to prevent accidental running situations under inspection.
 - 3. A stop switch.
 - 4. A duplex electrical socket standard type.
 - 5. A work light to be either plugged into the electrical socket or directly wired into the top of car station. If directly wired an "off/on" switch is required on the top of car station
- Q. When the station is switched to inspection, the lift speed is not to exceed 0.63 m/s and all operating devices in the cab are to be inoperative.
- R. Notices and signage: A stainless steel grade 304 load plate shall be provided inside the car indicating the following:
 - 1. Rated Load.

2. Name of the company, telephone number, and emergency instructions.
 3. Fire instructions “ **In Case Of Fire Do Not Use Lift** “
- S. Elevator Car Finishes: For walls, doors, ceiling, handrails, and floor finishes refer to the architecture detailed material finishing schedules.
- T. Loading Class: Swing and Service Elevators shall have a loading class C1. For C1 loading concentrated wheel loading on car and landing sills up to 80% of the rated load is never to be exceeded.
- U. Protection measures and provisions shall be secured for the protection of the Service elevator(s) car during their usage.
- V. Provisions/ interfaces for installation of IP Telephone, and IP CCTV inside each elevator car:
1. Security and IT Contractor
 2. All provisions / installations are subject to Architectural and Interior Design Engineer approval.
 3. Provide and install all necessary concealed conduits inside car as indicated on the security details drawings, along with all cabling works inside the elevator car.
 4. Provide and install of enclosure on the car top for installation of an industrial data switch by Elevator supplier in full coordination with IT Contractor.
- W. Elevators’ travelling cables shall include fiber optic cables (minimum 4 cores SM cable) along with all cabling and termination works in full coordination with the IT contractor.

2.5 AUXILIARIES

- A. Counterweight: Structural steel frame fitted with cast iron sub-weights secured with tie rods or steel weights with locks at the top. Weight is to equal total car weight plus 40 to 50% of contract load. Counterweight is to be screened to a height of 2 m from bottom of pit and fitted with renewable guide shoes at top and bottom, Blocking is to be provided between counter weight and buffer strike plate for at least 250 mm per 60 m rope length.
- B. Guide shoes are to be rolling type for speeds exceeding 1.6 m/sec and sliding type for speeds 1.6 m/sec and below. Guide shoes are to be adjustable, renewable, and fastened to top and bottom of car and counterweight frames.
- C. Roller guide shoes: roller guide shoes are to be adjustable mounting base type, rigidly bolted to the top and bottom of each side of car and counterweight frame. Roller guides are to consist of set of sound reducing rubber-covered wheels with precision ball bearings held in contact with the three finished rail surfaces by adjustable stabilizing springs. The bearings are to use permanent lubrication. Roller guides are to be equipped with adjustable stops to control past wise float. The car and counterweight roller guides are not to rotate at more than 400 rpm and 800 rpm respectively to maximize roller guide life and car ride comfort. Statically balance the car and counterweight to maintain uniform pressure on the roller guides.
- D. Guide Rails: Highest quality steel T-sections with tongue and grove joints for the car and counterweight. Hollow sections are not acceptable. Guide rails sections are to be connected with machined fishplates. Unless otherwise indicated, use car guide rails with a minimum of T127 rail sections for speeds up to 4 m/sec and a minimum of T140-1 for higher speeds. For lifts greater than 2500 kg capacity, use a minimum of T140-2 rail sections. For all counterweights and for cars with speeds lower than 2.5 m/s with loads up to 1600 kg, use suitable rail sizes to EN81-20 and EN81-50 and profiles as per ISO standards, connected with steel splice plates. Guide surfaces are to be accurately machined and polished. When rail length exceeds 30 m means are to be provided to absorb rail expansion and structural settlement. Guide rail fixings are to be heavy steel brackets with metal inserts in concrete

walls. Guide rail and fixings are to withstand sudden application of safety gear under maximum load.

- E. Inserts: coordinate with builder's works to furnish required concrete inserts and similar anchorage devices for the installation of guide rails, machinery, and other components of lift work where installation of devices is indicated as work. Provide necessary shop drawings for the required works.
- F. Suspension Ropes: Special acid quality steel or high grade traction steel single factory production patch with safety factor 14 or as specified in BS EN 81-1, EN81-20 and EN81-50 whichever greater. Ropes are to be securely attached to car and counterweight and are to have independent means of adjustment. There are to be minimum three ropes, each of minimum 8-mm diameter for elevators with traction sheaves. Provide test certificates of compliance with appropriate Code and/or Standard prior to shipment. For travels above 60 m, provide steel cord governor ropes to limit movement of the governor tension wheel due to changing humidity values. An automatic tension device shall be provided to equalize the tension of suspension ropes.
- G. Roping arrangement: arrangements used are subject to verification by the manufacturer and approval of the Engineer.
- H. Compensation Ropes: provide compensation for the weight of the hoist way ropes and unbalanced portion of the travelling cables whenever the travel exceeds 30 m so that the system balance is not to vary more than 50 kg over the entire range of travel.
- I. Compensation Ropes: compensation is to consist of steel wire ropes for speeds above 2.5 m/sec and Chain with a fire retardant round resilient rubber cover for rated speeds not exceeding 2.5 m/sec.
- J. Compensation Ropes: compensation ropes are to be attached to the underside of the car and to the counterweight passing under a weighted compensation sheave in the pit. Provide lockdown as described in BS EN 81-1, EN81-20 and EN81-50 to the compensation sheave assembly, whenever rope compensation is applied. Provisions are to be made for equalizing tension in the compensating ropes. The guide sheave is to be provided with bearings of antifriction bearing metal, ball or roller type. The guide sheave is to operate in guides, and the guide structure is to be securely fastened in place. Provide metal guards to prevent ropes jumping off sheave and to prevent foreign objects from falling between ropes and sheave grooves and to protect workmen. Provide upper and lower travel limit switches on the compensation guide sheave. When actuated, power to the drive and brake shall be removed.
- K. Buffers are to be approved design, oil type for speeds exceeding 1 m/sec and spring or polyurethane type for speeds of 1 m/sec and below. Buffers are to be installed under each car and counterweight. Use reduced stroke buffers with associated terminal slowdown devices where runbys are restrictive. Buffers are to be tested by a qualified testing laboratory and approved as complying with the governing code.
- L. Oil Buffers: provide oil buffers with necessary blocking and horizontal steel braces. Oil buffers are to bring the car and counterweight to rest from governor tripping speed at an average rate of retardation not exceeding gravity. Oil buffers are to be of the spring return type and shall have means of checking oil supply level. Oil buffers are to have a marking plate indicating the manufacturer's name, the buffers identification number and the stroke.
- M. Spring Type or Polyurethane Buffers shall be in full compliance with the code requirements. Buffers shall be designed and constructed to absorb within the limits of their stroke, the whole kinetic energy of the car carrying its rated load when the speed of impact is the maximum governor tripping speed
- N. Safety Gear and Governor (Governor Actuated Mechanical Safety Gear): Mechanical safety gear is to be mounted on and securely fastened to car frame and actuated by a governor

mounted in hoist way. Governor is to be directly driven by steel cable or chain, they are to be in compliance with BS EN 81-1, EN81-20 and EN81-50.

- O. Safety gear is to hold car securely under maximum load and governor tripping speed conditions. Jaws of gear are to engage guide rails through self-aligning shoes with surfaces carefully machined parallel to guide rail face. Pressure of jaws on the two guides is to be equal. Safety gear is to bring car to stop from governor tripping speed. Make provisions to release the car safety. In no event the safety is to be released by downward motion of the car. Raising the car to reset the safety gear is to be allowed. An electrical safety plank switch is to be provided to interrupt the power to the hoist machine when the safety gear is set.
- P. Safety gear type test is to be type tested in accordance with BS EN 81-1, EN81-20 and EN81-50 by an approved independent test body. Certified type test report is to be submitted for approval. Install a car safety marking plate of corrosion resistant metal and, in addition to the data required by the governing code, indicate the manufacturer's name and manufacturer's catalogue designation number for the safety gear.
- Q. Governor is to be accurately adjusted and sealed to trip safety gear at 115% of car's specified speed. Operation of governor on over speed is also to open a switch disconnecting power from motor and brake control circuits, which are to be open before safety gear is applied. Restoration of power is not to be possible until safety gear has been manually re-set. Governor shall be sealed and tagged in accordance to BS EN 81-1.
- R. Governor ropes: the over speed governor is to be driven by a wire rope designed for that purpose with minimum diameter of 6 mm and to be easily detachable from the safety gear. The ratio between the pitch diameter of the pulleys for the over speed governor ropes and the nominal rope diameter shall be at least 30. The over speed governor rope is to be tensioned by a tensioning guided pulley. For lifts with rated speeds above 2.5 m/s, grip jaws to be provided to clamp the governor rope in order to actuate the car safety upon a predetermined over speed downward. Design the governor rope-tripping device so that no appreciable damage to or deformation of the governor rope is to result from the stopping action of the device in operating the car safety.
- S. Counter weight safety gear: provide a governor actuated mechanical safety gear under the counterweight for all lifts having occupied space below their hoist-ways/ pits.
- T. Safety Gear Type shall be progressive (gradual) type if the lift rated speed is 1 m/sec or above and progressive (gradual) or instantaneous type if the lift rated speed is below 1 m/sec unless otherwise indicated.
- U. Lift Pit Stop Switch: A switch shall be provided at each lift pit to stop the lift and prevent it from any further movement until placed back to "Run" position.
- V. Pit access: An access door or cat ladder shall be provided for the access of the lift pit according to code requirement.

2.6 DOORS

- A. Opening Sizes: Landing and car door openings are to be same size.
- B. Automatic Sliding Car And Landing Doors: Power operated type, to open silently, and to have the following features:
 - 1. Hangers and tracks of two-point suspension ball or roller bearing type; doors guided at bottom by gibes in grooved sill; grooves and tracks cleaned automatically by operation of doors.
 - 2. All landing doors (except glass doors of panoramic lifts) shall be insulated, 2-hours fire rated as per NFPA 252, EN 81-58 and EN 1363 standards. Criteria of door performance shall satisfy both integrity (E) and thermal insulation (I) tests. For the

low rise buildings, 6 floors and less; non-insulated, 2-hours fire rated doors satisfying integrity test (E) can be used.

3. Infrared light-beam (minimum of 35 beams) and photo-electric cell device to open doors when light-beam is interrupted and to automatically optimize time of opening and reclosing through microprocessor based controller. Alternative protection devices may be used for service elevators, details shall be provided for engineer's review and approval.
4. Include extended door hold open button in the main car operating panel for all elevators to extend the door open time (10-20 sec time adjustable through proper programming) to facilitate transfer. Registration or re-registration for car call shall cancel the hold open time.
5. Doors shall open automatically and simultaneously when car stops at required floor, are to remain open for a reasonable, adjustable period, and automatically and simultaneously close, as set in elevator control sequence.
6. 'Door Open' push button on car control panel is to reverse door closing operation, but is not to open an interlocked door.
7. Door contact to prevent operation of the car unless the car door is in the closed position. The door contacts are not be readily accessible from the inside of the car.
8. Nudging facility so that if the doors are held open for a predetermined time (15 to 20 seconds) by interrupting the light beams or by holding the door, or by pressing the door open button, a buzzer is to sound and the doors is to start to close at reduced rate of speed. Doors are to continue to close unless the door force limits is not exceeded, which is to cause doors to reopen or stop. Process is to continue until obstruction is removed from entrance.
9. Adjustable door dwelling time, the time interval that elevator doors stand open after a stop shall be independently adjustable for car call stops and hall call stops. A separate door time shall be adjustable for lobby door hall calls.
10. Advance door opening, the car and hall doors shall begin to open while the car is preparing to stop at a landing to answer a call. The distance from a landing at which the doors begin to open shall comply with applicable codes.

- C. Electric door operator driven by an electric motor, minimum IP 23 for firefighting lifts and IP21 for other lifts, is to open and close car and landing doors simultaneously. Door operation is to be automatically controlled by lift control system, with facility to manually reverse door closing operation from car control panel. Doors are to be mechanically secured and electrically interlocked when closed. Electric door operator is to have the following features:

1. Variable voltage variable frequency (VVVF) electric motor driving unit, mounted on car top (vibration isolated from car body) to operate the car and hoistway doors simultaneously, with necessary gears, levers, door arms, belts and ropes to achieve smooth operation of doors in both directions and an opening speed higher than closing speed.
2. Digital closed-loop system to monitor and control the door speed.
3. Torque limiting clutch to prevent harm to persons caught by closing door, but to overcome small obstructions in bottom guide track.

4. Manual opening of doors is to be possible in the event of power failure, if car is at landing, landing door is to open with car door; mechanism is to reset automatically.
 5. With installations, in which doors commence opening while car is leveling to landing, mechanical and electrical devices are to ensure no dangerous situation can occur during this period.
- D. Emergency doors: for express runs exceeding 11m, provide emergency landing door every 11m. Emergency landing doors are to be automatic, sliding, central opening, of same type, size and finish of the landing doors of the same lift group, 2 hours fire rated and to be provided by the lift supplier.
- E. Door Frames and Sills: Door support units fitted at landing entrance are to be self-contained, comprising sill, two angle uprights and head. Non-slip sill is to be fitted at each landing and car entrance. Architraves are to be fixed at each landing. Sills shall be made of extruded hard aluminum with rubbish disposal halls.
- F. Sills shall be made of solid stainless steel grade 304 for service elevators with loading class C1.

2.7 VARIABLE VOLTAGE VARIABLE FREQUENCY (VVVF) DRIVE CONTROLLER

- A. Motor Drive: unless otherwise indicated or specified, use 3-phase, solid state, and variable-voltage variable-frequency (VVVF) power drive with regulated closed loop speed monitoring control system. Drive is to utilize IGBT power semi-conductors having means for heat dissipation and overheat protection (include thermal overload). Drive units are to be provided with isolation transformers and smoothing reactors to eliminate mechanical vibration from ripple voltage transients. Matched motor (high efficiency vector design) including encoder for speed feedback is to be provided. Air blower is to be used for thermal dissipation over the entire range of operation and stall.
- B. Continuous Operation: drive is to be designed for continuous operation at rated speed and rated load, and for 10 minutes at rated speed and 110 percent of rated load, without overheating. Ensure that, in such operating conditions, normal power sources are not adversely affected and emergency generator circuits (and loads connected to the emergency power bus) are not adversely affected during Standby Power operation. Protect each power feed line against surge currents. Prevent runaway in the event of closed loop feedback circuit failure.
- C. Electronic Negative Feedback System: is to be used to limit current through IGBT's and motor, incorporating:
1. Pattern-generator giving a velocity input signal modified by car position, with constant peak acceleration and constant change of acceleration.
 2. Encoder to provide a velocity feedback signal.
 3. Digital transducer to provide a position feedback signal.
 4. Current transformer to provide a current feedback signal.
- D. Power Line Noise is to be limited to a voltage distortion factor and line notch as defined in IEEE 519-1981 Edition, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters". The total voltage distortion is not to exceed 3 percent. Necessary filters are to be provided to limit the feedback current harmonics to 10%.
- E. Overall Drive System Response: arrange system response so that the elapsed time between fault detection and removal of electric power does not exceed 0.1 second. Overall drive efficiency is to be greater than 95 percent. Power factor is to be 0.95 minimum.
- F. Power Supply: equipment's are to be designed to operate at ± 10 percent supply voltage and ± 3 percent supply frequency, without damage to any equipment and to operate at ± 5 percent supply voltage and ± 3 percent supply frequency without affecting operational performance quality. Protective devices are to be provided for both over-voltage and under-voltage

conditions. Protect against loss of phase, phase reversal or overload. Incoming power supply is to be provided with contactor inside the control panel.

- G. Controller: the controller is to be microprocessor-based and provided with the following operating features and performance functions:
1. Digital control, with adjustments that do not vary, drift or age with line voltage changes.
 2. Linearity between required torque and torque output.
 3. Precise closed-loop speed, regulated to less than $\pm 1\%$ by frequency compensation.
 4. S-curve 'soft' start/stop, with a fast speed response system.
 5. Diagnostic record of the history of the lift operating conditions, from the instant of the last fault occurrence back 30 days minimum, and to include the following as a minimum:
 - a. Emergency Faults,
 - b. Fire service activation ,
 - c. Inspection mode,
 - d. Independent Service,
 - e. Time out of service,
 - f. Car out of service,
 - g. Safety Edge failure ,
 - h. Emergency Power.
 6. Application-specific memory to support logic function programming, to tailor the drive.
 7. Quiet motor operation, based on high switching frequencies and low harmonic content.
 8. Full function operator interface with alphanumeric display. Include: a menu structure with scrolling to reveal system options and display parameters; and interactive interface to permit. Display and ready changing of parameter values; constant pressure jog for pre-set speed control; motor rotation direction selector; run/stop commands.
 9. Protective features including phase-to-phase and phase-to-neutral short-circuit protection; ground fault protection; electronic motor overload protection; over-torque and under-torque detection; over current, over-voltage and over-temperature detection; input/output phase loss.
 10. Noise filter between hoist way wiring and controller to eliminate interference.
- H. Protection: system is to be protected against the following:
1. An error level exceeds the signal by more than 5 percent.
 2. Actual acceleration exceeds a pre-set pattern more than 15 percent.
 3. Excessive transistor switching time or overheating of solid-state components.
 4. Car positions as derived from a digital transducer and an integrated velocity feedback signals differ by more than 12 mm.
 5. No voltage or sustained under voltage.
 6. Over current in any component.
 7. Phase reversal of power supply.
- I. Wiring: install copper wiring runs are to be neatly installed. Wire is to be terminated at studs or terminal strips, with connections to ensure substantial electrical and mechanical integrity. All major components are to be exactly identified as indicated on wiring diagrams by engravings or tags mounted immediately adjacent to the component.
- J. Enclosure is to be a sheet metal cabinet totally enclosed, IP 21 with removable hinged doors (key-locked) and with filtered ventilation sufficient to maintain interior temperature at a reasonable level.
- K. Auxiliary Emergency Supply: control system shall operate from rectified AC supply, at a suitably selected and approved DC voltage. Negative terminal shall be connected to earth. Battery shall be sealed nickel cadmium or lithium type, capable of operating intercom, car fan, half of the car lights and alarm circuits for 1 hour, in the event of power failure

2.8 ELECTRICAL EQUIPMENT

- A. Equipment generally is to be in accordance with the requirements of relevant Division 16 Sections.
- B. Power Supply Variations: Equipment is to operate satisfactorily if voltage varies $\pm 10\%$ and/or frequency varies $\pm 63\%$ from nominal.
- C. Wires and cables inside hoist-way are to be silicon rubber or PVC insulated, 600/1000 V grade, flame retardant. MICC and silicon rubber insulated cables are to be used for high ambient temperatures. Conductors are to be copper.
- D. Conduits and wire ways: wiring and unarmored cables are to be enclosed in flame retardant PVC or galvanized steel trunking / conduits as per EN81-20: and EN 81-50, and to run in heavy gauge galvanized steel conduits or trunking for fire fighter lifts.
- E. Earthing: Metal frames of elevator installations are to be earthed according to Division 16 Section "Grounding and Bonding".

2.9 LIFT OPERATION MODES/SYSTEM

- A. Passenger/Service Elevators: Provide manufacturer's standard microprocessor operation system for each elevator or group of elevators as required to provide type of operation system indicated.

1. Multiple-Car Group for Office Buildings: Provide "Group-collective" as defined in BS 5655-6. Groups of two or three or four cars are frequently interconnected and collectively controlled. One pushbutton station is required at each landing and the call system is common to all lifts in the group. The pushbutton arrangements are the same as full-collective. Extra pushbutton stations shall be required for architectural balance (for each elevator), as in the case of a three-car group each landing call is automatically allocated to the best-placed car, often the nearest car. The traffic control system is designed to space the cars (provide a constant headway) and to give an even service. When a car reaches the highest requested floor, its direction of travel can be reversed when it starts its next trip. One or more cars can be made to return to a designated floor. Automatic bypassing of landing calls, when a car is fully loaded, is an essential feature. Any car under inspection or taken out of service is isolated from the group whilst the other cars continue to provide service to all floors.

It shall be possible for each elevator to be switched to attendant operation, removing it from the group. Elevator control system shall be so arranged that appropriate car responds to landing calls by automatic selection, and systematic spacing of cars is maintained to minimize delays. Direction in which car will travel shall be determined by calls stored in system. 'Up' and 'down' directional call pushes shall be provided at each landing served by bank, together with 'call registered' illuminated signal for each push. 'Up' or 'down' push only shall be provided at terminal landings. In each car, a push shall be provided for each floor served, marked with appropriate floor designation. When elevators are switched to passenger operation, calls by momentary pressure on 'floor' pushes in car or pushes at landings shall be registered in control system and automatically and selectively cause closing of respective car door and start car in direction of first registered call. Elevator shall collectively answer registered car and landing calls in sequence in one direction and then in the other. Having answered all calls stored in system, one car shall return automatically to reception/ground at main floor, with doors open, and other car(s) shall remain at floor last reached. When any elevator of a group is switched to attendant operation, car shall respond to car calls and landing calls stored in system, but car shall start when attendant presses 'start' button. When attendant presses 'pass' button, landing calls are by-passed but remain registered. When attendant presses 'reverse' button, car shall

stop and travel in opposite direction. Unanswered calls shall remain registered. 'Pass' and 'reverse' buttons shall be inoperative in passenger operation mode.

B. Auxiliary Operations: In addition to primary operation system features, provide the following operational features for elevators where indicated:

1. Standby Power Operation: On activation of standby power, cars are returned to a designated floor and parked with doors open. One car is returned at a time, with priority given to loaded cars. If a car cannot be returned after two attempts, each of a preselected length of time, it is removed from the system. When all cars have been returned or removed from the system, one car is automatically placed in service. If car selected for service cannot operate within 60 seconds, the system removes car from service and places another car in service. Cars can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at Manual operation causes automatic operation to cease.
2. Independent Service: Key switch in car control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from key switch when car is in independent service. When in independent service, doors close only in response to the door close button.
3. Loaded-Car Bypass: When car load exceeds a predetermined weight, car will respond only to car calls, not to hall calls. Predetermined weight can be adjusted.
4. Automatic Dispatching of Loaded Car: When car load exceeds a predetermined weight, doors will begin closing.
5. Nuisance Call Cancel: When car calls exceed a preset number while the car load is less than a predetermined weight, all car calls are canceled. Preset number of calls **and predetermined weight** can be adjusted.
6. Distributed Parking: When cars are not required for response to calls, they are parked with doors closed, distributed in predetermined zones throughout the building. One zone shall include the main floor and the adjacent floors; the remaining floors shall be divided into approximately equal zones.
7. Load-Weighing Device (Service Elevators): When car load exceeds 80 percent of rated capacity, a signal light is lit in the car control station; when car load exceeds rated capacity, car will not respond to car or hall calls.

C. Security Features: In addition to above operational features, provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.

1. Auxiliary Emergency Supply: Control system is to operate from rectified a.c. supply, at a suitably selected and approved D.C. voltage. Negative terminal is to be connected to earth. Battery is to be sealed lead-acid type, capable of operating all controls, car fan, lights and alarm circuits for 6 hours, in the event of power failure.
2. Key switch Feature: Car and hall push buttons are activated and deactivated by security key switches. Key is removable only in deactivated position.
3. Secured Landing Feature: Allows each landing to be secured or cleared. If landing is secured, car buttons for that landing do not register a call unless landing access code is entered within a predetermined time period after landing button is pressed. When a secured landing button is pressed, a "Restricted Floor" lamp lights and remains lit until landing access code has been entered or predetermined time period has elapsed.

- a. Access codes are programmed at each car operating panel using a security key switch. Secured landing feature is activated and deactivated by a security key switch at the main landing.
4. Car-to-Lobby Feature: Feature, activated by a key switch at main lobby that causes all cars in a group to return immediately to lobby and open doors for inspection. On deactivation by key switch, cars complete calls registered before key switch activation and resume normal operation.
5. Card-Reader Operation: For access to restricted landings. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space in car as indicated for card reader.
 - a. When system is activated, car calls to restricted landings do not register until card is accepted by security access system. Security access system determines which landings are restricted and which of those are accessible to cardholder.

2.10 SIGNAL EQUIPMENT

- A. General: Provide signal equipment for each elevator or group of elevators with hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements of acrylic or other permanent, non-yellowing translucent plastic.
- B. General: Provide signal equipment designed for destination-based system for each elevator or group of elevators. Fabricate lighted elements of acrylic or other permanent, non-yellowing translucent plastic.
- C. Car Control Stations: Provide manufacturer's standard semi recessed car control stations. Mount in return panel adjacent to car door, if not otherwise indicated.
- D. Car Control Stations: Provide fully recessed car control stations with applied metal faceplates. Mount in return panel adjacent to car door, if not otherwise indicated.
- E. Swing-Return Car Control Stations: Provide car control stations fully recessed in hinged return panel adjacent to car door.
- F. Emergency Communication System: Provide system that complies with BS EN 81-28, BS EN 81-20, BS EN 81-50, and BS EN 81-70. On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System shall allow a two-way voice allowing permanent contact with a rescue service. System provides two-way voice communication without using a handset and provides visible signals that indicate when system has been activated and when monitoring station has responded. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
- G. Fire Department Communication System: Provide **[flush-mounted cabinet]** in each car and required conductors in traveling cable for fire department communication system specified in Division 16 Sections.
- H. Car Position Indicator: For passenger elevator cars, provide illuminated-signal type, digital display type, or segmented type, located above car door or above car control station. Also provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served.
 1. Include travel direction arrows if not provided in car control station.
- I. Hall Push-Button Stations: Provide hall push-button stations at each landing for each elevator or group of elevators as indicated.
 1. Provide units with flat faceplate for mounting with body of unit recessed in wall.

2. Provide units with direction-indicating buttons; two buttons at intermediate landings; one button at terminal landings.
 3. Provide units with buttons for registering destination that incorporate a visual and audible signaling system to verify floor selection and to direct passenger to assigned car and a button to indicate that passenger has disabilities so control system can allow extra room in assigned car. **[Provide for connecting units to building security access system so a card reader can be used to register call and designate destination.]**
- J. Hall Lanterns: Provide units with illuminated arrows, but provide single arrow at terminal landings.
1. Provide units with flat faceplate for mounting with body of unit recessed in wall and with illuminated elements projecting from faceplate for ease of angular viewing.
 2. Place lanterns either above or beside each hoistway entrance, unless otherwise indicated. Mount at a minimum of **72 inches (1829 mm)** above finished floor.
 3. Place lanterns in both jambs of entrance frame for each elevator. Mount at a minimum of **72 inches (1829 mm)** above finished floor.
 - a. At manufacturer's option, for single elevators or for only two cars in a group, lanterns may be located in car doorjambs instead of entrance jambs.
 4. With each lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
 - a. At manufacturer's option, audible signals may be placed on each car.
- K. Hall Position Indicators: Provide illuminated-signal type or digital-display type, located above each hoistway entrance at ground floor. Provide units with flat faceplate for mounting with body of unit recessed in wall.
1. Integrate ground-floor hall lanterns with hall position indicators.
- L. Corridor Call Station Pictograph Signs: Provide signs matching hall push-button stations with text and graphics according to ISO and EN applicable codes.

2.11 DOOR REOPENING DEVICES

- A. Infrared Array: Provide door reopening devices with a uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.
- B. Door Edge Device: Provide retractable edge shoes on elevator entrance doors that cause doors to stop and reopen on contacting an obstruction. Include photoelectric device with timed cutout that projects dual-light beams across car entrance at **5- and 29-inch (127- and 737-mm)** heights; the beams, when interrupted, cause doors to stop and reopen.
1. Provide key switch in car operating panel for photoelectric device.
 2. Nudging Feature: After car doors are prevented from closing for a predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

2.12 PASSENGER ELEVATOR CAR ENCLOSURES

- A. General: Provide manufacturer's standard (Refer to the architecture material finishing schedules) **[enameled-steel car enclosures with removable wall panels] [steel-framed car enclosures with non-removable wall panels]**, suspended ceiling, trim, accessories, access doors, doors, power door operators, sills (thresholds), lighting, and ventilation.
1. Floor finish is specified in another Section.

2. Metal Wall Panels: Flush hollow-metal construction, fabricated from metal indicated.
3. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard with **[plastic-laminate panel backing complying with NEMA LD 3, Type BKV and]** manufacturer's standard protective edge trim. Panels have a flame-spread rating of **[25] [75]** or less, when tested according to ASTM E 84.
4. Fabricate car with recesses and cutouts for signal equipment.
5. Fabricate car door frame integrally with front wall of car.
6. Enameled-Steel Doors: Flush, hollow-metal construction.
7. Stainless-Steel Doors: Flush, hollow-metal construction, fabricated from stainless steel.
8. Textured Stainless-Steel Doors: Flush, hollow-metal, prime-painted-steel doors, faced with textured stainless-steel sheets. Laminate textured stainless steel to exposed faces and edges using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
9. Bronze Doors: Flush, hollow-metal, prime-painted-steel doors, faced with bronze sheets. Laminate bronze to exposed faces and edges using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
10. Plastic-Laminate Doors: Flush, hollow-metal, prime-painted-steel doors, faced with plastic laminate; with manufacturer's standard protective edge trim.
11. Sills: Extruded metal, with grooved surface, **1/4 inch (6.4 mm)** thick. Provide polished finish on **[bronze] [and] [nickel silver]**.
12. Luminous Ceiling: Led light fixtures and/or ceiling panels of translucent acrylic or other permanent rigid plastic complying with flammability requirements.
13. Polished Metal Ceiling: Flush panels, of metal indicated, with low-voltage downlights in the center of each panel.
14. Handrails: Manufacturer's standard handrails, of metal indicated.

2.13 SERVICE ELEVATOR CAR ENCLOSURES

- A. General: Provide car enclosures of service loading classes, sizes, door types, and opening sizes indicated. Include ventilation, lighting, finishes, access doors, thresholds, trim, and accessories. Fabricate car with recesses and cutouts for signal equipment.
 1. Provide power door operators with linkages for hoist-way door operation.
- B. Materials and Fabrication: Provide manufacturer's standard (Refer to the architecture material finishing schedules) flush panel welded construction made from **[prime-painted steel sheet with a minimum thickness of 0.0677 inch (1.7 mm)] [prime-painted, metallic-coated steel sheet with a nominal thickness of 0.079 inch (2.0 mm)] [stainless-steel sheet with a nominal thickness of 0.0781 inch (2.0 mm)]** reinforced at **16-inch (406-mm)** maximum spacing.
 1. Provide perforated panels for ceiling and walls 72 inches (1829 mm) or more above car floor, unless required to be solid by ASME A17.1.

2.14 PASSENGER HOISTWAY ENTRANCES

- A. General: Provide manufacturer's standard (Refer to the architecture material finishing schedules) horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Provide frame size and profile to coordinate with hoistway wall construction.
 1. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.

- B. Materials and Fabrication: Provide manufacturer's standards (Refer to the architecture material finishing schedules) but not less than the following:
1. Enameled-Steel Frames: Formed steel sheet.
 2. Stainless-Steel Frames: Formed stainless-steel sheet.
 3. Bronze Frames: Prime-painted, formed-steel frames faced with formed-bronze sheet.
 4. Laminate bronze to steel frames using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
 5. Enameled-Steel Doors **[and Transoms]**: Flush, hollow-metal construction. Stainless-Steel Doors **[and Transoms]**: Flush, hollow-metal construction, fabricated from stainless steel.
 6. Textured Stainless-Steel Doors **[and Transoms]**: Flush, prime-painted-steel, hollow-metal construction, faced with textured stainless-steel sheets. Laminate textured stainless steel to exposed faces and edges using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
 7. Bronze Doors **[and Transoms]**: Flush, prime-painted-steel, hollow-metal construction, faced with bronze sheets. Laminate bronze to exposed faces and edges using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
 8. Plastic-Laminate Doors **[and Transoms]**: Flush, prime-painted-steel, hollow-metal construction, faced with plastic laminate; with manufacturer's standard protective edge trim.
 9. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick. Provide polished finish on **[bronze] [and] [nickel silver]**.
 10. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, non-gaseous grout complying with ASTM C 1107.

2.15 SERVICE HOISTWAY ENTRANCES

- A. General: Structural-steel frames and sills for hoistway entrances are specified in Division 5 Section "Metal Fabrications." Unless otherwise indicated, provide hoistway entrance doors of type indicated below, with truckable sill bars and resilient safety meeting-rail gaskets.
1. Equip for power operation by coordinated linkage with power-operated car door.
 2. Where gypsum board wall construction is indicated, provide fire-resistance-rated, hollow-metal, door-and-frame hoistway entrances. Provide self-supporting frames with reinforced head sections.
- B. Materials and Fabrication: Provide selections indicated; provide manufacturer's standards (Refer to the architecture material finishing schedules) but not less than the following:
1. Metal Door Panels: Constructed of metal sheets, flush on room side, welded and reinforced in steel framing with vertical reinforcing spaced not more than **24 inches (610 mm) o.c.** Fabricate panel faces from **[prime-painted steel sheets with a minimum thickness of 0.0966 inch (2.5 mm)] [stainless-steel sheet with a nominal thickness of 0.1094 inch (2.8 mm)]**.

2.16 PASSENGER ELEVATORS

The specifications here below per each elevator are not limited to the following items and shall be carried out in conjunction with the whole specification and drawings.

- A. Elevator Type.: **< passenger elevator >**
1. Type: [Gearless] traction.
 3. Rated Load: **[(1600 kg)]**.
 5. Rated Speed: **[(1.6 m/s)]** in accordance with [BS EN 81-50:2014](#) [BS EN 81-20:2014](#).
 6. No of stops: elevators: **[(6)](B+G+1+2+3+4)**.
 7. Auxiliary Operations:

- a. Standby power operation.
- b. Independent service.
- c. Loaded-car bypass.
- d. Automatic dispatching of loaded car.
- e. Nuisance call cancel.
- f. Earthquake Emergency Operation: Comply with requirements of BS EN 81-77.

8. **Machine room type : [machine room less]**

9. Car Enclosures: As follows:

- a. Inside Width for passenger/general purpose elevators: [(2100 mm)].
- b. Inside Depth for passenger/general purpose elevators: [(1600 mm)].
- c. Inside Height: [(2400 mm)].
- d. Door opening: [1200 mm] Center Opening.

10. Hoist way Entrances: As follows:

- a. For passenger/general purpose elevators Width: Refer to Architecture Plans.
- b. For passenger/general purpose elevators Depth: Refer to Architecture Plans
- c. Height: [(2400 mm)]
- d. Pit depth: 1900 mm.
- e. Overhead: 4800 mm.
- f. Type: [Single-speed center opening].

B. Elevator Type.: < passenger elevator >

1. Type: [Gearless] traction.
3. Rated Load: [(1600 kg)].
5. Rated Speed: [(1m/s)] in accordance with [BS EN 81-50:2014](#) [BS EN 81-20:2014](#).
6. No of stops: elevators: [(2)](B+G).
7. Auxiliary Operations:
 - a. Standby power operation.
 - b. Independent service.
 - c. Loaded-car bypass.
 - d. Automatic dispatching of loaded car.
 - e. Nuisance call cancel.
 - f. Earthquake Emergency Operation: Comply with requirements of BS EN 81-77.

8. **Machine room type : [machine room less]**

9. Car Enclosures: As follows:

- a. Inside Width for passenger/general purpose elevators: [(2100 mm)].
- b. Inside Depth for passenger/general purpose elevators: [(1600 mm)].
- c. Inside Height: [(2400 mm)].
- d. Door opening: [1200 mm] Center Opening.

10. Hoist way Entrances: As follows:

- a. For passenger/general purpose elevators Width: Refer to Architecture Plans.
- b. For passenger/general purpose elevators Depth: Refer to Architecture Plans
- c. Height: [(2400 mm)]
- d. Pit depth: 1900 mm.
- e. Overhead: 4800 mm.
- f. Type: [Single-speed center opening].

2.17 PASSENGER / SERVICE ELEVATORS

A. Elevator type.: < combined passenger/service elevator.>.

1. Type: [Gearless] traction.
2. Rated Load: [(1600 kg)].
3. Service Loading Class: Class [C1]
4. Rated speed in accordance with BS EN 81-50:2014 BS EN 81-20:2014 (according to each projects' elevator sizes).

5. Rated Speed: [(1.6 m/s)].
6. Power Drive: **VVVF**
7. Operation System: [Group traffic supervisory control].
8. Auxiliary Operations: [**Key switch feature**].
9. **Machine room type: [machine room less]**.
10. Car Enclosures: As follows:
 - a. Inside Width for passenger/general purpose elevators: [(2100 mm)].
 - b. Inside Depth for passenger/general purpose elevators: [(1600 mm)].
 - c. Inside Height: [(2500 mm)].
 - d. Door opening: [1200 mm].
 - e. Front Walls: [Satin mat-stainless steel.] with integral car door frames “architect approval regarding finishes shall be prior to supply”.
 - f. Car Fixtures: Flush [Satin mat-stainless steel frame] “architect approval regarding finishes shall be prior to supply”.
 - g. Side and Rear Wall Panels: [Satin mat-stainless steel] “architect approval regarding finishes shall be prior to supply”.
 - h. Reveals: [Satin mat-stainless steel] “architect approval regarding finishes shall be prior to supply”.
 - i. Door Faces (Interior): [stainless steel] “architect approval regarding finishes shall be prior to supply”.
 - j. Door Sills: [Aluminum] “architect approval regarding finishes shall be prior to supply”.
 - k. Ceiling: [Luminous ceiling with large uniform LED light panel] [Satin mat-stainless steel].
 - l. Handrails: Flat straight ends with [Satin mat-stainless steel], at both side walls “architect approval regarding finishes shall be prior to supply”.
 - m. Floor prepared to receive black marble (specified in Division 9 Section "Marble") “architect approval regarding finishes shall be prior to supply”.
11. Hoistway Entrances: As follows:
 - a. For passenger/general purpose elevators Width: [(6200 mm)/(8300)].
 - b. For passenger/general purpose elevators Depth: [(2300 mm)].
 - c. Height: [(2300 mm)]
 - d. Pit depth: 1900 mm.
 - e. Overhead: 4800 mm.
 - f. Type: [**Single-speed center opening**].
12. Additional Requirements: As follows:
 - a. Door reopening device.

B. Elevator type.: < **combined passenger/service elevator**.>.

1. Type: [Gearless] traction.
2. Rated Load: [(1600 kg)].
3. Service Loading Class: Class [C1]
4. Rated speed in accordance with BS EN 81-50:2014 BS EN 81-20:2014 (according to each projects' elevator sizes).
5. Rated Speed: [(1m/s)].
6. Power Drive: **VVVF**
7. Operation System: [Group traffic supervisory control].
8. Auxiliary Operations: [**Key switch feature**].
9. **Machine room type: [machine room less]**.
10. Car Enclosures: As follows:
 - a. Inside Width for passenger/general purpose elevators: [(2100 mm)].
 - b. Inside Depth for passenger/general purpose elevators: [(1600 mm)].
 - c. Inside Height: [(2500 mm)].
 - d. Door opening: [1200 mm].
 - e. Front Walls: [Satin mat-stainless steel.] with integral car door frames “architect approval regarding finishes shall be prior to supply”.
 - f. Car Fixtures: Flush [Satin mat-stainless steel frame] “architect approval regarding finishes shall be prior to supply”.

- g. Side and Rear Wall Panels: [Satin mat-stainless steel] “architect approval regarding finishes shall be prior to supply”.
 - h. Reveals: [Satin mat-stainless steel] “architect approval regarding finishes shall be prior to supply”.
 - i. Door Faces (Interior): [stainless steel] “architect approval regarding finishes shall be prior to supply”.
 - j. Door Sills: [Aluminum] “architect approval regarding finishes shall be prior to supply”.
 - k. Ceiling: [Luminous ceiling with large uniform LED light panel] [Satin mat-stainless steel].
 - l. Handrails: Flat straight ends with [Satin mat-stainless steel], at both side walls “architect approval regarding finishes shall be prior to supply”.
 - m. Floor prepared to receive black marble (specified in Division 9 Section "Marble") “architect approval regarding finishes shall be prior to supply”.
11. Hoistway Entrances: As follows:
- a. For passenger/general purpose elevators Width: [(6200 mm)/(8300)].
 - b. For passenger/general purpose elevators Depth: [(2300 mm)].
 - c. Height: [(2300 mm)]
 - d. Pit depth: 1600 mm.
 - e. Overhead: 4800 mm.
 - f. Type: [Single-speed center opening].
12. Additional Requirements: As follows:
- a. Door reopening device.

2.18 LIFT COMMUNICATION SYSTEM

- A. Intercom: provide an intercommunication system for all lifts in each Office Building. System shall provide two-way communication between the lift car stations and the master stations.
- B. Station Types: the system shall have the following stations:
- 1. Master station at the main fire control room and/or entrance desk of each Building.
 - 2. Master station in the BMS room of each Building.
 - 3. Master station at the lift control station at last floor.
 - 4. Slave station above each lift car.
 - 5. Slave station in each lift pit.
 - 6. Slave station in each lift car
- C. Car Station shall have a loudspeaker and a microphone to provide hands-free communication. The station shall be installed behind the car operating panel.
- D. Master Station shall be provided with selector push buttons, annunciator lights for each connected station, speaker microphone, volume control and function buttons. The intercom system shall include test button to verify audio circuit path.
- E. Car Intercom Call: an intercom call shall be placed from the lift car station by pressing the emergency alarm push button. This action shall cause the lamp in the corresponding button of all the designated master stations to flash and an intermittent tone to be heard.

2.19 REMOTE MONITORING AND COMMAND SYSTEM

- A. Each building shall be provided with Remote Monitoring System: and shall be located in the building's BMS room.
- B. System: computerized Lift Remote Monitoring and Command System complete including software and necessary data and communication network shall be provided for all elevators and escalators of the project. All material and installation requirements of the communication network within the project shall be coordinated with lift supplier and shall be as per his requirements. Panel shall be located at the control room.
- C. Software Package: the software shall cover all required monitoring and command functions, maintenance program requirements in coordination with the maintenance contract and necessary communications and interfaces with lift control system and other concerned systems.
- D. System: lift remote monitoring and command system shall include a state-of-art, multi-color high resolution, minimum 17-inch display, personal computer with adequate mass storage capacity and a dedicated high quality printer. Monitoring and command facility shall be provided in each lift control panel located at the uppermost level, either through local fixed or portable computer unit. Equipment specifications shall be submitted for the Engineer's approval.
- E. Monitoring Display: the system shall be capable of displaying the information in graphic or tabular displays as follows:
 - 1. Graphic Status Display of an elevation representation for all cars in a group shall be shown in the same time for each group including the following as a minimum:
 - a. Floor status.
 - b. Group operational mode.
 - c. Car status.
 - d. Hall calls.
 - e. Date and time, building and group identification.
 - 2. Tabular Status Display shall include as a minimum the same information as above except for registered hall and car calls.
- F. Lift Alarm and Event Data Display: lift remote monitoring and command system shall monitor various discrete signals from the lift system and retain a log of alarms, faults and events. An audible alarm with adjustable volume and silencer shall automatically sound at each lift failure and or alarm condition.
- G. Security Display and Command Operation: system shall display one group at a time and shall allow through keyboard commands modification of the security status of the car in the group, including floors the car is allowed to serve, floors that the car is secured from serving and floors that are cut out from having hall calls registered from them.
- H. Interactive Lift Operations Display and Control: the ability to use the keyboard to initiate and display interactive lift, moving walk and escalator operations, including but not limited to, the following shall be provided:
 - 1. Display faults and events.
 - 2. Alarm messages.
 - 3. Any other special operations allowed by the manufacturer
- I. Traffic Analysis Display: system shall be capable for viewing various reports generated from the data including the following as a minimum:
 - 1. Total number of hall calls (up/down).

2. Average hall call times (up/down).
 3. Maximum hall call time.
 4. Number of car calls per car.
 5. Number of hall and car calls per landing (up/down).
 6. Average hall call time per landing.
 7. Histogram of registration times.
 8. Record of all events alarms.
 9. Statistics showing percentages of time in different operation modes.
 10. Playback of the graphic status display.
- J. Historical Data: system shall be capable of providing full historical data for minimum 30 days, and tendering for modes of operations, failures, alarms, maintenance requirements as a minimum.
- K. Command Control Feature: Proved password protected command control software to enable building manager to control operation of elevators using the following functions:
1. Floor lockout (hall and car simultaneously).
 2. Car call lockout (all cars within a group).
 3. Parking operation- remove car from group and place at predetermined zoning floor.
 4. Independent operation- remove car from group to respond to car calls only.
 5. VIP operation: send any car to any floor and remain there for period of three minutes reassigning all other calls to different cars automatically.
- L. Documentation: provide complete documentation, illustrating functions of software systems, including the following:
1. General system overview.
 2. High-level functional description.
 3. I-O tables and charts, showing output bus and input signals.
 4. Applicable technical manuals for adjusting, including drive control adjustment, terminal characteristics for diagnostic work, and user procedures.

2.20 LIFT FIRE CONTROL PANEL

- A. Lift fire control panel: design and provide lift fire control panel, with display of car position and door status, group and unit operating modes, and operating status for all elevators. In addition to indicators for each fire fighter car, when running on in-car fire emergency mode. Panel shall be located at main fire control room of the building. Panel shall consist of two sections, an analogue type section for the fire fighter elevators (for simultaneous indication of all lifts) and a digital type section for all other elevators comprising a PC with LCD screen. Panel shall be complete with all necessary controls, indicators, wiring, unless otherwise proposed by the supplier and approved by the engineer.

B. Control Devices: provide the following control devices as a minimum:

1. Fireman key switch, to select between normal (off) and emergency fire operation (on) modes,
2. Communication master station

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prior to commencing elevator installation, examine elevator areas, with Installer present, for compliance with requirements, installation tolerances, and other conditions affecting performance of elevator work. Examine hoist ways, hoist way openings, pits, and machine rooms (for machine-room lifts only), as constructed; verify critical dimensions; and examine supporting structure and other conditions under which elevator work is to be installed. Notify Contractor in writing of any dimensional discrepancies or other conditions detrimental to the proper installation or performance of the elevator work. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's instructions and recommendations.
- B. Coordination: Coordinate elevator work with work of other trades for proper time and sequence to avoid construction delays. Use established benchmarks, lines, and levels to ensure dimensional coordination of the Work. Coordinate equipment installations with the building construction to prevent alteration to structure and cutting of holes and chases after equipment installation has started. Ensure provision of pit screen separators between adjacent elevators and for screening off counterweight to a height of 1.8 m from bottom of pit for safety of maintenance personnel.
- C. Assembly: equipment is, as far as possible, to be factory assembled, wired and tested. Site work is to be limited to installation and assembly of parts dismantled at factory for transportation, or otherwise to work not possible at factory.
- D. Workmanship: Carry out work in a neat, workmanlike and efficient manner in accordance with specified requirements. Installation is to be performed by skilled personnel, specialized in elevator installation, who are in the permanent employment of the manufacturer or manufacturer's authorized dealer.
- E. Accessibility: Install equipment so that it is readily accessible for operation, maintenance and repair.
- F. Builder's Work: Carry out all builder's work necessarily required in connection with installation of elevators, including but not limited to, forming or cutting chases, rebates, etc., grouting, supports, steelwork, scaffolding, etc. Provide convenience power, lighting and other services required, from assigned terminal points, to carry out construction work.
- G. Secure machine beams to structural steel and set machines in position for proper alignment with car and counterweight.
- H. Elevator Shafts: Ensure that entrance shaft wall is in same vertical plane as face of landing doors and that whole face is perfectly smooth. Gap between shaft wall and car door sill is not to exceed 10 mm for whole length of shaft.

- I. Fixing Elevator Guide Rails: Keep rails in proper alignment using steel splice plates of adequate strength. Verticality of rail is to be within 0.2% tolerance. Space fixing brackets to minimize rail vibration during operation, and at not more than 2 m centres.
- J. Painting: Protect unfinished metalwork by painting, unless technically undesirable. Painting is to include thorough cleaning of metal, application of rust inhibiting prime coat and two finishing coats of approved enamel.
- K. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby, eliminate sources of structure-borne noise from elevator system.
- L. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.
- M. Alignment: Coordinate installation of hoist way entrances with installation of elevator guide rails for accurate alignment of entrances with cars. Where possible, delay final adjustment of sills and doors until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.
- N. Set sills flush with finished floor surface at landings. Coordinate with other trades to facilitate and ensure proper grouting of sills.

3.3 FIELD QUALITY CONTROL

- A. Acceptance Testing: Upon nominal completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by the "Code" and governing regulations and agencies.
- B. Advise Employer, Engineer, and authorities having jurisdiction in advance of dates and times tests are to be performed on elevators.
- C. Tests: After installation is complete and prior to Substantial Completion, carry out all tests including free-fall tests, load and speed tests, and other tests required by the Governing Regulations and Standards. Carry out any other tests the Engineer may require to check safety and compliance of installation with specified requirements. Tests are to be witnessed by the Engineer and, if required, by the authorities having jurisdiction.
- D. Equipment Failure: Repair and make good any damage to equipment caused by tests or damage to building caused by failure of any part of the installation, to the satisfaction of the Engineer.
- E. Organization of Tests: Provide all labor, materials and instruments required for tests.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Employer's maintenance personnel on procedures and schedules for maintaining, operating, adjusting, troubleshooting, and servicing elevators. Refer to Division 1 Section "[**Demonstration and Training**]" and "[**Closeout Procedures**]."
 - 1. Make a final check of each elevator operation, with Employer's maintenance personnel present, just prior to Substantial Completion. Determine that operation systems and devices are functioning properly.

3.5 PROTECTION

- A. Temporary Use: Do not use elevators for construction purposes unless otherwise approved in writing by Engineer, and cars are provided with temporary enclosures, either within finished cars or in place of finished cars, to protect finishes from damage.
 - 1. Provide full maintenance service by skilled, competent employees of the elevator Installer for elevators used for construction purposes. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Use parts and supplies as used in the manufacture and installation of original equipment.
 - 2. Provide protective coverings, barriers, devices, signs, or other procedures to protect elevators. If, despite such protection, elevators become damaged, engage elevator Installer to restore damaged work so that no evidence remains of correction work. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.
- B. Provide final protection and maintain conditions, in a manner acceptable to elevator manufacturer and Installer that ensure elevators are without damage or deterioration at the time of Substantial Completion.

END OF SECTION 14210

SECTION 143100 - ESCALATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes escalators.
- B. Related Sections include the following:
 - 1. Division 3 Section "Cast-in-Place Concrete" for setting sleeves, inserts, and anchoring devices in concrete.
 - 2. Division 5 Section "Structural Steel" for attachment plates, angle brackets, and other preparation of structural steel for supporting escalators.
 - 3. Division 8 Section "Access Doors" for wall and ceiling access panels and access doors in escalator enclosures.
 - 4. Division 26 Section "Basic Electrical Materials and Methods".
 - 5. Division 26 Sections for electrical service to escalators, including fused disconnect switches.

1.3 DEFINITIONS

- A. Escalators: Power-driven, inclined, continuous stairways used for raising or lowering passengers, including support trusses, balustrades, floor plates, components, machines, safety and control devices, internal electrical wiring of units, graphics, and other components necessary for complete escalator installations and as required to safely operate escalators at rated speed and capacity.
- B. Escalator Width: The width of the step treads.

1.4 PERFORMANCE REQUIREMENTS

- A. Rated Speed: 0.5 m/s.
- B. Braking Performance: Engineer, fabricate, and install escalators to stop the escalator in the up-running mode at a rate no greater than that allowed by the "Code" for the down-running mode.

1.5 SUBMITTALS

- A. Product Data: For each escalator. Include capacities, sizes, performances, safety features, finishes, and similar information.
 - 1. Sample Warranty: Copy of manufacturer's proposed warranty, stating obligations, remedies, limitations, and exclusions.

- B. Shop Drawings: For each escalator. Show plans, elevations, sections, and large-scale details indicating coordination with building structure and relationships with other construction. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and power requirements. Indicate access and ventilation for escalator machine space and well ways.
- C. Samples: For exposed finishes, 75-mm square samples of sheet materials, and 100-mm lengths of running trim members.
- D. 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.
- E. Maintenance Manuals: For each different escalator, including operation and maintenance instructions, parts listing with sources indicated, recommended parts inventory listing, emergency instructions, and similar information. Include all diagnostic and repair information available to manufacturer's and Installer's maintenance personnel. Submit for Employer's information at project closeout as specified in Division 1.
- F. Warranties: Warranties specified in this Section.
- G. Certificates and Permits: Provide Employer with inspection and acceptance certificates and operating permits as required by governing authorities for normal, unrestricted use of escalators.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Engage the escalator manufacturer or an experienced Installer approved by the escalator manufacturer who has completed escalator installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- B. Regulatory Requirements: In addition to local governing regulations, comply with the applicable provisions of the following Standards, referred to as the "Code", in order of priority:
 - 1. EN 115 or BS 5656, "Safety Rules for the Construction of Escalators and Passenger Conveyors".
 - 2. ASME A17.1, "Safety Code for Elevators and Escalators".
 - 3. DIN 8188.

1.7 WARRANTY

- A. Manufacturer's Warranty: Provide a written warranty signed by manufacturer agreeing to repair, restore, or replace defective escalator work during the specified warranty period.
 - 1. Warranty Period: 12 months from date of Substantial Completion.

1.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance service by skilled, competent employees of the escalator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper escalator operation at rated speed.

Use only parts and supplies as used in the manufacture and installation of original equipment.

1. Perform maintenance, including emergency callback service, during normal working hours.
2. Include 24-hour-per-day, 7-day-per-week emergency callback service.
 - a. Response Time: 2 hours or less.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. Fujitec, Inc. (Japan).
 2. Mitsubishi (Japan).
 3. Montgomery Elevator Co. (U.S.A.).
 4. O&K Escalators, Inc. (U.S.A.).
 5. Otis Elevator Co. (U.S.A. or France).
 6. Schindler Elevator Corp. (Germany).

2.2 COMPONENTS AND ACCESSORIES

- A. Supporting Truss: Welded steel lattice-girder construction, designed to support inherent weights of escalators, transport load of 6000 N/m² and dynamic loads (load surface = useable width of escalator x distance between support points). Sag or downward bending of supporting structure, when under load, is not to exceed 1/1000 of free distance between supports. Insulation pads are to be provided at both ends of main truss to prevent noise and vibration transmission to building structure.
- B. Machine Soffit: Smooth steel plate, 4 mm thick, welded and made oil-tight to side members of main truss, installed beneath step band over whole area of escalator, and having oil drain pit in bottom reversing station.
- C. Floor Coverings: Stationary parts of escalator are to be heavy duty aluminium profiles. Groove beds of floor surfaces are to be black anodized, and upper surfaces are to be smoothed to the base metal frames, and set flush with finished floor. Floor coverings in area of machine installations are to be squarely seated and tightly fitted to prevent noise development.
- D. Steps: Die-cast, corrosion proof, aluminium alloy with front edges grooved vertically so that edges of tread surfaces enmesh in grooves. Tread and front-edge surfaces of steps are not to end in a groove under balustrade skirting. Front edge between tread and front face is to be rounded or bevelled. Four support rollers to each step are to be at least 76 mm outside diameter and are to run on ball bearings completely encapsulated against dust and water (RS sealing), with lifetime lubrication, without lube nipples. Step chain rollers are to be fitted outside or inside chain link plates, depending upon manufacturer's design, and are to be at least 80 mm diameter. Running treads (tires) of rollers are to be non-ageing, hardwearing, noise-dampening and oil and acid-resistant synthetic rubber (e.g. NBR nitrile rubber). Treads are to be at least 15 mm thick and 25 mm wide. Rapid removal of steps is to be possible at both upper and lower ends of escalator without removing balustrade panels or skirting plates.

- E. Comb Plates And Combs: Comb segments are to be die-cast aluminium alloy, maximum 200 mm wide, easily exchanged, and with safety contacts on comb teeth. Combs are to be bevelled so that there is no danger of persons tripping when leaving escalator. Bevel angle is not to exceed 20 degrees to horizontal. Tread surface of comb plates is to be finished as floor coverings.
- F. Handrails Endless, high-quality vulcanized rubber composition with fabric insert, sliding layer of nylon webbing and steel cord. Required frictional contact to handrail drive wheel is to be ensured by drive mechanism. Handrail guides are to be stainless steel with minimum breaking strength of 25 K.N.
- G. Lubrication: Main drive chain, step band chains and handrail drive chain are to be connected to automatic lubricating system with electrical lube oil pump and dosing unit. Oil supply is to be sufficient for at least one month's operation. Float switch is to be provided to monitor oil level in reservoir and to give alarm to control cabinet in the event of low lubricant level. All bearing points of rotating components are to be fitted with roller/ball bearings, hermetically sealed against dirt and water. Where bearings require lubrication by grease guns, functional discharge openings are to be provided for used grease.
- H. Bolted Connections: Secure bolts by self- locking nuts or locking rings. Only high-tensile bolts are to be used.
- I. Corrosion Protection: Main supporting truss is to be shot-blasted and finished with two coats zinc dust paint, and one coat iron mica (each coat 40 microns). All traces of rust are to be thoroughly removed from steel components before painting. Handrail guide rails and roller guide rails are to be hot-dip galvanized.
- J. Balustrades: Inner balustrades, skirting, outer balustrades, central balustrades and floor coverings are to be as shown on Drawings, and to the following specification:
 - 1. Handrail profiles, skirting coverings and parapet coverings: Stainless steel, material 4401 (CR NI MO), 2 mm thick, surface ground, grain 240, and brushed.
 - 2. Inner balustrades, outer balustrades and parapet balustrades: Laminated panels, 20 mm thick; visible side stainless steel, material 4401 (CR NI MO), surface ground, grain 240, and brushed; rear side hot-dip galvanized steel.
 - 3. Skirting: Steel plate, 3 mm thick, coated with Teflon compound, surface black, or other equal and approved low friction material.

2.3 DRIVE UNIT

- A. Generally: Drive unit is to be self-contained, compact assembly, placed outside and in front of step band, and comprising motor, flange mounted to speed reducing gear box and resiliently coupled to drive input, service brakes and precision duplex chain mechanism to transmit motion to main drive shaft assembly comprising chain sprocket wheels for main drive, step band drive wheels, handrail drive and safety brake. Details of this or alternative arrangements are to be submitted to the Engineer for approval.
- B. Input stage of drive is to be a worm-gear for noise suppression. Worm shaft is to be case hardened and ground, and gear rim of worm wheel is to be hard-wearing special bronze.
- C. Manual emergency drive is to be provided at upper station, accessible without removal of steps or any part of drive systems.
- D. Drive components, including motor, are to be suitable for continuous operation.
- E. Bearings used in machine transmissions are to be top quality roller/ball bearings with minimal noise development. Plain friction or sleeve bearings are not to be used.

- F. Handrail drive is to be automatically tensioned and is to ensure synchronization with step band speed. Asynchronous running of handrails is not to exceed 2% of step band speed.
- G. Electric Motor: Totally enclosed, fan cooled, protection IP 65, fitted with low noise life-time lubricated roller/ball bearings.
- H. Brakes Generally: Preferably large area band type or approved stirrup-type shoe brakes. Braking force of each brake is to be selected in such a way that fully loaded step band, when travelling downwards at rated speed, comes to stop after maximum braking distance of approximately 0.8 m. Braking effect is to be absolutely smooth.
- I. Service Brake: Constant torque, self-adjusting, and servo-operated, to exert necessary braking torque for direction of travel (upward force approximately 1/3 of downward force), with braking force created by pressure spring. Upon tripping of any safety device, brake is to engage immediately and bring escalator to a smooth stop.
- J. Safety brake is to be provided, in addition to service brake, on main drive shaft assembly, and is to engage after an adjustable time-lag setting. Safety brake is to be actuated by brake release solenoid, manually resettable only, and is to engage in the event of power failure, by stop push button, or operation of any safety device.
- K. Step Guides: Guides for step chains and step rollers are to be hot-dip galvanized steel sections with smooth and even surfaces. Joints are to be formed diagonally in direction of travel. Guides are to be designed so that front edges of emerging steps, and rear edges of disappearing steps, follow a horizontal path at least equal to depth of three steps. Guides are to ensure that gap between step and balustrade skirting does not exceed 4 mm at either side or 7 mm at both sides cumulatively.
- L. Step Chains: High precision rolled, flat link, hardened chains, provided in pairs of equal length. Pins, sleeves and rollers are to be case-hardened and ground. Spur racks or gear chains are not to be used. Step chains and chain pins are to be 14.6 mm minimum diameter. Material for chain pins is to be 23 Cr Mo B33. Chain pitch is not to exceed 135 mm.
- M. Chain Tensioner: Constant and even pressure is to be maintained by adjustable compression springs. Chain tensioning wheels are to be seated in precision slides (ball and prism guides). Even tensioning of step band chains is to be ensured.

2.4 ELECTRICAL INSTALLATION

- A. Generally: Electrical installation comprises connection of all wiring systems from control cabinet to various control devices.
- B. Control Cabinet: Each escalator is to have individual instrument and control gear cabinet with transparent front cover, protection IP 55, shed mounted and located within upper escalator station (drive station), and comprising main circuit breaker, motor control gear, protective devices, relays, cut-off and tripping displays, etc.
- C. Control equipment is to include, in addition to the above, a fault finding digital panel with warning lights, located behind lockable cover in upper balustrade newel. Each safety contact is to be connected to one warning light. Cancelling is only to be possible using a separate switch in the balustrade. Key operated switch (up/down) for starting escalator is to be provided in handrail newel.
- D. Control Voltage: 220V, 50 Hz single phase A.C.
- E. Running time meter is to be provided.

- F. Main Circuit Breaker: Thermal magnetic type, with inverse time-overcurrent, instantaneous and adjustable earth fault protection. Circuit breaker is to be lockable, and with shunt trip coil for safety trips.
- G. Terminal Identification: All terminals are to be marked. All cables are to have coding colours and numbered ferrules.
- H. Wiring is to be arranged neatly and clearly in conduits and terminated on shrouded terminal blocks.
- I. Electrical cables in main truss are to be moisture and heat resistant and flame retardant with PVC/E insulation and sheathing, and are to have 1000 V rating.
- J. Maintenance power circuit at 220V, 50 Hz, is to be provided for power and lighting sockets. Dual sockets for power and lighting are to be provided at drive and tensioning stations.
- K. Control circuit breaker is to be provided at tensioning station.
- L. Maintenance sockets for plugging in maintenance push button control device for testing operation of escalator are to be provided at upper and lower stations, with maintenance control extension device and sufficient cable length.

2.5 SAFETY DEVICES

- A. Operation: Safety devices are to automatically interrupt power supply to drive motor and brake, thereby inducing braking of escalator.
- B. Devices to be provided are as follows:
 - 1. Emergency stop-buttons, at upper and lower newels.
 - 2. Step run-in monitors in area of comb plates and at point of entry of steps into combs, which are to induce safety braking of step chain when a foreign body enters between comb and step.
 - 3. Step band lock.
 - 4. Step sag monitors which are to stop escalator when a step sinks by more than 6 mm due to incorrectly formed or damaged steps or rollers; step is to stop before reaching comb run-in point.
 - 5. Motor overload earth-fault and phase-unbalance protection and excessive temperature protection by thermistors in motor coils.
 - 6. Motor overload earth-fault and phase-unbalance protection and excessive temperature protection by thermistors in motor coils.
 - 7. Handrail safety device to stop escalator immediately should foreign bodies become wedged between handrail and inlet points in balustrade newels.
 - 8. Skirting contacts on both sides of skirting, with micro switches to stop escalator in the event of wedging of objects between steps and skirting.
 - 9. Step chain monitors to stop escalator in the event of any chain breaking or becoming excessively elongated.
 - 10. Excessive speed and unintended reversal relay.
 - 11. Service brake-monitoring contact against failure or phase change.
 - 12. Handrail Speed Device: Sounds an alarm if handrail speed varies from step speed by more than 15% and stops escalators if this condition lasts more than 2 seconds.
 - 13. Skirt Obstruction Device: Stops escalator if an object gets caught between skirt panels and steps as the step approaches the comb plate.
 - 14. Handrail Entry Device: Stops escalator if an object gets caught between the handrail and the handrail guard or, alternatively, if an object approaches the area between the handrail and the guard.

2.6 LOOSE EQUIPMENT, SPARE PARTS AND ACCESSORIES

- A. Generally: Supply loose equipment, spare parts and accessories as required for normal operation and routine maintenance of the escalator(s) and as detailed by the Contractor in his offer, for two years continuous operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine escalator areas, with Installer present, for compliance with requirements, installation tolerances, and other conditions affecting performance of escalator work. Examine supporting structure, machine spaces, and pits; verify critical dimensions; and examine conditions under which escalator work is to be installed. Do not proceed with installation until unsatisfactory conditions have been corrected.
 - 1. For the record, prepare a written report, endorsed by the Installer, listing dimensional discrepancies and conditions detrimental to the performance of escalator work.

3.2 INSTALLATION

- A. Comply with manufacturer's instructions and recommendations for work during installation.
- B. Set escalators true to line and level, properly supported, and anchored to building structure. Use established benchmarks, lines, and levels to ensure dimensional coordination of the Work.
- C. Adjust installed components for smooth, efficient operation, complying with required tolerances and free of hazardous conditions. Lubricate operating parts, including bearings, tracks, chains, guides, and hardware. Test operating devices, equipment, signals, controls, and safety devices. Install oil drip pan and check to ensure that no oil drips outside of pan.
- D. Repair damaged finishes so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.
- E. Assembly: Equipment is, as far as possible, to be factory assembled, wired and tested. Site work is to be limited to installation and assembly of parts dismantled at factory for transportation, or otherwise to work not possible at factory.
- F. Workmanship: Carry out work in a neat, workmanlike and efficient manner in accordance with the specified requirements. Installation is to be performed by skilled personnel, specialized in escalator installation, who are in the permanent employment of the manufacturer or manufacturer's authorized dealer.
- G. Accessibility: Install equipment so that it is readily accessible for operation, maintenance and repair.
- H. Builder's Work: Carry out all builder's work necessarily required in connection with installation of escalators, including but not limited to forming or cutting chases, rebates, etc., grouting, supports, steelwork, scaffolding, etc. Provide convenience power, lighting and other services required from assigned terminal points, to carry out construction work.
- I. Coordination: Coordinate equipment installations with the building construction to prevent alteration to structure and cutting of holes and chases after equipment installation has started.

- J. Fire Protection: Coordinate installations with mechanical works, for provision of fire/smoke detection and fire fighting systems.
- K. Painting: Protect unfinished metalwork by painting, unless technically undesirable. Painting is to include thorough cleaning of metal, application of rust inhibiting prime coat and two finishing coats of approved enamel.

3.3 TESTS ON SITE

- A. Tests: After installation is complete and prior to Substantial Completion, carry out all tests required by the Governing Regulations and Standards. Carry out any other tests the Engineer may require to check safety and compliance of installation with specified requirements. Tests are to be witnessed by the Engineer and, if required, by the authorities having jurisdiction.
- B. Equipment Failure: Repair and make good any damage to equipment caused by tests, or damage to building caused by failure of any part of the installation, to the satisfaction of the Engineer.
- C. Organization of Tests: Provide all labour, materials and instruments required for tests.
- D. Before test run, ensure that step bands, skirtings and comb segments are in order, no foreign bodies are in or on escalator, all steps are fitted, main circuit breaker is in closed position, control switch is in on position, safety devices and protective switches are in operation, series of safety contacts are closed and manual control device is connected to inspection run power socket.
- E. Test run is to include checking starting from installed service panel, reversing direction of running from manual control device and checking that actual running direction corresponds with direction setting, allowing running in each direction for several cycles. Any adjustments are to be made with inspection control device connected.
- F. Testing Operation Of Safeties: In accordance with manufacturer's service and maintenance instructions, check all alarms and indicators and lubricating oil system against manufacturer's data.
- G. After testing, check, and if necessary, re-adjust spring tensions on return shaft, handrail pretension, drive rollers, step inlet and outlet, sag, skirting, gaps etc., brake stopping distance, and gear oil level.
- H. Measurements: Measure motor current in both directions of escalator, and insulation resistance to truss or earth of motor circuit, control circuits, brake circuit, lighting circuits, pump circuit and any other circuits. Insulation resistance is not to be less than 20 M-ohms using a minimum 1000 V dc. megger.

3.4 FACTORY WITNESS TEST

- A. Factory inspection visits are to cover complete checking and testing of selected units according to requirements of the specified regulations and standards as well as special requirements finishes, software and controls. Inspection visits are also to cover spot checking of manufacture work progress to ensure conformance of the equipment being fabricated with requirements of the contract. Inspection and test procedures and programs are to be submitted for approval prior to factory visit.
- B. Factory visits are to include for business class air tickets, five star hotel full accommodations, transportation and all inspections/test expenses.

- C. Allow for One man-visit for the Consultant and Client representative to cover all types of escalators.

3.5 FIELD QUALITY CONTROL

- A. Acceptance Testing: Upon nominal completion of each escalator installation, and before permitting the use of escalators (either temporary or permanent), perform acceptance tests as required and recommended by the "Code" and by governing regulations or agencies.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Employer's maintenance personnel on procedures and schedules for maintaining, operating, adjusting, troubleshooting, and servicing escalators. Refer to Division 1 "Section Closeout Procedures".
 - 1. Make a final check of each escalator operation, with Employer's maintenance personnel present, just prior to Substantial Completion. Determine that control systems, operation components and devices are functioning properly.

3.7 PROTECTION

- A. At completion of escalator work, provide suitable protective coverings, barriers, devices, signs, or such other methods or procedures to protect escalator work from damage or deterioration. Maintain protective measures throughout remainder of construction period.

3.8 ESCALATOR SCHEDULE

- A. Escalator No [**4 Escalators**]:
 - 1. Conveying Height: As indicated in the Drawings.
 - 2. Angle: 30°.
 - 3. Step Width: 1000mm.
 - 4. Step Depth: 400mm.
 - 5. Speed: 0.5 m/sec.
 - 6. Electrical Power Supply: 380V, 50 Hz.
 - 7. Pit Depth: 1400mm.
 - 8. Width of Pit: 1600mm
 - 9. Balustrade Height : 1000mm.
 - 10. Step Run: 3 Horizontal Step at least.
 - 11. Intermediate Supports: The exact position is indicated on the layout drawings & The suspension points must be rated for a load of 60 KN at least.
 - 12. Passenger Load: 80KG kg per step.
 - 13. Location : As indicated in the Drawings.
 - 14. Finishes: As indicated in the Drawings with any additional Client remarks.

END OF SECTION 143100

SECTION 26 05 00- BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
1. General provisions applicable to Division 26 work and other Sections of the Specification that refer to this Section.
 2. Supporting devices for electrical components.
 3. Electrical identification.
 4. Covers, brackets and supports.
 5. Electricity-metering components.
 6. Concrete equipment bases.
 7. Electrical demolition.
 8. Cutting and patching for electrical construction.
 9. Touchup painting.
- B. Electrical Work, unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the Drawings and/or described in the Bills of Quantities and Specification together with all associated ancillary work, support work and builder's work in connection required to achieve full functionality as per the design intent, all in coordination with other involved Packages Contractors and Employer.
- C. The Scope of electrical works shall include, but shall not be necessarily limited to the following:
1. Power Service and Distribution consisting of
 - A) Medium Voltage Network:
 - 1- MV distributor
 - 2- MV ring main units.
 - 3- MV network.
 - B) Low Voltage Distribution Network:
 - 1- MV/LV Transformers.
 - 2- LV Standby Generators.
 - 3- Distribution Panels (switchboards).
 - 4- Final Branch Circuits Panelboards and Feeder Pillars.
 - 5- Automatic Transfer Switches.
 - 6- Motor Control Centers/Panels.
 - 7- Feeders, busways, Sub feeders, and wires.
 2. Conduits, cable trays, wire ways and supporting systems
 - A) Lighting and Small Power Installations:
 - 1) Functional and decorative indoor lighting.

- 2) Building facade lighting.
- 3) Emergency lighting and exit signs.
- 4) Lighting control and dimming systems.
- 5) Wiring Devices and miscellaneous equipment.
3. Telecommunications, life safety and security Systems:
 - 1) Fire alarm system.
 - 2) Security systems.
 - 3) Public address and sound systems
 - 4) Structured cabling system.
4. Other Electrical Systems:
 - 1) Uninterruptible Power Supply.
 - 2) Earthing and Bonding System protection.
 - 3) Electricity Metering Components.
5. Vertical Transportation System consisting of Passenger and Service Elevators
6. Civil Works for Medium Voltage Network and Telecom Networks, including duct banks and manholes.
7. External Site landscape and Street Lighting.

1.3 REGULATIONS AND STANDARDS

- A. Regulations: Carry out electrical work in accordance with the current issue of the local codes of practice, local power authority regulations and [Requirements for Electrical Installations – IET Wiring Regulations (BS 7671) as published by the Institution of Engineering and Technology [International Electro-technical Commission (IEC) Standards of all applicable codes] where not in contradiction with the local codes of practice and regulations, herein referred to collectively as 'the Regulations'.
- B. Conflict: Should an instance occur in this Specification or on the Drawings in which material or construction methods called for is less than minimum requirement of the Regulations, immediately inform the Engineer in writing. Consequent to Engineer's approval, supply the materials and perform the work as though called for to minimum code standards.
- C. Standards: Unless otherwise specified, equipment and materials are to be manufactured and installed in compliance with the relevant recommendations of the following or other equal and approved standards:
 1. IEC: The International Electro-technical Commission
 2. NFPA: National Fire Protection Association.
 3. ISO: The International Standardization Organization.
 4. CCITT: The International Telephone and Telegraph Consultative Committee.
 5. ITU-R: International Telecommunication Union (Radio communication Sector).
 6. CISPR: The International Special Committee on Radio Interference
 7. NETA: International Electrical Testing Association (tests for site acceptance).
 8. IET: Institution Engineering and Technology.
 9. BS: British Standards.

10. CENELEC: European Committee for Electro technical Standardization.
11. CIE: International Commission of Illumination.

- D. Local standards, where enforced and relevant, are to have precedence over the Standards.

1.4 POWER SUPPLY

- A. The Local Power Authority/ Service Provider will provide incoming power supply and connection at [22 KV] to the location shown on the Drawings.
- B. Power Supply: Liaise with the Local Power Authority/ Service Provider to confirm:
1. Characteristics of supply and system earthing.
 2. Location of incoming supply shown on the Drawings.
 3. Space requirements and associated builder's work for the Authority's installations.
 4. Make necessary arrangements at the earliest opportunity to ensure connection as and when required, and inform the Engineer in the event of any foreseen delay.
- C. KWH-metering: Liaise with the Local Power Authority/ Service Provider and provide necessary instrumentation, enclosures and accessories required by them to effect a complete kWH-metering installation.
- D. KWH-metering will be at [medium] voltage as shown on the Drawings.
- E. Electricity Metering at Low Voltage:
- Smart Digital Energy Metering shall be provided to the following as shown on the Drawings:
- A- Individually measure and record the electricity consumption of each Tenant so that the Tenants shall be charged for electricity based on their own consumption.
- B- Separately measure and record the electricity consumption of the Landlord's common public service loads.
- F. Nominal characteristics of power supply and distribution are as follows:
1. Medium voltage: [22] kV, [3] phase, 3 wire [low resistance] neutral earthing.
 2. Low voltage: [380/220] V, [3] phase, [5] wire, solidly earthed neutral.
 3. Frequency: [50] Hz.
- G. Distribution systems are to be supplied or derived from the voltage system previously described, as shown on the Drawings, or as otherwise specified.

1.5 TELEPHONE PUBLIC EXCHANGE LINES

- A. The Local Telephone Authority/Service Provider will bring telephone public exchange lines into the premises to the location shown on the Drawings and/or to be agreed with the Authority/ Service Provider. Liaise with the Local Telephone Authority/ Service Provider to confirm location of connection of public telephone exchange lines into the premises.

1.6 MOTORS AND OTHER ELECTRICALLY OPERATED EQUIPMENT

- A. All electrical work from and including motor control centers / panels to motors and other electrically operated equipment, which is included in Division 26 Section "Motor Control Centers", form part of the Electrical Work.
- B. Power supply to motors and other electrically operated equipment, which are not connected to a motor control center / panels, 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, including the starting device or combination starter

1.7 EQUIPMENT

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

1.8 CLIMATIC CONDITIONS

- A. Equipment, including transformers, switchgear, cables, relays, lighting fixtures, motors etc., is to be designed and derated for continuous and trouble free service under the project climatic site conditions where the project will be constructed.
- B. Where design and operating conditions, different from the above are required for particular equipment, they are described in the specification of the equipment concerned.
- C. Climatic Conditions for reference according to the metronomes;
 - 1. Altitude above sea level according to project site.
 - 2. Maximum Ambient Temperature: 40 degree C (in the shade)
 - 3. Minimum Ambient Temperature: 7.8 degree C.
 - 4. Resultant relative humidity at summer peak condition: 31.8%.
 - 5. Interior Environment; where installed indoors.
 - 6. Exterior Environment; where installed outdoors.

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

1.9 DRAWINGS

- A. Equipment locations shown on the Drawings indicate approximate locations and general layout of equipment. Exact and final locations and layouts together with dimensions, weights, mounting methods and accessories, where relevant, are to be shown on Contractor's shop and construction drawings.
- B. Symbols: In order to provide sufficient detail and a minimum degree of clarity on the Drawings, the symbols used for various electrical devices, particularly wall mounted devices, take up more space on the Drawings than the device does on the wall. Because of drafting limitations these locations must be considered as being indicative rather than exact physical locations of the devices. The devices shall be installed with prime regard for convenience of operation and the proper usage of the wall space rather than to coincide with the scaled locations of the symbols. In locating the outlets, follow the criteria provided on detail Drawings where provided, and coordinate with furniture. Do not scale from design Drawings.
- C. Wiring layouts shown on the Drawings 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 Contractor's shop and construction drawings.
- D. Wiring layouts shown on the Drawings for work not included in the Electrical Work, such as motors, cables from motor control panels to motors and other similar electrically operated equipment are shown for convenience and reference only.

1.10 SUBMITTALS

- A. Generally: Submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.
- B. Product Data: Submit for approval detailed product data such as model reference no., all relevant ratings, country of manufacture, interface details as necessary, electricity-metering equipment, covers and supports.
- C. Calculations: Submit for approval the manufacturer/supplier calculations for the following systems, prior to ordering/manufacturing the material.
 - 1. Indoor and outdoor lighting distribution, with necessary supporting documents and photometric data of the lighting fixtures proposed and approved by the Contractor.
 - 2. Circuit breakers selectivity and discrimination calculation study based on IEC Standards for a full selective and discriminated distribution scheme.
 - 3. Voltage drop and short circuit calculations after verification of cable and breaker sizes.
 - 4. Power factor correction capacitors sizing based on the final approved loads.
 - 5. Battery bank calculations to fulfill the specification requirements provided for the specific equipment.

6. Rating / derating calculations for the specified equipment.
7. Earthing.
8. Relay Settings.
9. Harmonic Analysis.

D. Shop and Construction Drawings:

1. Dimensioned plans and sections or elevation layouts of electricity-metering equipment.
2. Shop and construction drawings must demonstrate that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings are to clearly state the name and location of the work, the names of Engineer and Contractor, submission date, cross-references to the Drawings and Specification and the specific reference number, location, service and function of each item.
3. Shop and construction drawings are to be submitted at a scale of 1:50 for general layout plans, and 1:10, or 1:20 as approved by the Engineer for sections, details, elevations, congested layouts, etc. Drawings shall include but not be limited to the following:
 - a. Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for passage through floor structure.
 - b. 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
 - c. Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
 - d. Plans, sections and elevations of electrical spaces to illustrate compliance with Standards for allocation of spaces for maintenance, movement, installation, etc.

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

F. Coordination (Selectivity) Study: Carry out a short circuit and protection coordination (Selectivity) study, for the electrical distribution network, and submit to the Engineer for approval. Make all necessary modifications in all levels of the electrical distribution network to satisfy the outcome of the selectivity study including all engineers comments.

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

- H. List of Proposed Manufacturers: Submit a list of all equipment and materials, including all items for which choice of manufacturer is at own discretion of the Contractor, to the Engineer for approval along with the Tender bid. The manufacturer or authorized representative is required to have a full technical support facility within 160 km radius of the Project, and available for an emergency callout within 24 hours and 7 days a week,
- I. Assembled Equipment: Any assembled equipment to be supplied for the project is to be assembled by the manufacturer or his authorized assembler. 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 rejection in that respect is final and not subject to discussion.
- J. Test Certificates and Reports: Submit manufacturer's type and routine test certificates and reports for equipment and devices. Complete test results are to be submitted in clearly identified and organised 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. Type tests or Special tests will not be required if the Contractor can provide evidence / substantiation, in a form acceptable to the Engineer, which demonstrates that the required tests were successfully conducted on identical units in the previous twelve months.
- K. Factory Testing: Locally manufactured/assembled equipment is to comply with the relevant standards recommendations and are to be witnessed by Engineer. If the manufacturer's 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 Engineer. The Engineer's requirements in that respect are final and not subject to discussion.
- L. Spare Parts Schedules: Submit with the Tender itemised 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.
- M. 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.
- N. 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.
- O. 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 manufacturer's information, test certificates and reports.
- P. As-Built (Record) Drawings: Prior to substantial completion submit Record Drawings certified by the Consultant on installed electrical systems, in accordance with requirements of the Specification, Division 1. The As-Built (Record) Drawings, where applicable, shall include data on existing works. The As-Built Records shall be made progressively as the Work proceeds.

- Q. CVs of electrical Engineers, electrical personnel, and quality personnel, for the Engineer review and approval. Prequalification of subcontractors shall be submitted for the Engineer review and approval.

1.11 QUALITY ASSURANCE

- A. Comply with related Standards, specified therein.
- B. Comply with IEC- 60204 “Safety of machinery – Electrical equipment of machines”.
- C. Installations are to be carried out by qualified personnel.

1.12 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
 - 1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
 - 2. Set out location and provide equipment bases for electric panels and machinery.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- C. Coordinate electrical service connections to components furnished by utility companies.
 - 1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
 - 2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.
- D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."
- E. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- F. Where acoustical ceilings and similar finishes will conceal electrical identification markings and devices, coordinate installation of these items before ceiling installation.
- G. Location of all ceiling lighting fixtures, fire alarm detectors, emergency lighting, and CCTV cameras to be coordinated with false ceiling subcontractor and other mechanical services outlets, to the satisfaction of the Engineer and technical and functional requirements.

1.13 EQUIPMENT AND MATERIALS

- A. Availability: Confirm availability of equipment and materials proposed for use in the work prior to submission for approval. If, after approval, equipment or materials cease to be available, submit alternative items of equal quality and type for approval.
- B. Acceptance by Authority: Confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other Authorities having jurisdiction and are acceptable to them. Inform Engineer of any modifications necessary to comply with the Local Power Authority's requirements.
- C. Manufacturers' Standards: Equipment 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.
- D. Approved Manufacturers: 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.
- E. 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.
- F. 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.
- G. 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.
- H. 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. Assign the benefits of such warranty to the Employer.
- I. 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.
- J. 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.

- K. Label and identify all equipment, instruments, control and electrical devices etc. to indicate duty, service or function, to the satisfaction of Engineer. Labels are to have [English].language Alternative methods of labelling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent surfaces or as approved by Engineer.
- L. Systems used before substantial completion 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.
- M. All panels and electrical boards shall have designs permitting easy access of internal components for maintenance and replacement without disturbing other components. All equipment shall be designed for easy and simple operation.

1.14 SAFETY REGULATIONS

- A. The Contractor shall observe and comply with any Safety Regulations enforced by the Employer who is responsible for operation of the existing electrical system. Where a shut down of the existing system is required to enable work to proceed, reasonable notice shall be given to the Engineer and the Employer and a program agreed. Before work commences, the Employer's representative will deenergize, earth and safeguard the relevant portion of the equipment. He will obtain the necessary Work Permit in his name, from the Employer/ Engineer Based on this Work Permit, he will arrange to issue to the Contractor a permit to work. The recipient of a Permit to Work shall satisfy himself that the Employer has made the equipment to be worked on dead, locked off any disconnectors, switches, or circuit breakers from which such equipment may be energized, posted any necessary warning notices and earthed the equipment in an approved manner. The Contractor shall be responsible for any possible damage and casualties resulting from his breach of safety regulations for staff under his control observing the limitations of access stated on the Permit and shall ensure that such Staff is fully informed of the areas covered by the Permit. He shall also be responsible for informing all staff (including Employer's and Engineer's staff) employed on work covered by a Permit, when the Permit has been canceled. Any equipment or section of line not included in the Permit shall be considered to be live and be roped off and Danger Notices posted in prominent positions. Access to the work zone shall be along and only along an agreed safe path.

PART 2 - PRODUCTS

2.1 SUPPORTING DEVICES

- A. Material: Hot-dip galvanized steel.
- B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel with epoxy powder paint coating, or stainless steel, as per requirements.
- C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 14-mm diameter slotted holes at a maximum of 50-mm centers in webs.
 - 1. Channel Thickness: Selected to suit structural loading.
 - 2. Fittings and Accessories: Products of the same manufacturer as channel supports.

- D. Nonmetallic Channel and Angle Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 14-mm diameter holes at a maximum of 200-mm centers in at least one surface.
 - 1. Fittings and Accessories: Products of the same manufacturer as channels and angles.
 - 2. Fittings and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
- E. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.
- F. Pipe Sleeves: Schedule 40, galvanized steel, plain ends.
- G. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.
- H. Expansion Anchors: Carbon-steel wedge or sleeve type.
- I. Toggle Bolts: All-steel springhead type.

2.2 ELECTRICAL IDENTIFICATION

- A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by these Specifications.
- B. Raceway and Cable Labels: Minimum size of letters for legend and minimum length of color field for each raceway and cable size to meet Standards.
 - 1. Type: Pre-tensioned, wraparound plastic sleeves. Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the item it identifies.
 - 2. Type: Pre-printed, flexible, self-adhesive, vinyl. Legend is over-laminated with a clear, weather- and chemical-resistant coating.
 - 3. Color: Black letters on orange background.
 - 4. Legend: Indicates voltage; and type of service.
- C. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 25 mm wide by 0.08 mm thick.
- D. Underground Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape with the following features:
 - 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 that indicates type of underground line.
- E. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

- F. Equipment Nameplates: Non-corroding, robust metal, inscribed in [English] language, 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.
- G. Color-Coding Cable Ties: Nylon, self-locking type. Colors to suit coding scheme.
- H. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1.6-mm minimum thickness for signs up to 129 sq. cm and 3.2-mm minimum thickness for larger sizes. Engraved legend in black letters on white background.
- I. Interior Warning and Caution Signs: Preprinted, aluminum, baked-enamel-finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.
- J. Exterior Warning and Caution Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 1-mm, galvanized-steel backing, with colors, legend, and size appropriate to the application. 6-mm grommets in corners for mounting.
- K. Fasteners for Nameplates and Signs: Self-tapping, stainless steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.
- L. Provide identification for all socket outlets ceiling roses and switches, on face plate ferrules, on wires, with circuit and panelboard reference, UPS socket outlets shall be labeled: "Computer Use Only".
- M. All external labels for manholes shall be stainless steel, engraved type, fixed with stainless steel screws.

2.3 COVERS FOR TRENCHES

- A. Covers in electrical rooms and the like, unless otherwise specified or shown on the Drawings, are to be flanged checkered steel plates with angle or channel- section frames, suitably reinforced to support anticipated loads, and finished with zinc chromate primer and two coats gray enamel. Covers shall be suitably dimensioned and matched to provide perfect level surface with flush mounted lifting handle.

2.4 BRACKETS, SUPPORTS, RAILS AND TRACKS

- A. Brackets, supports, rails and tracks for supporting electrical installations are to be galvanized steel, fixed with expansion bolts of approved size and material. Plastic inserts and lead anchors are not acceptable unless approved for specific light duty installations.

2.5 CONCRETE BASES

- A. Concrete Forms and Reinforcement Materials: As specified in Division 3 Equipment Foundations and Bases: Reinforced concrete, as approved by Engineer after submission of design calculations. Dimensions, levels and surface finishes are to be suitable for equipment installed, as shown on the Drawings or in accordance with approved shop and construction drawings.

2.6 EQUIPMENT FOR ELECTRICITY METERING BY EMPLOYER

- A. Meter: Electronic kilowatt-hour measuring to record electricity used.
- B. Meter: Electronic kilowatt-hour/demand measuring to record electricity used and highest peak demand over a time period according to electric utility. Meter is designed for use on the type and rating of circuit indicated for its application.
 - 1. Kilowatt-Hour Display: Digital.
 - 2. Kilowatt-Demand Display: Digital, type to register highest peak demand.
 - 3. Enclosure to have hasp for padlocking or sealing.
 - 4. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
 - 5. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for the ratings of the circuits indicated for this application.
- C. Current-Transformer Cabinets: Recommended by metering equipment manufacturer for use with sensors indicated.

2.7 ELECTRICAL INSULATION

- A. All insulating materials are to be suitably finished so as to prevent deterioration of their qualities under the specified working conditions. Plastics, elastomers, resin-bonded laminates and inorganic materials are to be of suitable quality selected from the grades or types in the appropriate British Standard.

2.8 ANTI-CONDENSATION HEATERS AND VENTILATORS

- A. Any major items of electrical equipment which are liable to suffer from internal condensation due to atmospheric or load variations shall be fitted with heating devices suitable for electrical operation at 220 volts a.c. 50Hz single phase of sufficient capacity to raise the internal ambient temperature by 5 deg. C (41 deg. F). A suitable thermostat shall be included in the heater circuit. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation. Where fitted, a suitable terminal box and control switch, with indicating lamp shall be provided and mounted in an accessible position. All such equipment, whether fitted with a heating device or not, shall be provided with suitable drainage and shall be free from pockets in which moisture can collect.

2.9 ELECTRICAL CONTROL LOCATIONS

- A. Equipment may be electrically controlled from a number of different control points as specified in the appropriate sections of the Specification. The control positions shall be designated as follows:
 - 1. Local Control: Located adjacent to the item of plant to facilitate maintenance, inspection and emergency operation.
 - 2. Remote Control: Located at a substation control room where specified items of Plant are monitored and controlled by direct wire connection.
 - 3. Supervisory Control: Located at a System Control Centre where principal items of plant at a number of substations are remotely controlled via a tele control system.

2.10 TOUCHUP PAINT

- A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.
- B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

- A. Installations Generally:
 - 1. 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.
 - 2. Installations are to be complete, ready for operation and fully integrated and coordinated with all other work.
 - 3. Provide accessories necessary to complete the installations, of the types specified or recommended for the purpose by the manufacturer of the equipment or accessories.
- B. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.
- C. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- E. Right of Way: Give to raceways and piping systems installed at a required slope. Generally all cabling power conductors routing shall be located above any piping unless specifically approved otherwise.

3.2 ELECTRICAL SUPPORTING DEVICE APPLICATION

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.
- B. Dry Locations: Steel materials.
- C. Support Clamps for PVC Raceways: Click-type clamp system.
- D. Selection of Supports: Comply with manufacturer's written instructions.
- E. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four or minimum of 90-kg concentrated design load, whichever is more stringent.

3.3 SUPPORT INSTALLATION

- A. Install support devices to securely and permanently fasten and support electrical components.
- B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
- C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.
- E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.
- F. Avoid sharp 90° bends on cable trunking/trays/ladders. Use 2 45° bends.
- G. Install 6-mm- diameter or larger threaded steel hanger rods, unless otherwise indicated.
- H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.
- I. Simultaneously install vertical conductor supports with conductors.
- J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 600 mm from the box.
- K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

- L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.
- M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:
 - 1. Wood: Fasten with wood screws or screw-type nails.
 - 2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
 - 3. New Concrete: Concrete inserts with machine screws and bolts.
 - 4. Existing Concrete: Expansion bolts.
 - 5. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
 - 6. Steel: Welded threaded studs or spring-tension clamps on steel.
 - 7. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
 - 8. Light Steel: Sheet-metal screws.
 - 9. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.4 IDENTIFICATION MATERIALS AND DEVICES

- A. Comply with BS 822 and IEC 60034-8.
- B. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.
- D. Self-Adhesive Identification Products: Clean surfaces before applying.
- E. Identify raceways and cables with color banding as follows:
 - 1. Bands: Pre-tensioned, snap-around, colored plastic sleeves or colored adhesive marking tape. Make each color band 50-mm wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
 - 2. Band Locations: At changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 8-m maximum intervals in congested areas.
 - 3. Colors: As follows:
 - a. Fire Alarm System: Red.
 - b. Security System: Blue and yellow.
 - c. Telecommunication System: Green and yellow.
 - d. Lighting and power: Orange and black.

- F. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color-coding may be used for voltage and phase identification.
- G. Install continuous underground plastic markers during trench backfilling, for exterior underground power, control, signal, and communication lines located directly above power and communication lines. Locate 150 to 200 mm below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 400 mm, overall, use a single line marker.
- H. Install warning, caution, and instruction signs where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
- I. Install engraved-laminated emergency-operating signs with white letters on red background with minimum 9-mm- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

3.5 FIRE STOPPING

- A. Apply fire stopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Fire stopping materials and installation requirements are specified in Division 7 Section "Through-Penetration Firestop System."

3.6 CABLE SEGREGATION AND FIRE RISK

- A. All cables shall be routed and connections designed to reduce fire risk, outage and damage to other plant and buildings.
- B. Cables shall be segregated to reduce damage if fire occurs and avoid faulty operation of equipment due to induced voltages as follows:-
 - 1. Control and protection cables shall be separated from power cables to avoid damage in the event of a power cable fault.
 - 2. Telephone, communication, analogue and digital system cables shall at no point be less than 300 mm away from power cables.
 - 3. All cable holes through walls and floors shall be sealed with approved silicone foam fire seals or other approved materials after the cables have been installed and the cost thereof is deemed to be included in the Contract.
- C. Each cable shall be run in one continuous length, straight through joints will not be permitted unless specifically authorized by the Engineer in writing.

3.7 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated or otherwise required, but not less than 100 mm larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 21-MPa, 28-day compressive-strength concrete and reinforcement as specified in Division 3."

3.8 SUPPORT FRAMES FOR SWITCHGEAR

- A. Support frames for switchgear located over cable trenches are to be installed prior to pouring concrete.

3.9 HOLES AND ANCHORS

- A. Drilling for anchor bolts is to be carried out using appropriate electric drills and in approved positions.
- B. Holes and chases in in situ concrete are to be cast in. Do not cut hardened concrete or drill holes larger than 10-mm diameter without prior approval.
- C. Holes and Chases in Pre-cast Concrete: do not cut or drill pre-cast concrete without prior approval.
- D. Holes in Structural Steelwork: Do not cut or drill structural steelwork without prior approval.
- E. Holes and chases in masonry must not exceed:
 - 1. Size of holes: 300-mm square.
 - 2. Depth of vertical chases: 1/3 wall thickness or, in cavity walls, 1/3 leaf thickness.
 - 3. Depth of horizontal chases: 1/6 wall or leaf thickness.
- F. Cutting Masonry:
 - 1. Ensure mortar is fully set before commencing.
 - 2. Cut carefully and neatly, avoiding spalling, cracking or other damage to surrounding structure.
 - 3. Keep holes to smallest practicable size and do not exceed specified dimensions.
 - 4. Cut chases in straight lines and horizontally and vertically only; do not set back to back; offset by a distance not less than wall thickness.
- G. Preformed Holes in Masonry: Submit proposals for bridging over holes for ducts etc. which exceed 450-mm width.

3.10 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing fire stopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.11 DELIVERY, STORAGE AND HANDLING

- A. Install equipment only in dust-free environment and maintain the condition with protective covering as necessary. If air-conditioning is required, ensure it is available by installation time. In general, ensure that locations are complete and ready to receive equipment
- B. Ensure that rooms where equipment are installed are provided with lockable doors.

3.12 FIELD QUALITY CONTROL

- A. Inspect installed components for damage and faulty work, including the following:
 - 1. Supporting devices for electrical components.
 - 2. Electrical identification.
 - 3. Electricity-metering components.
 - 4. Concrete bases.
 - 5. Electrical demolition.
 - 6. Cutting and patching for electrical construction.
 - 7. Touchup painting.
- B. Test Employer's electricity-metering installation for proper operation, accuracy, and usability of output data.
 - 1. Connect a load of known kW rating, 1.5 kW minimum, to a circuit supplied by the metered feeder.
 - 2. Turn off circuits supplied by the metered feeder and secure them in the "off" condition.
 - 3. Run the test load continuously for eight hours, minimum, or longer to obtain a measurable meter indication. Use a test load placement and setting that ensure continuous, safe operation.
 - 4. Check and record meter reading at end of test period and compare with actual electricity used based on test load rating, duration of test, and sample measurements of supply voltage at the test load connection. Record test results.
 - 5. Repair or replace malfunctioning metering equipment or correct test setup; then retest. Repeat for each meter in installation until proper operation of entire system is verified.

3.13 REFINISHING AND TOUCHUP PAINTING

- A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."
 - 1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
 - 2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
 - 3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.14 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

3.15 TESTING AND COMMISSIONING

- A. Consistent coordination shall be carried out with the involved MEP systems commissioning Agent for all the required testing and commissioning procedures.
- B. Consistent coordination shall be carried out with other involved Packages Contractors to achieve the proper and full functionality of the systems and networks as per the design intent.

END OF SECTION 26 05 00

SECTION 260513 – MEDIUM- VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems above 1000V rating.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods" for cable and termination supports.
 - 2. Division 26 Section "Basic Electrical Materials and Methods" for cable markers.

1.3 SUBMITTALS

- A. Technical Data: Submit data for approval including, but not limited to, the following:
 - 1. Constructional details, standards to which cables comply, current carrying capacities, de-rating factors for grouping and temperature.
 - 2. Manufacturer's catalogue cuts.
 - 3. Dimensional and electrical characteristics.
- B. Samples of each cable and, if requested by the Engineer, other accessories.
- C. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Exact routing layouts, showing coordination between various trades.
 - 2. Details of supports and fixings for trays and cables.
 - 3. Details of connections to transformers, switchgear, etc.
 - 4. Details of terminations, splices and tapings where permitted, glands and bushings at enclosures.
- D. Certificate of Origin: For each lot of cable supplied, provide a certificate of origin issued by manufacturer stating origin, date of manufacture, composition, Standards to which it complies and test certificates. All test certificates are to comply with the test requirements of the relevant standard to which the cable is manufactured. As-Built (Record) Drawings: At Project close-out, submit Record Drawings of installed electrical ducts, and manholes.
- E. Cable Jointing Qualifications: Submit details of the proposed cable jointers qualifications prior to work commencing on site.
- F. Product Certificates: Signed by manufacturers of cables and accessories certifying that the products furnished comply with requirements.
- G. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

- H. Routine tests at factory.
- I. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- J. Product Test Reports: Indicate compliance of cables and accessories with requirements based on comprehensive testing of current products.
- K. Maintenance Data: For cables and accessories to include in the maintenance manuals.
 - 1. Include periodic tests of cables in service.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced and certified cable splicer to install, splice, and terminate medium-voltage cable.
- B. Standards: Cables are to comply with the following IEC or other equally approved Standards, and are to bear the mark of identification of the Standards to which they are manufactured, cable size, voltage grade, etc. Cables not having this identification will be rejected.
 - 1. IEC 60060: High Voltage Test Techniques - Part I: General Definitions and Test Requirements.
 - 2. IEC 60183: Guide to the selection of high voltage cables.
 - 3. IEC 60228: Conductors of insulated Cables.
 - 4. IEC 60230: Impulse Tests on Cables and their Accessories.
 - 5. IEC 60502-2: Power Cables with extruded insulation and their accessories for rated voltages from 1kV ($U_m = 1.2$ kV) up to 30 kV ($U_m = 36$ kV) -Part 2: Cables for rated voltages from 6kV ($U_m = 7.2$ kV) up to 30 kV ($U_m = 36$ kV).
 - 6. IEC 60502-4: Power Cables with extruded insulation and their accessories for rated voltages from 1kV ($U_m = 1.2$ kV) up to 30 kV ($U_m = 36$ kV) -Part 4: Test requirements on accessories for cables with rated voltages from 6 kV ($U_m = 7.2$ kV) up to 30 kV ($U_m = 36$ kV).
 - 7. IEC 60811: Common test methods for insulating and sheathing materials for electric cables.
 - 8. IEC 60885: Electrical test methods for electric cables.
 - 9. IEC 60986: Guide to the short circuit temperature limits of electric cables with a rated voltage from 1.8/3 (3.6) kV to 18/30 (36) kV.
 - 10. IEC 60287: Electric Cables - Calculation of the current rating.
- C. Current carrying capacities of conductors have been determined in accordance with the Regulations for specified type of insulation and expected conditions of installation. No change will be accepted in specified type of insulation unless warranted by special conditions and approved by the Engineer. Check various loads and current carrying capacities and report any discrepancies or insufficiency of sizes indicated to Engineer.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver medium-voltage cable on factory reels complying with applicable Standard.
- B. Store cables on reels on elevated platforms in a dry location. Protect from weather, fumes, water, debris, etc.
- C. Handle wire and cable carefully to avoid abrading, puncturing and tearing cable insulation and sheathing. Ensure that dielectric resistance integrity of cables is maintained.

- D. Before dispatch, the manufacturer shall cap the ends of all cables so as to form a seal to prevent the ingress of water during transportation, storage and installation. The cable shall be supplied on stout wooden drums, which shall be designed so as to protect the cable from damage.
- E. The lagging batten shall be secured at least with 2 nails of each end in addition to steel bonding straps. No drum shall contain more than one length of the cable.
- F. The cable shall be tightly wrapped on the cable drum and no turn shall be left loose. Both ends of the cable shall be adequately secured to the cable drum. Inner end of the cable shall be suitably fixed/gripped to the cable drum so that it will not come out during cable laying operation. The cable shall be wrapped on drums of suitable diameter such that the radius of bend of the innermost layers is not less than the minimum radius of bend stipulated in relevant BS/IEC for installation of the cable.
- G. No space shall exist between the adjacent layers of the cable and between the drum flange and the cable.
- H. Cable shall be wrapped with black polyethylene sheet inside the wood covering of the drum.
- I. Central lifting hole of the cable drum shall be provided with a steel pipe. The pipe shall be welded with steel plates at both ends and these plates shall be duly secured to the flanges of the cable drum with suitable size bolts. The pipe and the welded end plates shall be of robust design to withstand the weight of the cable drum during unrolling.
- J. Each drum shall bear a distinguishing number on the outside of the flanges and particulars of the cable, i.e. voltage, length, conductor size, cable type and gross weight shall also be clearly visible. The direction for rolling shall be indicated by an arrow.
- K. Immediately after the Works tests, both ends of every length of metal-sheathed cable shall be sealed by means of a metal cap fitted over the end and plumbed to the sheath. All cables shall be sealed by enclosing the ends in approved caps, which shall be tight fitting and adequately secured to prevent ingress of moisture.
- L. The ends of factory lengths of cable shall be marked "A" and "Z", "A" being the end at which the sequence of core numbers is clockwise and "Z" the end at which the sequence is anti-clockwise. The words "Running End "A"" or "Running End "Z"" shall be marked on the flange and the direction for rolling shall be indicated by an arrow. The method of drum marking shall be to the Purchaser's approval.
- M. The cable end, which is left projecting from the drum, shall be adequately protected against damage.
- N. Cable drums shall be non-returnable and shall be made of timber; pressure impregnated against fungal and insect attack or made of steel suitably protected against corrosion. They shall be arranged to take a round spindle and be lagged with strong closely fitting battens of minimum 40 mm thickness and in accordance with BS 1559.
- O. All cables and accessories shall be carefully packed for transport and storage on Site in such a manner that they are fully protected against all climatic conditions, particular attention being paid to the possibility of deterioration during transport to the Site by sea or overland and to the conditions prevailing on the Site.
- P. Wooden drums shall be suitably constructed to avoid problems due to shrinkage, rot and attack by insects.
- Q. Drums, etc., for maintenance spares shall be non-returnable. Cable maintenance lengths and spare lengths shall be wound onto steel drums inspected and tested by the Engineer before they are handed over to the Purchaser's stores. Particulars of the cable (as stated above) shall be clearly marked.

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify Engineer at least 2 days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Engineer's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. El Sewedy Cables (Egypt)
 2. BICC (Egypt)
 3. Egyptian Electric Cables (Egypt)
 4. Egytech (Egypt)
 5. Prysmian (England)
 6. Siemens (Germany)
 7. BICC (England)

2.2 30 kV MV CABLE

- A. Three Core MV Cable **36 kV** maximum between phases, XLPE insulated, for use on systems with voltages between 22 kV and 36 kV, is to comply with IEC 60502, and have the following characteristics:
1. Conductor: Aluminum, circular, stranded and compacted.
 2. Conductor Screen: Extruded semi-conducting layer.
 3. Insulation: Extruded cross-linked polyethylene (XLPE), minimum 8 thick.
 4. Insulation Screen Part: Non-metallic directly applied extruded semi-conducting material, readily strippable.
 5. Metallic Part: Layer of copper tape applied with 30% overlap.
 6. Filling and Bedding: Polypropylene extruded over laid up cores to form compact circular bedding.
 7. Armor: Single layer of round galvanized steel wire.
 8. Outer Sheath: Extruded PVC (color red) type ST2 to IEC 60502.
 9. Embossing: "Electric cable **30000 V**".
 10. Short-circuit: 21.7 kA (minimum) for one second rating for 185 mm² cables, and 40 kA (minimum) for one second for 300 mm² cables.
- B. Single Core MV Cable **36 kV** maximum between phases, XLPE - insulated, for use on systems with voltages between 22 kV and 36 kV, is to comply with IEC 60502, and have the following characteristics:
1. Conductor: Aluminum, circular, stranded and compacted.
 2. Conductor Screen: Extruded semi-conducting layer.
 3. Insulation: Extruded cross-linked polyethylene (XLPE), minimum 8 mm thick.
 4. Copper Screen: Layer of copper wires with copper tape applied in opposite direction bedding. Inner tape covering and separation sheath of extruded PVC.
 5. Over-sheath extruded PVC (color red) type ST2 to IEC 60502.
 6. Short-circuit rating 21.7 kA (minimum) for one second for 185 mm² cables and 40 kA (minimum) for one second for 300 mm² cables.

- C. Armored cable, where required or shown on the Drawings, is to have single layer of aluminum wire or two layers of aluminum tape between bedding and over-sheath.
- D. Cable joints to be as recommended by manufacturer, to render joints equal to cable in characteristics, in terms of insulation, stress distribution and water-tightness. Materials and methods of jointing are to be approved before confirmation of order.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine raceways to receive medium-voltage cables for compliance with requirements for installation tolerances and other conditions affecting performance of cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Refer to Division 26 Section "Low Voltage Electrical Power Conductors and Cables" for feeder and sub-feeder cable installation requirements applicable to this Section.
- B. Install cables as indicated, according to manufacturer's written instructions.
- C. Pull Conductors: 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.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceways. Do not use rope hitches for pulling attachment to cable.
- E. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Division 26 Section "Basic Electrical Materials and Methods."
- G. Install direct-buried cables on leveled and tamped 75-mm bed of clean sand at bottom of trench. Separate cables crossing other cables or piping from those items by a minimum of 100 mm of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
- H. Install "buried cable" warning tape 305 mm above cables.
- I. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.
- J. Seal around cables passing through fire-rated elements using approved fire-stopping material.
- K. Identify cables according to Division 26 Section "Basic Electrical Materials and Methods."

3.3 CABLE JOINTING AND TERMINATING

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

- B. Recommendations: Through joints and terminations are to be carried out strictly in accordance with cable manufacturer's recommendations, and made with correct specified materials, boxes, tapes, compounds or mixtures, stress cones, glands and bonds as applicable.
- C. Jointing: Qualifications of operatives are to be submitted to Engineer prior to work commencing on site. Joints are to be filled with epoxy resin after taping unless contrary to cable manufacturer's recommendations. Sample site constructed cable terminations and through-joints are to be submitted to the Engineer prior to commencing work on site. Samples are to be constructed in the presence of the Engineer and are to be available for test and inspection in accordance with manufacturer's recommendations.
- D. Cutting tools for jointing and terminating cables are to be purpose made, to prevent damage to insulation in general, and to cable shielding of MV cables.
- E. Cleaning of lacquer on conductors is to be by use of 'Scotch Brite' sponge and white spirit or equal approved.
- F. Tighten electrical connectors and terminals including screws and bolts, in accordance with manufacturers published torque-tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with international standards.

3.4 FIELD QUALITY CONTROL

- A. Cable tests are to be carried out in accordance with the requirements of the Regulations and Standards.
- B. Test Equipment: Provide megger testers of various ranges as applicable, and HV test equipment as necessary for testing MV installations. Use 1000 V megger on installations with nominal voltage over 500 V up to 1000 V, and 5000 V megger on MV installations for voltage level above 5000v for initial checks.
- C. Testing: On installation of medium-voltage cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. MV Cable Testing: Provide cable test set with D.C. output voltage and ampere range sufficient to test MV cables. Cables are to be laid in position (trench or duct bank), jointed where applicable, but left uncovered, with ends free of equipment and clear of ground.
 - 2. MV Cable Testing: D.C. test voltage is to be applied between core under test and the screen in steps, pausing one minute or more each step (first step being the A.C. rms rated voltage of the cable, followed by two equal steps) up to maximum test voltage. At each step, and for the last 5-15 minutes duration at maximum test voltage, the ammeter (normally a micro-ammeter) is to be monitored closely and recorded. If, except as voltage is increased, the current starts to increase, test is to be stopped and the installation inspected and tested for the fault.
 - 3. MV Cable Testing: Each cable/core is to be tested independently. Maximum D.C. test voltage for grounded neutral system is to be 3 times rated A.C. rms voltage of cable.
 - 4. MV Cable Testing: Alternative test is to apply A.C. rms voltage up to 1.5 times A.C. rms rating of cable (26 kV for 17.5 kV cable), applied for 15 minutes, by an approved A.C. test set. Readings are to be within same range and in accordance with IEC 60 502.
 - 5. MV high pot testing shall be conducted with 5000 V insulation Megger test before and after installation. The test is valid only for 48 hours within which time the MV cable is to be energized, failing which MV cable pot test is to be re-done at 60 percent value.

- 6. Cable joints and terminations shall be carried out under low humidity and dry ambient conditions.
 - D. Correct malfunctioning cables and accessories at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
- 3.5 PROTECTION
- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, to prevent entrance of moisture into the cables and to ensure medium-voltage cables are without damage or deterioration at the time of Substantial Completion.

END OF SECTION 26 05 13

SECTION 26 05 19 - LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes low voltage (LV) feeder cables, branch circuit wiring, control and signal cables, termination, jointing and splicing.
- B. Related Sections include the following:
 - 1. Division 07 Section "Fire Stopping for fire stopping materials and installation equipment".
 - 2. Division 26 Section "Basic Electrical Materials and Methods".
 - 3. Division 26 Section "Cable Trays for Electrical Systems" with its related sections.
 - 4. Division 26 Section "Raceways and boxes for Electrical Systems" with its related sections.
 - 5. Division 26 Section "Under Floor Raceways for Electrical Systems" with its related sections.

1.3 SUBMITTALS

- A. Technical Data: Submit data for approval including, but not limited to, the following:
 - 1. Constructional details, standards to which cables comply, current carrying capacities, de-rating factors for grouping and temperature.
 - 2. Manufacturer's catalogue cuts.
 - 3. Dimensional and electrical characteristics.
 - 4. Manufacturer's drawings showing the outline of the lugs and sleeve connectors together with all pertinent dimensions. Any variation in these dimensions due to manufacturing tolerances shall be indicated.
- B. Samples of each cable and wire and, if requested by Engineer, other accessories.
- C. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Exact routing layouts, sections and profiles of trays, feeder, sub-feeder cables and branch circuits, with indication of any equipment to show and verify coordination between various trades.

2. Details of supports and fixings for buses, trays and cables.
 3. Details of connections to transformers, switchboards, panelboards etc.
 4. Details of terminations, splices and tapings where permitted, glands and bushings at enclosures.
 5. Number and size of conductors in conduit for all branch circuits in accordance with final conduit routing.
 6. Cable sizing calculations.
 7. Cable schedule.
 8. Cable termination schedule.
- D. Certificate of Origin: For each lot of cable supplied, provide a certificate of origin issued by manufacturer stating origin, date of manufacture, composition, standards to which it complies and test certificates. All test certificates are to comply with the test requirements of the relevant standard to which the cable is manufactured.
- E. As-Built (Record) Drawings: Near Project Substantial Completion, submit, certified by Consultant, Record Drawings of installed electrical systems, indicating all existing services and those installed, in accordance with requirements of the Specification, Division 1.
- F. Routine tests at factory.
- G. Tests and Certificates: Submit complete certified manufacturer's type test records for cables and accessories in accordance with the Standards.
- H. Point-wise compliance statement to the specifications, duly signed by the manufacturer / manufacturer's authorized representative and the contractor.
- I. Cable Jointing Qualifications: Submit details of the proposed cable jointers qualifications prior to work commencing on site.
- J. Field Test Reports: Field tests to be as per NETA and approved by the Engineer. Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced and certified cable splicer to install, splice and terminate low-voltage cables.
- B. Standards: Wires and cables are to comply with IEC or other equally approved standards and are to bear the mark of identification of the Standards to which they are manufactured. Wires and cables not having this identification will be rejected.
- C. Current carrying capacities of conductors have been determined in accordance with the Regulations for specified type of insulation and expected conditions of installation. No change will be accepted in specified type of insulation unless warranted by special conditions and approved by Engineer. Check various loads and current carrying capacities and report any discrepancies or insufficiency of sizes indicated to Engineer.
- D. List of standards: Carry out work in accordance with the following:
1. BS EN 10257: Part 1: Zinc or zinc alloy coated non-alloy steel wire, for armouring either power cables or telecommunication cables, land cables.

2. BS EN 50265: Common test methods for cables under fire conditions.
3. BS EN 50266: Common test methods for cables under fire conditions.
4. BS 5467: Specification for 600/1000V and 1900/3300V armoured cables having thermosetting insulation.
5. BS 6004: Electric cables PVC insulated, non armoured for voltages up to and including 450/750 volts, for electric power, lighting and internal wiring.
6. BS 6121: Mechanical cable glands.
7. BS 6234: Specification for polyethylene insulation and sheath of electric cable.
8. BS 6360: Specification for conductors in insulated cables and cords.
9. BS 6231: Specification for PVC - insulated cables for switchgear and control gear wiring.
10. BS 6346: Specification for 600/1000 V and 1900/3300 V armoured electric cables having PVC insulation.
11. IEC 60189-2: Cables in pairs, triples, quads, quintuples for inside installations.
12. IEC 60228: Conductors of insulated cables.
13. IEC 60332: Tests on electric cables under fire conditions.
14. IEC 60287: Calculation of continuous current rating of cables (100% load factor).
15. IEC 60502-1: Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.
16. IEC 60840: Tests for power cables with extruded insulation for rated voltages above 30kV up to 150kV.
17. IEC 60885: Electrical test methods for electric cables.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver wires and cables properly packaged in factory packed or fabricated containers, wound on factory reels.
- B. Store wires and cables in dry areas, and protect from weather, fumes, water, debris, etc.
- C. Handle wire and cable carefully to avoid abrasing, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.
- D. Before dispatch, the manufacturer shall cap the ends of all cables so as to form a seal to prevent the ingress of water during transportation, storage and installation. The cable shall be supplied on stout wooden drums which shall be designed so as to protect the cable from damage.
- E. The lagging batten shall be secured at least with 2 nails of each end in addition to steel bonding straps. No drum shall contain more than 1 length of the cable.
- F. The cable shall be tightly wrapped on the cable drum and no turn shall be left loose. Both ends of the cable shall be adequately secured to the cable drum. Inner end of the cable shall be suitably fixed/gripped to the cable drum so that it will not come out during cable laying operation. The cable shall be wrapped on drums of suitable diameter such that the radius of bend of the innermost layers is not less than the minimum radius of bend stipulated in relevant BS/IEC for installation of the cable.

- G. No space shall exist between the adjacent layers of the cable and between the drum flange and the cable.
- H. Cable shall be wrapped with black polyethylene sheet inside the wood covering of the drum.
- I. Central lifting hole of the cable drum shall be provided with a steel pipe. The pipe shall be welded with steel plates at both ends and these plates shall be duly secured to the flanges of the cable drum with suitable size bolts. The pipe and the welded end plates shall be of robust design to withstand the weight of the cable drum during unrolling.
- J. Each drum shall bear a distinguishing number on the outside of the flanges and particulars of the cable, i.e. voltage, length, conductor size, cable type and gross weight shall also be clearly visible. The direction for rolling shall be indicated by an arrow.
- K. Immediately after the Worktests, both ends of every length of metal sheathed cable shall be sealed by means of a metal cap fitted over the end and plumbed to the sheath. All cables shall be sealed by enclosing the ends in approved caps, which shall be tight fitting and adequately secured to prevent ingress of moisture.
- L. The ends of factory lengths of cable shall be marked "A" and "Z", "A" being the end at which the sequence of core numbers is clockwise and "Z" the end at which the sequence is anti-clockwise. The words "Running End "A"" or "Running End "Z"" shall be marked on the flange and the direction for rolling shall be indicated by an arrow. The method of drum marking shall be to the Purchaser's approval.
- M. The cable end which is left projecting from the drum shall be adequately protected against damage.
- N. Cable drums shall be non-returnable and shall be made of timber, pressure impregnated against fungal and insect attack or made of steel suitably protected against corrosion. They shall be arranged to take a round spindle and be lagged with strong closely-fitting battens of minimum **32 mm** thickness.
- O. All cables and accessories shall be carefully packed for transport and storage on Site in such a manner that they are fully protected against all climatic conditions, particular attention being paid to the possibility of deterioration during transport to the Site by sea or overland and to the conditions prevailing on the Site.
- P. Wooden drums shall be suitably constructed to avoid problems due to shrinkage, rot and attack by insects.
- Q. Drums, carts, cases, etc., for maintenance spares shall be non-returnable. Cable maintenance lengths and spare lengths shall be wound onto steel drums inspected and tested by the Engineer before they are handed over to the Purchaser's stores. Particulars of the cable (as stated above) shall be clearly marked.

1.6 COORDINATION

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following as per the Project's Approved Vendors/Manufacturers List:

- | | | |
|----|--------------------------|---------|
| 1. | El Sewedy Cables | (Egypt) |
| 2. | BICC | (Egypt) |
| 3. | Egyptian Electric Cables | (Egypt) |
| 4. | Egytech | (Egypt) |

For Fire Resistant Cables :

- | | | |
|----|----------|-----------|
| 5. | B.I.C.C. | (England) |
| 6. | Nexans | (France) |
| 7. | Prysmian | (Italy) |
| 8. | Siemens | (Germany) |
| 9. | Draka | (England) |

2.2 GENERALLY

- A. Conductors: Unless otherwise specified or shown on the Drawings, cables and other feeders are to have copper conductors. Cable conductors are to be stranded for sections 4 mm² and above, based on IEC 60228 Class 2. Signal and control cables are to have solid conductors unless otherwise specified. Flexible cords are to have finely stranded conductors. Conductors of single-core cables 25-mm² and above are to be compacted. Multi-core cables 35-mm² and above are to be sectoral shape.
- B. Conductor sizes are to be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted.
- C. Building wiring insulation is to be color coded or otherwise identified as required by the Regulations and as follows:
- | | |
|----|---|
| 1. | Neutral is to be light blue or white. |
| 2. | Protective earth is to be green or green/yellow striped. |
| 3. | Phase colors are to be Brown, Black, Grey , or to local Regulations and consistent throughout the installation, or use color coding in accordance with local regulations and standards. |
| 4. | Alternatively, use color coding in accordance with local regulations and standards. |
- D. Maintain color coding throughout installation. Phase-conductors for which outer jacket is not color-coded are to have engraved alphanumeric mark (L1, L2, L3) or color coded heat-shrinkable sleeves.

- E. Buried Cables: Cables buried directly in the ground are to be armored type, unless otherwise indicated in particular Sections of the Specification or on the Drawings.
- F. Outdoor Cables (where required) exposed to sunlight shall be provided with ultraviolet resistant PVC sheath having 2.5% black carbon content.

2.3 LV WIRES AND CABLES

- A. Single Core PVC Insulated Non-Sheathed Cables (Building Wires): Unless otherwise specified, single conductor cables for wiring in conduit are to have annealed copper conductors, compacted, generally with concentric strands and insulated with flame retardant to IEC 60332-1, moisture and heat resistant PVC/E to IEC 60227-1, 60227-3 (and To BS 6004), suitable for wet locations and for conductor temperature of 70 deg. C. Wires and cables are to be 450/750 V grade.
- B. Multi-Core PVC Insulated Cables (0.6/1 kV): To have Aluminum conductors, compacted, insulated with PVC/E to IEC 60502-1, moisture and heat resistant, suitable for wet locations and conductor temperatures of 70 deg. C, laid up, bedded with suitable filler and sheathed with flame retardant PVC/ST2. Armored cables are to have single layer of galvanized steel wire armor with PVC over-sheath. Cables are to comply with IEC 60332-3 and IEC 60811.
- C. Multi-Core PVC Insulated Cables (0.6/1 kV): To have annealed, copper conductors, compacted, insulated with PVC/A to IEC 60502-1 (or to BS 6746), flame retardant, moisture and heat resistant, suitable for wet locations and conductor temperatures of 70 deg. C, laid up, bedded with suitable filler and sheathed with PVC. Armored cables are to have single layer of galvanized steel wire armor with PVC over-sheath. Cables are to comply with IEC 60332-3 and IEC 60811.
- D. Single Core XLPE Insulated Feeder Cables (0.6/1 kV): Single-core circular stranded, Aluminum conductors, compacted, insulated with moisture and heat resistant cross-linked polyethylene (XLPE), suitable for wet locations and conductor temperatures of 90 deg. C. and flame retardant PVC/ST2 over-sheath. Armored cables are to have taped bedding, single wire aluminum armor and PVC over-sheath. Cables are to comply with IEC 60502-1, IEC 60332-3 and IEC 60811.
- E. Multi-Core XLPE Insulated Feeder Cables (0.6/1 kV): Multicore Aluminum conductors, compacted, XLPE insulated, for conductor temperature of 90 deg. C, laid up and bedded with suitable non-hygroscopic material compatible with the insulation and flame retardant PVC/ST2 over-sheathed, color black. Armored cables are to have single layer of galvanized steel wire applied helically over extruded PVC bedding (which may be an integral part of filling) and over-sheathed with PVC, color black. PVC over-sheaths are to be type ST2 to IEC 60502, IEC 60332-3, IEC 60811 and BS 6346.
- F. Cables Feeding Life Safety Equipment (Such as smoke / pressurization fans , Jet fans, Parking Exhaust fans ... etc.): Class 2 to IEC 60228, fire resistant type to IEC 60331-21 with LSOH over sheath to IEC 61034 for low smoke emission, IEC 60754-1 for halogen acid gas content and IEC 60754-2 for degree of acidity of evolved gas.

- G. Core identification: The cores of all cables shall be identified by color as follows:

<u>Number of Cores</u>	<u>Identification</u>
Single Core	Red or Black
2 Core	Red, Black
4 Core	Red, Yellow, Blue, Black

- H. Armor: Multi-core cables shall be provided with a single layer of galvanized steel round wire armor over the inner covering. The armor wires shall cover the entire periphery of the inner covering (PVC inner sheath). When joints in the armor are necessary, they shall be brazed or welded and any surface irregularity shall be removed. A joint in any wire shall be not less than 1 metre from the nearest other wire joint in the completed cable. If an open helix consisting of galvanized steel tape is provided over the round steel wire armor this shall be clearly stated by the Tenderer when submitting his offer and the thickness of the tape shall be indicated.
- I. Low Smoke and Fume (LSF) Cables: 600/1000 V grade, copper conductor, compacted, insulated with extruded LSF material in compliance with BS 6724 for armored cables and BS 7211 for un-armored cables. Materials used in construction of LSF cables are to be nominally free from halogens (fluorine, chlorine and bromine). When material is tested in accordance with BS EN 50267: Parts 1-3 and IEC Publication 60754, Part 1, the acidic gas evolved during combustion is to be less than 0.5%. When tested in accordance with ASTM method S2863, the oxygen index of bedding and sheathing materials is not to be less than 30. Completed cable is to meet the requirements for tests under fire conditions when tested in accordance with BS 4066, Part 1 and NMV 1.5 of BS EN 50266. Cores and cross sectional area are to be as shown on the Drawings. Phases are to be color coded in conformity with the Standards, and overall cable sheath is to be extruded black LSF material. Cables shall comply with IEC60331 and IEC60332.
- J. Low Smoke Zero Halogen (LS0H) Cables: 600/1000 V grade, copper conductor, compacted, insulated with extruded material to IEC 61034 for low smoke emission, IEC 60754-1 for halogen acid gas content and IEC 60754-2 for degree of acidity of evolved gas. Cores and cross sectional area shall be as shown on the Drawings. Phases shall be color coded in conformity with the Standards, and overall cable sheath shall be extruded black LS0H material. Cables shall comply with IEC 60332-3.
- K. Flexible cable for connection to appliances, window fans, pendants etc. is to be 300/500 V grade to IEC 60227-5, class 5 to IEC 60228, and BS 6500, three or four core, with tinned finely stranded copper wires, heat resistant with PVC/E insulation and PVC/ST10 sheath. As an alternative, EPR insulated, twisted and sheathed With Chlorosulphonated Polyethylene (CSP) Compound and with strengthening cord may be used.
- L. Fire resistant LS0H Cable (abbreviated as FR1 on the drawings, similar to Prysmian - Type FP 100 , or approved equal): Single core stranded plain annealed copper conductors to IEC 60228, fire resistant insulation category CWZ to BS 6387 for sizes up to 6 mm², PH120 classified to BS EN 50200, and 120 minutes rating when tested in accordance with BS 8434-2 when tested in 20 mm rigid steel conduit and Low Smoke Zero Halogen (LS0H) composite sheath to IEC 61034 and IEC 60754 or BS EN 50267-2-1. Cable shall comply with IEC 60332-1 & 3 (category C) for flame retardant properties. Cable shall comply with BS EN 50363 and rated 450/750 V, capable of accepting voltage surges up to 5 kV, operating conductor temperature of 90 deg. C. Cable shall be LPCB and BASEC certified, audited and marked by embossing on cable sheath. Cable shall be used as branch circuits

installed in steel conduits for use in central battery system, motorized dampers, smoke curtains and other similar loads where shown on the drawings

- M. Fire resistant LS0H Cable 600/1000 V, (abbreviated as FR6 on the drawings, similar to Prysmian - Type FP-600S, or approved equal): Multi core plain copper stranded circular or shaped conductor (sizes up to 400 mm²) complying with IEC 60228 with fire resistant insulation category F120 to BS 7846 and tested in accordance with BS 8491 and complying with BS EN 50363 operating conductor temperature 90°C, single galvanized steel wire armour and extruded low smoke zero halogen (LS0H) over sheath wire to IEC 61034 and IEC 60754 or BS EN 50267-2-1. Cable shall comply with IEC 60332-1 & 3 (category C) for flame retardant properties. Cable shall be LPCB and BASEC certified, audited and marked by embossing on cable sheath. Cable shall be used for feeders of the smoke and pressurizing fans, parking jet fans and exhaust fans, firefighting elevators, motorized fire smoke dampers, FM200 system control panels and other firefighting and life safety loads requiring category 2&3 circuits in accordance with BS 8519 including buildings with evacuation time higher than 30 minutes, such as high assembly and high rise buildings and where shown on the drawings
- N. Fire resistant LS0H Cable (abbreviated as FRE on the drawings, similar to Prysmian - Type FP 100, or approved equal): Single core stranded plain annealed copper conductors to IEC 60228, fire resistant insulation to IEC 60331 and Low Smoke Zero Halogen (LS0H) composite sheath to IEC 61034 and IEC 60754 or BS EN 50267-2-1. Cable shall comply with IEC 60332-1 & 3 (category C) for flame retardant properties. Cable shall comply with BS EN 50363 and rated 450/750 V for sizes up to 10 mm² and 600/100 V for sizes greater than 10mm², capable of accepting voltage surges up to 5 kV, operating conductor temperature of 90 deg. C.[Cable shall be LPCB and BASEC certified, audited and marked by embossing on cable sheath.] Cable shall have green/yellow striped color and shall be used as earth conductor for fire resistant feeders.
- O. High Temperature Cable - Type MICC: 1000 V grade, annealed solid copper conductors, embedded in densely compacted mineral insulated, and contained in seamless annealed tubular copper sheath for continuous operation at 250 deg. C, and for short duration at temperatures up to 1000 deg. C, and waterproof. Cable is to be BICC type Pyrotenax or other equal and approved, supplied with standard fittings, terminations etc. by the manufacturer.
- P. High Temperature Cable - Type Firetuf or FP 200: Solid or stranded plain annealed copper Part 1 and BS 6387 (0.6 mm radial thickness), aluminum/PVC laminate and PVC composite sheath with tinned earth continuity conductor/drain wire. Cable is to be rated 300/500 V, capable of accepting voltage surges up to 5 kV, to operate continuously at 150 deg. C and for short duration at 200 deg. C. It is to be certified to have passed IEC 60331 and IEC 60332 flame resistance and fire retardant tests. Cable is to be Pirelli Cables type FP200 or Delta Firetuf or other equal and approved.
- Q. High Temperature Cable (125 deg. C) - TYPE SA: Single conductor, rated for maximum 600 V service, suitable for special applications. Silicone rubber insulated with outer covering of asbestos, glass or other suitable braid material.

2.4 CONTROL AND SIGNAL CABLES

- A. Multi-Core PVC Insulated Control Cables: 0.6/1 kV rating, solid 1.5 mm², 2.5 mm² or stranded 4 mm² plain circular copper conductors, with heat resistive PVC/E to IEC 60227 (PVC type 5 to BS 6746), rated for 70 deg. C, of 7, 12, 19, 24, 30 or 37 cores. Cores are to be laid up together and filled with non-hygroscopic material, PVC over-sheathed, to form compact and circular cable for use in switchgear, control gear and generally for control of power and lighting systems. 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 IEC 60502, color black. Core identification is to be white printed numbers 1, 2, 3 etc. over black insulation.
- B. PE insulated control and signal cables, for use on data systems, are to be generally 300 V rating, polyethylene insulated, color-coded, tinned copper conductors (0.6-mm diameter), twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075-mm bare copper shielding tape and provided with drain wire and overall PVC sheath.
- C. Control and signal cables, enclosed in conduit and raceways with power cables, are to be insulated for same voltage grade.
- D. Multi core PVC insulated cables (300/500 V) annealed copper conductors, solid conductors, up to 4 mm² unless otherwise indicated, insulated with moisture and heat resistant PVC/C to IEC 60227 and with over sheath of flame redundant PVC type ST1 to IEC 60227 and IEC 60332-1.

2.5 TERMINATION AND SPLICE CONNECTORS (LV POWER)

- A. Connector - Type A-1: Heat shrinkable or cold shrinkable for making T-taps and splices on conductors used in external lighting fittings connections.
- B. Connector - Type A-2: Pressure indent type, for terminating or making T-taps and splices on conductors 10 mm² and smaller. Connector is to be non-ferrous copper alloy applied to conductor by mechanical crimping pressure, with vinyl insulating sleeves or phenolic insulating covers.
- C. Connector - Type A-3: Bolted pressure split type for terminating or making T-taps and splices on conductors 16 mm² and larger. Connector is to be cast non-ferrous copper alloy applied to conductor by clamping with minimum of two screws and provided with phenolic insulating cover.
- D. Connector - Type B-1: Pre-insulated, spring type, for branch circuit and fixture wiring. Connector is to be steel encased spring with shell, insulated with vinyl cap and skirt, type Scotchlok brand, as manufactured by Minnesota Mining & Mfg. Co. or other equal and approved.
- E. Connector terminations and splices shall be of class A to IEC 61238-1.
- F. Connectors shall be compression, barrel crimped type.
- G. Connectors for aluminum conductors shall be made of aluminum alloy of purity not less than 99.5%.

- H. Connectors for copper conductors shall be made of electrolytic copper.
- I. All termination and splice connectors specified above shall be tin plated with minimum thickness of 5 microns for copper material and 7 microns for aluminum material. Aluminum connectors shall incorporate neutral grease to avoid aluminum oxidation.
- J. Termination connectors for aluminum-copper termination shall consist of barrel made of aluminum alloy of purity not less than 99.5% and palm made of forged copper connected using a friction stir welding.
- K. Splice connectors for aluminum-copper termination shall consist of two barrels, one is made of electrolytic copper and the other is made of aluminum alloy of purity not less than 99.5% connected using a friction stir welding.
- L. Splice connectors shall have a central stop to divide the connector into two equal parts to facilitate the correct cable positioning.
- M. Connectors shall be as recommended by manufacturer, to render joints equal to cable in characteristics, in terms of insulation, stress distribution and water-tightness. Materials and methods of jointing shall be approved before confirmation of order.
- N. Connectors shall be suitable for cable size used.
- O. All components of lugs and connectors shall be clearly marked with the manufacturer's name, die number, cable / conductor size, number of crimps and position.

2.6 CABLE GLANDS

- A. Cable glands shall comply with BS 6121-1, BS 6121-5 and BS EN 50262.
- B. Cable glands used with unarmored cables shall be made of brass, type A2 to BS 6121-5, with mechanical retention class B to BS EN 50262, impact resistance category 8 to BS EN 50262 and an environmental seal to the cable outer sheath. Glands shall be deluge protected, with IP66 degree of protection to IEC 60529.
- C. Cable glands used with single steel wire armored cables shall be made of brass, type CW to BS 6121-5, with mechanical retention class B to BS EN 50262, impact resistance category 8 to BS EN 50262, electrical continuity via armor wire termination category B to BS EN 50262, earth tag to BS EN 50262 and an environmental seal to the cable outer sheath. Glands shall have IP66 degree of protection to IEC 60529.
- D. Cable glands used with steel tape or wire braid armor shall have similar characteristics as specified in paragraph 2.6C except gland type which shall be CX instead of CW to BS 6121-5.

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

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Before pulling wires in conduit check that inside of conduit (and raceway in general) is free of burrs and is dry and clean.

3.2 INSTALLATION

- A. General: Building wires and cables are to be installed in conduit, trunking or ducts indoors and in conduit outdoors, unless otherwise shown the Drawings.
- B. Circuits: Unless otherwise shown on the Drawings, final branch circuit wiring is to be run inside trunking or conduits, D.C. wiring is to be run in separate conduits from A.C. wiring, and emergency lighting and power circuits are to be run in separate conduits from normal circuits.
- C. Branch circuit work originating from light and power panelboards is to be arranged as shown on the Drawings. Loads on various phases of panelboards are to be balanced. Ensure that the lighting load and other loads are balanced with a difference of not more than 10% between the phases.
- D. Control cables may be fixed to racks, installed directly on cable trays or pulled in conduit and trunking indoors, and in underground ducts or in conduit outdoors.
- E. Bunching of wires in raceways is to be in accordance with raceway filling factors permitted by the Regulations.
- F. Lubricants are to be used for pulling wire or cable if character of pull would otherwise damage conductors, insulation or jacket. Lubricants are to be approved by the Engineer.
- G. Pull conductors into raceways simultaneously where more than one is being installed in the same raceway.
- H. Support: Cables and wires pulled inside very high conduit risers are to be supported at upper end of risers and at intermediate points by split rubber grommets to relieve any stresses on conductors, where required.

- I. Wiring At Outlets: Leave a slack of at least 200mm at each outlet.
- J. Extra Length: At every branch circuit outlet and pull-box, every cable passing through is to be left slack to allow inspection and for connections to be made. Cables terminating in outlet boxes are to be left with at least 250-mm extra length for terminations.
- K. Joints or taps in wires and cables, if permitted, are to be permanently accessible or made only in boxes or cabinet gutters.
- L. Connectors for terminating or making T-taps and splices are to be Type A-2 on conductors 10 mm² or smaller, Type A-3 for conductors 16 mm² and larger, and Type B-1 for branch circuit and fixture wiring.
- M. Insulating covers are to be applied to prevent exposure of bare cable connections.
- N. Switch legs for local wall switches are to have distinctive color, selected as complementary to cable color coding used in the project.
- O. Terminations: Conductors of wires and cables up to 6mm² for copper and up to 10mm² for aluminum conductors are to be tightly twisted and where possible doubled back before being clamped with set screws. Where two or more wires are looped into same terminal these conductors are to be tightly twisted together before inserting into terminals. In no case is bare conductor to be allowed to project beyond any insulated shrouding or mounting of a line terminal. Cables sizes 16 mm² and larger are to terminate in tunnel lugs with setscrew, or by using bolted or sweated compression connectors.
- P. Tagging: Tag main and feeder cables in pull-boxes, wireways and wiring gutters of panelboards or distribution cabinets. Tags are to identify cable or circuit number and conductor size in accordance with the Schedules.
- Q. Tagging: Where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit is to be tagged as a guide in making connections.

3.3 FEEDER AND SUB-FEEDER INSTALLATION (0.6/1 KV)

- A. Cables generally are to be run through duct-banks, shafts or special recesses, clamped to steel racks or cable trays. Cables run through ventilation shafts shall be LS0H type or installed in steel conduits.
- B. Fixing: Single cables above suspended ceilings or in concealed spaces are to be fixed directly to walls or ceilings but must be accessible. Where two or more cables are run in parallel, they are to be fixed on galvanized steel perforated trays or on other approved special cable supporting and protecting arrangement.
- C. Clamps: Where cables are fixed to steel trays or supporting structures, approved galvanized cast steel clamps (or molded plastic clamps for single core cables) are to be used at distances not exceeding 20 diameters.
- D. Joints or splices will not be accepted on main and sub-feeders. Cables are to be supplied in lengths sufficient for straight-through un-jointed termination to termination pull.

- E. Directly buried cables crossing under roads, pipe banks or other services, 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 finishing.
- F. Buried cables liable to mechanical damage are to be drawn through PVC conduit or asbestos cement pipe. If steel conduit is used, all three-phase conductors, neutral and protective earth circuits are to be in the same conduit.
- G. Exposure to Heat: Route wires and cables to prevent exposure to excessive heat or to corrosive agents. If such condition is unavoidable, cables are to be type designed for particular condition.
- H. Insulating covers are to be applied to prevent exposure of bare cable connections. Insulating cover is to be purpose made and is to provide minimum insulation level equal to that of conductor insulation.
- I. Glands for various single-core and multi-core cables are to be purpose made and suitable for rigid mounting to equipment enclosure.
- J. Seal around cables penetrating fire-rated elements using approved fire-stopping material according to Division 7 Section "Through-Penetration Firestop Systems".
- K. Identify wires and cables according to Division 26 Section "Basic Electrical Materials and Methods."

3.4 CABLE CONNECTIONS, JOINTING AND TERMINATIONS

- A. Through joints will not be allowed in feeder cables where adequate manufacturer's lengths are available. Where a joint is necessary, it has to be made inside boxes, handholes or manholes.
- B. Recommendations: Through joints and terminations are to be carried out strictly in accordance with cable manufacturer's recommendations, and made with correct specified materials, boxes, tapes, compounds or mixtures, stress cones, glands and bonds as applicable.
- C. Jointing: Joints are to be filled with epoxy resin after taping unless contrary to cable manufacturer's recommendations. Sample site constructed cable terminations and through-joints are to be submitted prior to commencing work on site. Samples are to be constructed in the presence of the Engineer and are to be available for test and inspection in accordance with manufacturer's recommendations.
- D. Cutting tools for jointing and terminating cables are to be purpose made, to prevent damage to insulation in general, and to cable shielding of MV cables.
- E. Cleaning of lacquer on conductors is to be by use of 'Scotch Brite' sponge and white spirit or equal approved.
- F. Tighten electrical connectors and terminals including screws and bolts, in accordance with manufacturers published torque-tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with international standards.

3.5 FIELD QUALITY CONTROL

- A. Cable tests are to be carried out in accordance with the requirements of the Regulations and Standards.
- B. Test Equipment: Provide megger testers of various ranges as applicable, and HV test equipment as necessary for testing MV installations. Use 500 V megger on installations with nominal voltage up to 500 V, and 1000 V megger on installations with nominal voltage over 500 V up to 1000 V.
- C. Insulation resistance for LV power and lighting installations is to be carried out in accordance with BS 7671 (IEE Regulations 613-5 through 613-8 and 713-04.)
- D. Insulation resistance for control and signal cables is to be minimum 10000 Megohm-km for PE insulated cables and 100 Megohm-km for PVC insulated cables, all measured core-core and core-earth, in accordance with the Regulations.
- E. Prior to energization of circuitry, check installed wires and cables with megohm meter to determine insulation resistance levels to ensure requirements are fulfilled.
- F. Prior to energization, test wires and cables for electrical continuity and for short-circuits.
- G. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.
- B. The following Sections contain special requirements that relate to this Section:
 - 1. Division 2 Section "Underground Ducts and Utility structures for Electrical Systems.
 - 2. Division 26 Section "Basic Electrical Materials and Methods".
 - 3. Division 26 Section "Medium Voltage Cables and Low Voltage Electrical Power Conductors and Cables".

1.2 SUMMARY

- A. This Section includes complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TN-S system arrangement, including:
 - 1. Medium voltage switchgear or Ring Main Unit earthing
 - 2. Transformer neutral earthing.
 - 3. Standby generator neutral earthing.
 - 4. Telecommunications, control, security and life safety systems
 - 5. Main earthing terminals or bars.
 - 6. Exposed conductive parts of electrical equipment.
 - 7. Extraneous conductive parts.
 - 8. Building main integrated ring electrode.

Earthing requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 DEFINITIONS

- A. The following terms used on the Drawings and in the Specification are equivalent and may be used interchangeably: "earth" and "ground"; "earthing" and "grounding".
- B. Earth: Conductive mass of the Earth whose electric potential at any point is conventionally taken as zero.
- C. Earth Electrode: Conductor or group of conductors in initial contact with, and providing electrical connection to, Earth.
- D. 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.
- E. 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.

- F. 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).
- G. 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).
- H. 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.
- I. Equipotential Bonding: Electrical connection to put exposed and extraneous conductive parts at a substantially equal potential.
- J. Earthing Conductor: Protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.4 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, earth terminal bar, and bonding conductors.
 4. Connectors and other accessories
 5. Exothermic welding kits and tools.
- 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.
- D. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Overall earthing schematic indicating cross sectional area of all earthing, protective and bonding conductors.
 2. Overall earthing layout indicating earthing provisions at substations, generator rooms, switchgear, distribution panelboards etc., identifying fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts, and exact location of earth pits, rods and details of installation and connections, and exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.
- E. 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.
- F. Samples: Submit samples of conductors, grounding rods, clamps, and earth terminal bar, as requested by Engineer.
- G. Final earthing design calculations for approval.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who has specialized in installing lightning protection systems similar in material, design and extent to 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, IEC 60364-5-51 and IEC 60364-5-55/AMD and IEC 60364-4-41: Electrical Installations in Buildings.
 2. Latest edition IEE Regulations for Electrical Installations in Buildings – London.
 3. ANSI/IEEE/std 80: IEEE Guide for Safety in AC Substation Grounding.
 4. ANSI/IEEE/Std 81: IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grounding System.
 5. BS 7430: Code of Practice for Earthing.
 6. DIN VDE 0141: Earthing Systems for Power Installations with Rated Voltages above 1 kV.
 7. BS EN 13601 Copper and copper alloys. Copper rod, bar and wire for general electrical purposes.
 8. BS EN 13601: Specification for copper for electrical purposes. Rod and bars.
 9. BS EN 1057: Copper and copper alloys. Seamless round tubes for water and gas in sanitary and heating applications.
 10. BS EN 12449: Copper and copper alloys. Seamless round tubes for general purposes.
 11. BS EN 12451: Copper and copper alloys. Seamless, round tubes for heat exchangers.
 12. BS 7668: Specification for weldable structural steels. Hot finished structural hollow sections in weather resistant steels.
 13. BS EN 60228: Specification for conductors in insulated cables and cords.

14. BS EN 10029: Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above.
15. BS EN 10025-1 , BS EN 10025-3 and BS EN 10025-4: Hot-rolled products in weldable fine grain structural steels. Delivery conditions for thermomechanical rolled steels.
16. BS EN 10025-1 and BS EN 10025-3:1: Hot-rolled products in weldable fine grain structural steels. Delivery conditions for normalized/normalized rolled steels.
17. BS EN 10025-1 and BS EN 10025-3: Hot-rolled products in weldable fine grain structural steels. Delivery conditions for thermomechanical rolled sheets.
18. BS EN 10025-1 and BS EN 10025-5: structural steels with improved atmospheric corrosion resistance. Technical delivery conditions.
19. BS EN 10210-1: Hot finished structural hollow sections of non-alloy and fine grain structural steels. Technical delivery requirements.
20. BS EN 10025-1: Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions. General delivery conditions.
21. BS EN 10025-1 and BS EN 10025-6: Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions. Delivery conditions for quenched and tempered steels.
22. : Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened condition. Delivery conditions for precipitation hardened steels.
23. BS EN 10025-1 and BS EN 10025-2: Hot rolled products of non-alloy structural steels. Technical delivery conditions.
24. BS 7655-1-5: Specification for insulating and sheathing materials for cables. Elastomeric insulating compounds. Flame retardant composites.
25. BS 7655-0: Specification for insulating and sheathing materials for cables. General introduction.
26. BS EN 50525-1 and BS EN 50525-2-31 and BS EN 50525-2-51: Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring.
27. ISO 630-1, ISO 630-2, ISO 630-3 and ISO 630-4: Structural steels.
28. IEC 60502-1: Extruded solid dielectric insulated power cables for rated voltages from 1 kV to 30 kV.
29. ITU: Directives concerning the protection of telecommunications lines against harmful effects from electricity lines.

C. Comply with BS EN 62305 for lightning protection system.

PART 2 - PRODUCTS AND SYSTEMS

2.1 MANUFACTURERS:

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

1. Furse (England)
2. Wallis (England)
3. G.E.C. (England)
4. BICC (England)

2.2 SOIL SURVEY AND CALCULATIONS

- A. The Contractor shall carry out an earth resistivity survey on each site and report in writing to the Engineer in accordance with the approved program. The report shall detail the methods and instruments used and the results of the surveys. Based on the results the Contractor shall include in the report his proposals for the resistivities to be used in the design of the earthing system.
- B. The value of resistivities to be used in the design of the earthing system shall be subject to the Engineer's approval.
- C. The surveys shall show the variation of resistivity across the site and with the depth below the site. The Contractor shall consider if there is a need to model the resistivity in two layers and if there is any advantage in the use of long rods. The surveys shall also determine the depth and nature of any underlying rock, which may limit the depth for driving earth rods or if boring will be necessary for installing earth rods.
- D. The weather conditions prior to and at the time of the surveys shall be recorded in the report and an assessment made of the seasonal variations in resistivity based on meteorological data for the area. The program for the project should, as far as possible, time the resistivity surveys to take place during a dry season.
- E. The report should also state if there are any indications that the ground is corrosive to copper or if there is any risk of galvanic corrosion on other metal structures in the neighbourhood.
- F. The report shall be approved by the Engineer before proceeding with the design of the earthing system.
- G. The calculations shall be submitted for approval prior to commencing the design of the earthing systems.

2.3 EARTH ELECTRODE SYSTEM DESIGN

- A. Design Calculations:
 - 1. The design of the earth electrode systems shall be based on the approved earth resistivity data and the system's fault currents and their duration.
 - 2. The design calculations shall be to the approval of the Engineer and shall be based on the methods given in the standards listed. The calculations shall include the following parameters:-
 - a. Earth resistance of the whole system of its components.
 - b. Earth potential rise.
 - c. Step, touch and mesh potentials inside and outside the perimeter fence.
 - d. Requirements for a high resistance surface layer.
 - e. Conductor ratings.
 - 3. The earth potential rises shall not exceed the ITU limits appropriate to the classification of the system unless special precautions are taken to cater for transferred potentials.
 - 4. Step, touch and mesh potentials shall be within the limits calculated in accordance with the standards given in IEEE 80 and BS 7430 for the proposed surface layer. The formula for allowable body current shall be used for 50 Kg body weight.

B. Earth Electrode:

1. The earth electrode system shall compose of interconnected earthing rods driven into the ground or installed in bored holes. The design calculations shall identify the required number of interconnected rods to achieve the required resistance to earth.
2. Rods shall be installed inside the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. (The spacing between rods shall not be less than twice their length, unless rating considerations determine otherwise). The rods shall be interconnected by bare copper conductors to form a ring. .
3. Rods installed in bored holes may be used to reach lower resistivity ground strata at depths beyond the reach of driven rods or where rock is encountered and it is not possible to drive rods. After installing the rod the bored hole shall be back-filled with a low resistivity liquid mixture that shall not shrink after pouring to ensure good contact between the rod and the ground for the life of the installation.
4. The resistance and rating of individual rods and the combined resistance of the groups of rods in the proposed design shall be calculated and the rating of the interconnecting conductors shall not be less than that of the main grid conductor.
5. The calculation of potentials in the design of the complete installation shall be made without the group of rods with the lowest estimated resistance to simulate the condition with the group disconnected for testing.

C. Reinforcing Steel:

1. The reinforcing steel in the foundations of buildings containing the primary electrical equipment may be used as auxiliary electrodes subject to the approval of the Engineer. The Contractor shall show in the design calculations that the fault currents and dc. stray currents will not damage the structure.
2. Steel reinforcing mesh in the floors of the building may also be used for the control of step and touch potentials within the building subject to the approval of the Engineer.

D. Conductors Outside Perimeter Fence:

1. If the design calculations show that the step and touch potentials outside the perimeter fence, gate or wall exceed the limits then additional bare conductors shall be buried in the ground outside the fence in the form of rings encircling the whole site.
2. The distance of the conductors from the fence and the depth shall be determined in the design to ensure that step and touch potentials are within the limits.
3. The minimum conductor size shall be 70 mm² and shall be connected to the fence or the earth electrode with 70 mm² conductors at each corner of the site and at intervals of not more than 100 m. These conductors shall not be included in the calculations called for above.

E. Gas Insulated Switchgear:

1. The earthing of gas-insulated switchgear (GIS) installations shall be subject to special considerations regarding step and touch potentials in accordance with the standards listed. However, the earthing conductor shall be yellow-green

colored PVC insulated stranded copper conductor of minimum overall conductor size of 300 mm². The connection shall be at multiple points.

2.4 GENERAL REQUIREMENTS

- A. Component parts of earthing system are to include the following:
1. Earth electrode (rods, tapes etc.)
 2. Main earthing terminals or bars, equipotential earthing bar, and supplementary equipotential earthing bar.
 3. Earthing conductors.
 4. Protective conductors.
 5. Equipotential bonding conductors.
 6. Electrically independent earth electrodes for special systems.
 7. Accessories and termination fittings, bonding, welding kits and other materials.
- B. Earth electrode is to consist of one or more earth rods, interconnected by buried earthing tape or cable, which is to have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, not exceeding 2 ohms for power network (Unless otherwise indicated on the drawings). Distance between two rods is not to be less than twice the length of one rod driven depth.
- C. 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, medical areas etc.) as required by the particular Section of the Specification and recommendation of manufacturer.
- D. Alternative Earth Electrode: other types of earth electrode may be used, after approval, including:
1. Copper plate(s)
 2. Tape mats (strips).
- E. Main earthing bar is to be provided at point of service entrance or main distribution room, and as described in the Specification or shown on the Drawings. Connect all earthing conductors, protective conductors and bonding conductors to the main earthing bar. 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 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 120 mm² or as otherwise required by the particular Section of the Specification.
- F. The main earth bar shall be in the form of a ring or rings of bare conductors surrounding or within an area in which items to be earthed are located. Where 2 or more rings are installed they shall be interconnected by at least two conductors which shall be widely separated.
- G. 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.

- H. 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.
 - 1. Selection of sizes is to be in accordance with IEE Regulations.
- I. Protective conductors are not to 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.
- J. 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.
 - 1. Conductor sheaths shall be of yellow-green coloured PVC to meet the requirements of BS 6004 or IEC 60502-1 Grade ST1 with a minimum thickness of 1.5 mm.
- K. Bare strip conductors only shall be used for earth electrodes or voltage control meshes.
- L. Conductors buried in the ground shall normally be laid at a depth of 1000 mm below the underground power cables in an excavated trench. The backfill in the vicinity of the conductor shall be free of stones and the whole backfill shall be well consolidated.
- M. All conductors not buried in the ground shall be straightened immediately prior to installation and supported clear of the adjacent surface.
- N. 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.
 - 1. Use appropriate tables and present same for approval by the Engineer (IEE Regulations).
- O. 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 6-mm² copper conductor and not greater than 25 mm² copper conductor.
 - 1. Individual components of metallic structures of plant shall be bonded to adjacent components to form an electrically continuous metallic path to the bonding conductor.
 - 2. Small electrically isolated metallic components mounted on non-conducting building fabric need not be bonded to the main earth bar.
 - 3. Bolted joints in metallic structures including pipework, which do not provide direct metallic contact shall be bridged by a bonding conductor or both sides

of the joint shall be separately bonded to earth unless the joint is intended to be an insulated joint for cathodic protection or other purposes.

- P. 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 6 mm².
- Q. 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:
 - 1. SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE.
- R. 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.
- S. Identification: Source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labeled 'neutral earthing'.
- T. Exposed external earth / grounding conductor connection joints are to be protected from corrosion with grease caps or Denso tape (dibutinous tape) or approved equal.
- U. The earthing and lightning protection system for any new extension shall be suitably connected to the existing system.

2.5 GROUNDING CONDUCTORS

- A. Buried Earth Conductors: Bare copper conductors and is to be sized to carry maximum earth fault current of system as per earthing calculations.
- B. Earthing Conductors: Insulated or bare copper conductor as described in the Specification for the particular application and is to be sized as per earthing calculations.
- 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 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.

- F. Disconnecting links shall comprise a high conductivity copper PVC insulated link supported on two insulators mounted on a galvanized steel base for bolting to the supporting structure. The two conductors shall be in direct contact with the link and shall not be disturbed by the removal of the link. Links for mounting at ground level shall be mounted on bolts embedded in a concrete base.
- G. Disconnecting links mounted at incoming service level and the connections at the earth rods shall be enclosed in concrete inspection pits, with concrete lids, installed flush with the ground level.

2.6 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. Connections to metallic structures for earthing conductors and bonding conductors between electrically separate parts of a structure shall be either by direct exothermic welding or by bolting using a stud welded to the structure. Drilling of a structural member for a directly bolted connection shall only be carried out to the approval of the Engineer.
 - 1. 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. Bolted connections are not permitted in run of the earthing conductors unless approved by the Engineer.
 - 2. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions. Welded connectors are to be used only in inaccessible locations and at "T" joints, to the approval of the Engineer.
- C. Bi-metallic connectors shall be used between conductors of dissimilar materials and insulating material shall be interposed between metallic fittings and structures of dissimilar materials to prevent corrosion.
- D. When the reinforcing in concrete is used as a part of the earthing system the fittings used to provide a connection point at the surface of the concrete shall be exothermically welded to a reinforcing bar. This fitting shall be provided with a bolted connection for an earthing conductor. The main bars in the reinforcing shall be welded together at intervals to ensure electrical continuity throughout the reinforcing.
- E. No connections shall be made to reinforcing bars and other steelwork which do not form part of the earthing system and are completely encased in concrete.

2.7 GROUNDING ELECTRODES

- 1. Minimum Length of Rod: 3 m, with 17.2 mm diameter extendible as necessary to obtain required earth resistance.
- 2. Rods, and driving caps and tips shall abut at couplings to ensure that the couplings and screw threads are not subject to driving forces. All screw threads shall be fully shrouded at the couplings.

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

PART 3 - EXECUTION

3.1 TRANSFORMER SUBSTATION EARTHING

- A. MV switchgear is to have separate main earthing bar connected to framework or earth bar of each item by PVC insulated stranded copper conductor and the earth-electrode by two insulated or bare earthing conductors, one at each end of bar, via testing joints. Earthing conductor is to be minimum 150 mm² unless size determine otherwise.
- B. Outdoor ring main units, which are individually mounted, are to be connected to earth electrode by 2 insulated earthing conductor, bolted at earthing terminal.
- C. LV switchgear is to have separate main earthing bar connected to framework or earth bar of each item by PVC insulated stranded copper conductor and the earth electrode at two extreme ends by 2 insulated or bare earthing conductors through testing joints. Earthing conductor size is to be minimum 240 mm² unless size determine otherwise.
- D. Transformer earthing terminal is to be connected to MV main earthing bar by insulated copper earthing conductor not less than 20 mm² per 100 kVA of transformer rating, with a minimum of 35 mm².
- E. Transformer neutral (star point) is to be connected by insulated earthing conductor (color 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.
- F. Lightning arresters are to be directly connected to earth electrode, following the shortest path. Each lightning down conductor is to be connected at a dedicated earth rod.

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

- A. 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.
- B. Earthing bars of main distribution boards are to be connected, by bare earthing conductor, directly to main earthing bar at main distribution 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.

- C. 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.
- D. Final Ring Sub-Circuits: 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.
- E. 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.

3.3 GENERATOR PLANT EARTHING

- A. Generator neutral (star point) is to be connected by insulated earthing conductor through the neutral earthing link or device to separate earthing bar. Neutral earthing conductor is to be suitably sized to carry maximum earth fault current for time it takes the system protection to operate with final conductor temperature not exceeding 160 deg. C, but not less than 30 mm² per 100 kVA of generator rating, with a minimum of 50 mm².
- B. Generator earthing terminal is to be connected to main earthing bar by bare copper conductor of cross section not less than 20 mm² per 100 kVA of generator size, with a minimum of 35 mm².
- C. Switchgear (ATS) and Control Gear: Earthing terminals or bars of switchgear and control gear are to be connected by separate protective conductors to respective normal and emergency main distribution board earth bars.
- D. Extraneous conductive parts including steel frames, battery racks, day-tank, pumps and piping are to be connected by bare copper earthing conductors to main earth bar in compliance with bonding regulations.

3.4 MECHANICAL PLANT ROOMS AND FIXED MACHINERY

- A. Main earthing bar or loop is to be conveniently located in mechanical plant rooms, and connected by earthing conductors to exposed conductive parts of motor control centre at its earthing bar, and to motors, switches and other electrical equipment etc. at their earthing terminals, using 20 x 2 mm bare copper strips or 35 mm² bare copper conductor (minimum size) or as required to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200 deg. C. Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.
- B. Main earthing bar or loop is to be connected at two extremely separate points to earth electrode, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.

- C. Motor and other equipment earth terminals are to be connected also by protective earth conductors of each branch circuit to earth terminal/bar at motor control centre, panel or distribution unit.

3.5 ROAD LIGHTING

- A. Earthing Cables: separate protective earthing cables for lighting column circuits are to be run with power circuit, terminated at LV supply position in lighting control panel and looped into column earthing terminals. The last column is to be bonded via an earthing bolt to a single 14 mm diameter copper covered steel rod, 2.5 m long, driven into ground adjacent to column. Bonding is to be 16 mm² stranded bare copper conductor.
- B. Connections between rods and earthing conductors are to be made by the Cadweld process producing a fused joint. Bolted connections may be used for connection to removable items of equipment only.

3.6 SIGNAL AND COMMUNICATION SYSTEMS

- A. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide 16mm² minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 6.4-by-50-by-300-mm grounding bus.
 - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.7 EARTHING AND BONDING MULTICORE CABLES

- A. The metallic sheath and armor of multicore cables shall be bonded together and earthed.
- B. Cable earthing conductors shall be copper strip with appropriate section laid in formed cable trenches or ducts, or fixed to walls, concrete or steel work, by means of clamps or claw type cleats, appropriately secured into suitable wall plugs or tapped holes. The spacing of fixings shall not be greater than 1 m. Where earth strip is buried or laid in positions in which there is danger of corrosion it shall be provided with a corrosion-proof serving of extruded thermo-plastic or self-adhesive PVC tape which for short lengths may be hand applied on Site.
- C. The Contractor shall connect, unless otherwise instructed, all cable sheaths and armor, supporting steel work and the metal enclosure of sealing boxes, joints, etc., to the main earth bar by suitable branch connections which may be of bare or insulated stranded conductor as required to suit the cable system.
- D. Concentric type bonding leads of suitable impedance shall be employed where necessary. The bonding and earthing system shall be subject to the approval of the Engineer and shall be designed to meet the subsequent maintenance requirements.

3.8 EARTHING OF FENCES

- A. Method: Metallic fences shall be separately earthed unless they come within 1.8 m of any equipment or structure above the surface of the ground, which is connected to the main earthing system. If the separation of 1.8 m cannot be obtained the fence shall be bonded to the earthing system.
- B. Separately Earthed Fences: The earthing of a fence shall be provided by connecting certain metallic fence posts to an earth rod by a copper conductor. The earth rod shall be driven adjacent to the posts inside the fence line to a depth of not less than 3.0 m. Where no metallic posts are provided the earth rods shall be connected directly to the metal wires, mesh or other components of the fence.
- C. Bonded Fences: Fences which need to be bonded to the main earthing system of the installation shall be connected by copper conductors to the nearest accessible point on the main earthing system at each point where the fence comes within 1.8 m of any electrical equipment. Bonds shall also be made to each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.
- D. Bonding of Fence Components:
 - 1. Fences made up of bolted steel or other metallic components do not require bonding between components. Where such fences have non-metallic components bonds shall be installed to maintain continuity between metallic components. Reinforced concrete components shall be treated as being non-metallic.
 - 2. Longitudinal wires for supporting other fence components or for anti-climbing guards and the wires of chain link shall be directly bonded to each fence earth electrode or to each bond to the main earthing system.
 - 3. Metallic components on masonry, brick, concrete or similar boundary wall shall be treated in the same manner as metallic fences.
 - 4. Wire fence components coated for anti-corrosion protection or PVC coated fence shall be earthed in accordance with this Clause.
- E. Gates: The fixed metallic components on both sides of the gate shall be directly bonded together by a copper conductor installed under the surface of the access way. Flexible conductors shall be installed to bond the moving parts of the gates to the metallic fixed parts. An earth rod or a bond to the main earthing system shall be installed at each gate.
- F. Potential Control Outside Fences:
 - 1. Where the approved design calculations show that the touch or step potentials outside the fence or boundary wall would otherwise be excessive, bare copper conductors shall be buried in the ground outside the fence or boundary wall at such depths and spacings as are shown in the approved design calculations to give acceptable touch and step potentials. The conductors shall form complete rings surrounding the installation and each ring shall be bonded to the adjacent ring and to the fence at each corner. Below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m. In this case separate earth electrodes are not required for the fences.
 - 2. If the boundary fence or wall is substantially non-metallic the rings of conductors shall be bonded to the main earth system at each corner of the site and at intervals of not more than 100 m. Any metallic components on such

boundary fences or walls shall be bonded to the earthing system in accordance with this Specification.

3. If the boundary fence is metallic and is not within 1.8 m of any part of the main earthing system or equipment bonded thereto the fence and outer conductor rings shall not be connected to the main earthing system unless the approved design calculations show otherwise.
4. Any meshes formed by bonding the outer conductors to the main earthing system shall be sub-divided by additional conductors, if required, to give acceptable touch, step and mesh potentials.

- G. Conductors: All conductors used for earthing and bonding the fences and components and for outer rings shall have a cross-sectional area of not less than 185 mm² copper.
- 1.

3.9 INSTALLATION

- A. Continuity: Ensure that complete earthing system is electrically continuous and mechanically secure.
- B. Earth Rods: While siting earth rods, ensure that resistance areas associated with individual rods do not overlap. Earth rods are to be located at a distance greater than 600 mm from foundations of buildings. Where rock is encountered, a hole of sufficient size is to be drilled before lowering the rod. Conductive filler such as Marconite or Bentonite or equal filler that will not corrode, is to be provided around the rod.
- C. Buried earthing conductors are to be laid at a depth not less than 0.8 m from ground surface.
- D. 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.
- E. 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.
- F. Protective Bonding: Remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.

3.10 CONNECTIONS

- A. Protection against Corrosion: Protect bolted connections against corrosion either by filling with vaseline or coating with a special anti-corrosion compound and proper capping.
- B. Connections: Earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.

- C. 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.
- D. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.11 FIELD QUALITY CONTROL

- A. Combined resistance of earth electrodes is to be measured during dry season and checked against specified resistance.
- B. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.
- C. Electrical continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.
- D. Earth fault loop impedance of all circuits is to be measured and checked against calculated impedance figures.
- E. Operation of residual current protective devices is to be checked.

3.12 GRADING AND PLANTING

- A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2 Section "Landscaping." Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION 26 05 26

SECTION 26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetal conduits, tubing, and fittings.
 - 3. Metal wire-ways and auxiliary gutters.
 - 4. Nonmetal wire-ways and auxiliary gutters.
 - 5. Surface raceways.
 - 6. Boxes, enclosures, and cabinets.
 - 7. Accessories necessary to support and protect cables, feeders, sub-feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.
- B. Related Sections include the following:
 - 1. Division 7 Section "Through-Penetration Firestop Systems"
 - 2. Division 26 Section "Basic Electrical Materials and Methods" for raceways and box supports.
 - 3. Division 26 Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.
 - 4. Division 26 Section "Low Voltage Power Conductors and Cables".
 - 5. Division 27 Section "structured cabling network".

1.3 DEFINITIONS

- A. RGS: Rigid heavy gauge steel conduit.
- B. EMT: Electrical Metal Tubing.
- C. PVC: Polyvinyl chloride.

1.4 SUBMITTALS

- A. Product Data: Submit data for approval including, but not limited to, manufacturers' catalogues with specifications of raceways including conduits, trunking, boxes, etc. and related accessories.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:

1. Exact routing of conduits, trunking etc. with indication of boxes, accessories and expansion joints, size and type of conduits and boxes.
 2. Typical assembly details of installation of trunking, trays etc.
 3. Construction details of pull boxes.
 4. Typical installation details including connection of conduits to metal enclosure, connection of flexible conduits, vapour-tight installations in cold rooms, weatherproof installations outdoors etc. and earthing connections.
- C. Samples of each type of wire way, raceway, box, and accessory.
- D. As-Built (Record) Drawings: At Project close-out, submit Record Drawings of installed electrical ducts, and manholes, in accordance with requirements of the Specification,

1.5 QUALITY ASSURANCE

- A. Regulations and Standards: Conduits, wireways, cable trays and fittings are to be designed, constructed and installed to give safe installation and reliable mechanical protection for wires and cables in accordance with the Regulations. Standards of products are to be as specified.
- B. All products shall be sourced from Manufacturer approved agent/dealer. Documentation to be provided.
- C. Codes and Standards: Comply with the latest issue of:
1. IEC 60269 Low voltage fuses.
 2. IEC 60296 Specification for unused mineral insulating oils for transformers and switchgear.
 3. IEC 62052-11 Electricity metering equipment (AC) - General requirements, tests and test conditions - Part 11: Metering equipment.
 4. IEC 62053-11 Electricity metering equipment (AC) - Particular requirements – Part 11: Electromechanical meters for active energy (classes 0, 5, 1 and 2).
 5. IEC 60529 Degrees of protection provided by enclosures (IP code).
 6. IEC 60947 Low voltage switchgear and control gear.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.

- C. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 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.
 4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 NONMETAL CONDUITS, TUBING, AND FITTINGS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Conduit, Wireways, Boxes and Related Accessories:
 - a. Engineering home (Egypt)
 - b. Decoduct (Egypt)
 - c. Simplex (England)
 - d. Ega Tubes (MK) by Honeywell (England)

2.2 METAL CONDUITS, TUBING, AND FITTINGS

1. Conduit, Wireways, and Related Accessories:
 - a. Allied (USA)
 - b. Wheatland (USA)
 - c. Simplex (England)
 - d. Ega Tubes (MK) by Honeywell (England)
2. (Heavy Duty)
 - a. Cary, Type 'F', of pre-designed sections (lengths) to meet modular construction on site.
 - b. Schneider (France),
3. Plug-In Overhead Lighting Trunking (Light Duty)
 - a. Wiremold by Legrand (France), ,
4. Metallic Outlet Boxes
 - a. Same manufacturer as conduit or other approved, and to the satisfaction of Engineer.

2.3 RIGID HEAVY GAUGE STEEL CONDUIT (RGS)

- A. Material: Heavy gauge drawn and welded steel, threaded at both ends, to BS EN 61386- 1 (threaded), with class 4 protection for rigid steel conduit, zinc coated inside and outside by hot-dip process or sherardizing.
- B. 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 CEE 23, BS EN 61386-1 .
- C. Locknuts for securing conduit to metal enclosure are to be heavy hexagonal or castellated pattern, for fastening.
- D. Bushings for terminating conduits are to be smooth rounded brass rings.
- E. 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.

2.4 LIGHT GAUGE STEEL CONDUIT (ELECTRICAL METALLIC TUBING-EMT)

- A. Material: Welded steel, non-threaded type galvanized externally and protected internally with corrosion resistant enamel, and to BS EN ISO 14713-2 & BS EN 61386-21.
- B. Corrosion Resistance: Conduits used in corrosive atmospheres are to be copper silicon alloy, highly resistant to corrosion.
- C. Fittings Generally: Threadless pressure type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.

2.5 FLEXIBLE STEEL CONDUIT

- A. Material: Steel, cold rolled and annealed, non-threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside, and to BS EN 61386-1 and BS EN 61386-24.
- B. Liquid-tight flexible conduit is to have PVC jacket extruded over core.
- C. Fittings Generally: Threadless, hinged clamp type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
- D. 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.
- E. 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.

2.6 RIGID HEAVY GAUGE PVC CONDUIT

- A. Material: Rigid unplasticized polyvinyl chloride with high impact and high temperature resistance, flame retardant, non-hygroscopic and non-porous, to, BS

4607 and BS EN 61386-1 and BS EN 61386-24, DIN 49016 or other equal and approved standards conforming to IEC 60423, IEC 61386-1 and IEC 61386-21.

- B. 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.
- C. 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.

2.7 FLEXIBLE PVC CONDUIT

- A. Material: Flame retardant, heat resistant, non-hygroscopic PVC, high resistance to impact, ribbed on circumference for flexibility.

2.8 STEEL CONDUIT ACCESSORIES

- A. Sleeves Through Outside Walls: Cast iron, with end and intermediate integral flanges, and internal diameter larger than diameter of through-conduit. Length is to correspond to wall thickness. Space between sleeve and conduit is to be packed with oakum to within 50 mm of both faces of wall, remainder of sleeve packed with plastic compound or lead, held in place by heavy escutcheon plates bolted at both ends to flanged ends of sleeve. Alternatively, sleeves are to be O.Z./Gedney, Type WSK or other equal and approved, with cable or conduit bolted pressure sealing.
- B. Supports and Hangers: Galvanized malleable cast iron straps or structural steel sections with hot dip galvanized bolts and nuts.
- C. Expansion Joint for Embedded Steel Conduits - Type A: Watertight, flexible conduit with end fittings to receive fixed conduits. Length is to allow movement within range of joint and is not to be less than 20 times diameter of conduit. Conduit is to be covered with thick rubber tubing with 5 mm minimum gap all around tube. Bonding jumper with earth clamp is to electrically connect both sides of joint. Fitting is to be O.Z./Gedney, Type DX or other equal and approved.
- D. Expansion Joint for Exposed Steel Conduits - Type B: Sleeve with fittings to permit telescoping of one conduit into sleeve. Movable conduit is to be fitted with watertight bushing. Joint is to be weatherproof, of galvanized malleable iron or steel. Bonding jumper with earth clamp is to electrically connect both sides of joint. Expansion Joint for Exposed Steel Conduits - Type C: PVC sheathed flexible steel conduit terminating in pull boxes and securely fixed on each side of structural expansion joint. Bonding jumper is to electrically connect both sides of joint.
- E. Tags: 50 mm diameter steel with indented lettering, rust inhibiting treatment and baked enamel finish.

2.9 WIRING AND CABLE TRUNKING

- A. Components are to include wireway base, clip-on covers, couplings, end plates, wall flanges, panel to trunking rubber grommets, elbows, tees, adaptor plates and necessary hangers, supports and accessories.

- B. Steel Trunking: To BS EN 50085-2-1 and BS EN 50085-1, galvanized sheet steel, minimum 1.5 mm thick, protected internally and externally with corrosion resistant finish such as zinc or cadmium with top coat of enamel.
- C. PVC Trunking: high impact, heavy duty, self-extinguishing, rigid PVC with grooved double locking action of the clip-on cover. Design is to be approved by Engineer before ordering materials. Trunking is to be capable of receiving functional slot-in hangers and demountable separators to segregate wiring systems as needed.
- D. Sizes: As required to accommodate number of conductors permitted by the Regulations and/or as shown on the Drawings.

2.10 WEATHERPROOF WIRING AND CABLE TRUNKING

- A. Type: Hot-dip galvanized sheet steel trunking and cover, similar to Simplex, Power Center type or other equal and approved.
- B. Construction: Trunking is to have outwardly turned flanges to receive cover, and internal sleeve coupling between sections, permitting cutting of trunking on site.
- C. Gaskets: Neoprene bonded cork gaskets are to be fitted throughout, between any two attached surfaces.
- D. Screws: Removable flanged covers are to be secured with galvanized steel holding screws.

2.11 PREWIRED PLUG-IN LIGHTING TRUNKING (HEAVY DUTY)

- A. Type: Overhead supported and prewired, supplied complete with 16 A, 3-pin special non-standard socket outlet for each luminaire, at spacing required and shown on the Drawings. Lengths of sections are to be determined by centers at which support brackets are to be mounted. Expansion is to be taken up by expansion fittings, and spacing of sections where applicable, and as recommended by the manufacturer.
- B. Construction: 1.5 mm (16 b.g.) thick rigid mild steel sheet, with flanged cross-section to withstand loads up to 180 lbs (vertical/horizontal) with negligible deflection when supported at 4.0 m, and finished in stove enameled gray. Socket outlets are to be earth bonded. Purpose made support brackets are to be provided at regular spacing. Connecting set between sections (lengths) is to provide a stiffening joint and access into trunking through top plate. Flexible is to be provided between trunking sections to enable trunking to be turned in the horizontal plane for negotiating bends or curves.
- C. Wiring and Plugs: Each trunking length is to be wired with five single-core, 4 mm² PVC cables for alternate 3-phase, neutral and earth distribution, extended at least 150 mm beyond each end for easy field wiring between sections, and supplied with one 30 A connector block per length. Plugs are to be fused. End cable adapter on header is to be provided at each connection to a branch circuit.
- D. Lighting Fitting Suspension: Underside of trunking is to be formed in a continuous edge from which lighting fittings are to be suspended at two points, each by bolted hooks with locking screws to prevent accidental unhooking of fixture.

2.12 SKIRTING TRUNKING

- A. Type: Comprising wireway base, snap-on cover, couplings, end plates, wall flanges, elbows, tees, adapters, if required, and necessary clamps, hangers, supports and accessories. Wires and cables are to be laid from front and held in place by clamps.
- B. Steel Skirting Trunking: Sheet steel, 1.5 mm minimum thickness, protected internally and externally with corrosion resistant finish such as zinc or cadmium with top coat of enamel.
- C. UPVC Skirting Trunking: High impact resistant, flame retardant UPVC (unplasticized polyvinyl chloride) to BS 476-12, BS 476 Part 6 and BS4678 Part4.
- D. Partitions: Trunking is to be partitioned continuously into compartments for separate circuits. Size of each compartment is to be determined by size and number of conductors housed, in accordance with the Regulations and/or as shown on the Drawings.
- E. Dimensions: As shown on the Drawings and as required to accommodate specified wiring devices.

2.13 PLUG-IN OVERHEAD LIGHTING TRUNKING (LIGHT DUTY)

- A. Regulations: Trunking is to conform to the National Electrical Code for overhead distribution of lighting circuits and low current circuits.
- B. Components comprise wireway base, snap-on covers, couplings, end plates, wall flanges, panel to wireway rubber grommet, elbows, tees, adaptor plates and necessary hangers and supports.
- C. Construction: 1 mm (0.04 inch) thick, galvanized steel, gray enameled (ANSI-61 gray). Sizes are to be selected to comply with the NEC and provide at least 25% space for future wiring.
- D. Laterals are to be supplied with 16 A 230 V grounding receptacles spaced to correspond with equipment layout and wired to correspond with control requirements shown on the Drawings.

2.14 OUTLET BOXES, GENERAL

- A. Surface or recessed boxes are to be suitable for type of related conduit or cable system. Shapes and sizes of boxes are to be of compatible standards as switches and socket outlets specified under Division 26 Section "Wiring Devices", and lighting fixtures selected and of various types and mounting methods required.
- B. Unused openings in outlet boxes are to be closed with knock-out closers manufactured for the purpose.
- C. Floor outlets and plates are to be water-tight and high impact resistant.

2.15 METALLIC OUTLET BOXES

- A. Recessed and Concealed Boxes: Galvanized pressed steel, with knock-outs for easy field installation. Special boxes are to be punched as required on Site.
- B. Exposed Surface Mounted Boxes: Galvanized cast iron with threaded hubs.
- C. Outdoor Surface or Recessed Boxes: Galvanized cast iron with threaded hubs and PVC gaskets to ensure water tightness and with stainless steel or non-ferrous, corrosion resistant screws.
- D. Floor Boxes - Type A: Watertight, cast iron or cast metal alloy with corrosion resistant finish, adjustable mounting, standard duty, round or square, factory drilled and tapped for required conduit sizes, and with brass cover and flange with brushed finish free from markings other than required for mounting screws.
- E. Floor Boxes - Type B: Non-standard size, flush floor mounted, cast metal alloy, with watertight neoprene gasketed and hinged cover, and with drilled and tapped conduit entries and adjustable mounting. Metal barriers are to separate services for power and low current.
- F. Flame-Proof Boxes: Malleable iron or cast iron, with gas threaded hubs, special covers with silicon rubber gaskets, gas tight, and water-tight. Boxes are to comply with the Regulations for explosive areas.

2.16 MOULDED PLASTIC OUTLET BOXES

- A. Type: Boxes and covers used with PVC conduit systems are to be heavy gauge pressure moulded plastic, minimum 2 mm thick, self-extinguishing, with softening point not less than 85 deg. C. Boxes are to have provision for securely terminating conduits and are to be manufacturer's standard for required application.
- B. Fittings: Boxes are to have brass inset threads to receive cover screws and for mounting devices or accessories, push-fit brass earth terminals, and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets are to be provided for weatherproof installations.

2.17 TERMINAL COLORING AND LABELING

- A. Phase identification shall be marked in an approved manner on cable boxes, tail ends and single core cables and at all connecting points. Cable boxes shall be marked with stamped brass labels indicating the purpose of the supply where such supply is not obvious.

2.14 TERMINAL BOXES

- A. The outer case of terminal boxes shall be constructed of steel sheet or weather resistant reinforced plastic subject to approval and fitted with one or more hinged covers provided with fasteners and padlocking facilities. The boxes shall be of IP56 for outdoor installations and IP51 for indoor installations.
- B. The case shall be adequately ventilated also dust and vermin proof. Removable gland plates shall be provided at the top and bottom. They shall be supplied complete with suitable insulating material capable of withstanding the climatic conditions and test

voltages specified herein where the glands are required to be insulated from the terminal boxes. If the width of the box necessitates the provision of 2 hinged front covers they shall close on to a centre post which shall be removable to facilitate cable termination. The depth of the outer case shall be not less than 200 mm unless otherwise approved.

- C. The outer cases shall be treated before painting to prevent corrosion and shall be finished in glossy enamel to an approved colour externally and white internally. Where terminal boxes are required for installation outdoors or in damp situations, they shall be of water tight construction and galvanized.
- D. Terminal boards shall comprise banks of rail mounted, screw clamp, spring loaded insertion, solder lug or stud type terminals as required to suit the design and duty of the cables to be terminated, arranged in pairs horizontally and grouped in vertical formation to provide a rigid assembly. Each pair of terminals shall be connected together at the base with a fixed or plug type link as specified. Insulating material of self-extinguishing or resistant to flame propagation and substantially non-hygroscopic type shall be molded around the base of the screws or studs, links connecting pairs of screws or studs or plug sockets to prevent exposure of live metal at the back of the terminal boards and to secure the terminals against rotation and displacement.
- E. Stud type terminal boards shall have screws or studs of 5 mm dia. for phosphor bronze or stainless steel, and 6 mm dia. for high tensile brass, unless otherwise approved. They shall be complete with the appropriate clamps, springs, nuts, locknuts and washers.
- F. Terminal boards shall be complete with approved means for securing the wires, identification ferrules, insulating barriers between pairs of terminals and removable transparent non-inflammable terminal covers fitted with marker strips for identifying the terminals. All nuts, washers, links and other components provided for securing the wires shall be electro-tinned. Springs shall be aged and shall withstand corrosion.
- G. The clearance between adjacent terminal boards and from the sides of the case shall not be less than 100 mm. The minimum clearance between terminal boards and the top and bottom of the case shall be 150 mm.
- H. All terminal boxes and boards shall meet the associated cable site tests.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 CONDUIT, WIREWAYS, AND BOXES, GENERAL

- A. Use: Unless otherwise specifically indicated all light and power circuits, communications, signal and low current systems wiring are to be drawn inside

conduits or wireways up to the various electric power consuming equipment as shown on the Drawings.

- B. Separate conduits and wireway installations are to be used for medium voltage cables, low voltage feeders and sub-feeders, normal light and power circuits, emergency light and power circuits and communication, signal and other low current systems wiring. Cables of different voltages are not to be mixed within the same conduit or wireway as per the regulations.
- C. Boxes: Junction, pull, and splice boxes of ample capacity are to be provided as indicated or required. Boxes are to remain permanently accessible.
- D. Exposed Outlet Boxes: Securely fasten to wall with machine screws to permanent inserts or lead anchors.
- E. Recessed Outlet Boxes: Make neat openings, to the satisfaction of Engineer, allowing for thickness of finishings, and use extension rings if required. Repair damaged finishings to original condition before installation of fittings or plates.
- F. Boxes Mounting Heights and Location: As specified under Division 26 Section "Wiring Devices".
- G. Tools and accessories for forming and installing conduit and wireway systems are to be purpose made for the particular application and used in accordance with manufacturers' instructions.
- H. Fixing: Conduits and wireway installations are to be concealed as much as possible.
- I. Sizes of conduits and wireways, not shown on the Drawings, are to be selected in accordance with the Regulations and in relation to the number and size of conductors and the space factor as recommended by the regulations. Minimum size of conduit for all applications is to be 20 mm diameter, unless otherwise shown on the Drawings.
- J. Mechanical Continuity: Conduits and wireways are to be effectively joined together and connected to electrical boxes, fittings and cabinets to provide firm mechanical assembly. Earthing jumpers are to be installed on steel conduits where required to ensure effective electrical continuity irrespective of whether a separate protective earth conductor is required or not.
- K. Metal conduits and enclosures are to be mechanically fastened, and to be connected to electrical boxes, fittings and cabinets to form low electrical resistance continuity and firm mechanical assembly.
- L. Dissimilar Metals: Use of dissimilar metals is to be avoided throughout the system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, treat surfaces with corrosion inhibiting compound before assembling.
- M. Miscellaneous fittings such as reduces, chase nipples, 3 – piece unions, split couplings and plugs that have been specifically designed and manufactured for their particular application are to be installed as necessary.
- N. Conduits are to be tested with a mandrel. Conduits that reject a mandrel are to be replaced. Restore conduit and surrounding surfaces to original condition.

3.3 CONDUITS AND WIREWAYS APPLICATIONS AND INSTALLATION, GENERAL

- A. Conduits and wireways installations are to be as described below, unless otherwise shown on the drawings or described in the particular section of the Specification.
- B. 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, and service areas. Use rigid steel conduit in areas classified as hazardous explosive area. Flexible conduit is not acceptable.
- C. Light gauge steel conduit (EMT) is to be used for exposed installations over false ceilings when the false ceiling is used as a return plenum.
- D. Light gauge steel conduit (EMT) is to be used for exposed and above false ceiling wiring installations used in conjunction with exit and escape route lighting, fire and life safety and security systems.
- E. Conduit termination in sheet metal enclosures is to be fastened by lockouts, and terminate with bushing. Install locknuts inside and outside enclosure.
- F. 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.
- G. 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.
- H. 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.
- I. 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.
- J. Liquid-tight flexible steel galvanized conduit is to be used in one or more of the following conditions:
 - 1. Exterior location.
 - 2. Moist or humid atmospheres where condensate can be expected to accumulate.
 - 3. Corrosive atmosphere.
 - 4. Subjected to water spray or dripping oil, water or grease.
- K. Exposure to Damage: Conduit considered to be subject to undue risk of damage by shock or corrosion is to be brought to the attention of the Engineer. Copper silicone alloy tubes may be used in corrosive atmospheres.
- L. Crossing: Conduits are not to cross pipe shafts, vents or openings.

- M. Clearances: Install conduits at least, 150 mm clear of and preferably above pipes of other non- electrical services. (Hot water pipes, etc.). Wherever possible, install horizontal conduit and wireways runs above water and steam piping.
- N. Sleeves: Obtain approval for positioning sleeves where conduits pass through reinforces concrete. Additional opening may be allowed in finished slabs, but are to be drilled. Fix sleeves rigidly to maintain position and alignment during construction work.
- O. Waterproof Construction: Conduits are not to cross waterproof construction unless permitted by Engineer. Specially designed and approved fittings are to be used.
- P. Expansion Fittings: Provide in each conduit and wireways run every 30 meters, or wherever structural expansion joints are crossed.
- Q. Make good all holes for conduits passing through walls, floors and ceilings with cement or similar fire-resisting material to full thickness.
- R. Bends: Conduit runs between outlet and outlet, fitting and fitting or outlet and fitting are not to contain more than the equivalent of 2 quarter bends (180 degree total).
- S. Bending is to be made without damaging conduit or tubing and without reducing internal diameter. Methods of field bending are to be approved.
- T. Cut ends are to be reamed to remove burrs and sharp edges.
- U. Conduits entering cold stores are to be made vapour tight, so that vapour from outside cannot enter conduit.
- V. Draining: Arrange conduits so that condensed moisture can drain to screwed plug at lowest point.
- W. Before wiring, conduits are to be swabbed through. Do not draw cables into any section of system until conduit and draw boxes are fixed in position, and the raceway installation is completed.
- X. Capping: Conduits are to be properly capped until wiring conductors are drawn in.
- Y. Conduit and fittings installed outdoors are to be watertight and highly resistant to corrosion. Use appropriate fittings, threaded and hubbed boxes, gaskets with screw on covers and the like.
- Z. Terminations: Do not terminate or fasten rigid conduits to motor frame or base.
- AA. Length and radius of flexible conduit used for motors and vibrating equipment are to permit bending of feeder cables without damage to conductor or insulation.
- BB. Flexible conduit for slide rail mounted motor is to have sufficient slack to allow for movement of motor over entire slide rail length.
- CC. Pulling Wire: Install 3 mm galvanized stranded steel wire or equivalent strength cord with wooden blocks fastened at ends, in empty service conduits (power, low current and signal).
- DD. Standard elbows are to be used for conduit sizes over 40 mm. For smaller sizes, field bends may be used provided no damage occurs to conduit.

- EE. Tags: Fit to conduits entering or leaving floors, walls or ceilings for identification of conduit and circuits. Tags are also to be placed at suitable intervals throughout the system.
- FF. Non – ferrous conduit is to be installed for circuits operating above 60 Hz.

3.4 STEEL CONDUITS

- A. Termination: Conduit entering sheet metal enclosure or outlet boxes, when not terminated in a threaded hub, is to be securely held in place by two lock-nuts, placed inside and outside enclosure, and terminated with an insulating bushing.
- B. Running Threads: Do not use running threads at joints and terminations, but use 3-piece unions or split couplings.
- C. Additional threaded cuts on galvanized steel conduits are to be painted with zinc based coating resistant to corrosion.
- D. Damage to protective coating of conduits is to be repaired to original degree of protection.
- E. Outdoor Mounted Steel Conduit: Apply anti-corrosion coating of zinc-chromate based paint and two weather resistant finish coats of enamel, of approved colour, or other equal and approved coating.
- F. Galvanized conduit run in screed is to be painted with heavy coat of emulsified bitumen.
- G. Galvanized steel conduits buried in ground or placed in wet or damp locations are to be coated with two heavy coats of hot bitumen. Conduits are to be covered by at least 600 mm of earth if buried in planting soil and by 300 mm if under walkway.
- H. Plugs: Use hardwood or threaded iron plugs for blanking ends of steel conduit not used.

3.5 PVC CONDUITS

- A. Coupling of conduit and/or termination into spouted fittings are to be made watertight and permanent using special cement.
- B. Termination: Connect conduits terminating in switchgear, fuseboards, trunking, adaptable boxes or other non-spouted enclosures etc. with smooth bore male PVC bushes and sockets.
- C. Ends of conduit and conduit fittings are to be cleaned and jointed using PVC cement recommended by manufacturer.
- D. Semi-Permanent Adhesive: Use in joints requiring expansion couplers.
- E. Bends: Conduits not exceeding 25 mm diameter may be cold bent using bending springs. Conduits over 25 mm are to be hot bent by an approved method.

3.6 EMBEDDED CONDUITS

- A. Conduits in Concrete Slabs: Place conduits parallel or at right angles to main reinforcing steel, between bottom reinforcing and top reinforcing steel. Fasten conduits to reinforcing steel by positive wire, fasteners at the proper distance from the concrete face. Embedded conduit diameter is not to exceed 1/3 of slab thickness. Special cases shall be referred to Engineer.
- B. Conduits in Partitions or Side Walls: Horizontal or cross runs are to be avoided.
- C. Pull-boxes are not to be used. If unavoidable, pull-boxes may be approved if located inconspicuously.
- D. Conduits in floor of beds on grade: Encase in concrete, minimum thickness 50 mm or to thickness allowed by architectural detail.
- E. PVC conduits in reinforced concrete structures are generally to be installed after placing reinforcement and before concreting, if protected against damage, or are to be placed in grooves formed in the concrete, if approved.

3.7 EXPOSED CONDUITS

- A. Conduits on walls are to be run neatly, horizontally or vertically.
- B. Supports: Use approved clamps, hangers or clips fastened by machine screws to expansion sleeves in inserts or to lead anchors.
- C. Spacing of clamps or clips for supporting steel conduits is not to be greater than:

	<u>Conduit Size</u> <u>mm</u>	<u>Maximum Spacing of Supports</u> <u>meters</u>
1.	20	3.00
2.	25	3.60
3.	32-38	4.25
4.	50-63	5.00
5.	75 and larger	6.00

- D. Spacing of clamps or clips for supporting PVC conduits is not to be greater than:

	<u>Conduit Size</u> <u>mm</u>	<u>Maximum Spacing of Supports</u> <u>metres</u>	
		<u>Conductors Rated</u> <u>60 deg.C and below</u>	<u>Conductors Rated</u> <u>more than 60 deg.C</u>
1.	20	1.25	0.60
2.	25-50	1.50	0.75
3.	63-75	1.80	0.90
4.	90-125	2.00	1.00
5.	150	2.50	1.25

- E. Bends and Fittings: Firmly fasten conduit at each side of bends and within 900 mm of each outlet box, junction box, cabinet or fitting.

- F. Outlets: Do not run more than the permissible numbers of conduits to any surface wall outlet.
- G. Exposed conduit work is to be installed so as not to interfere with ceiling inserts, lights or ventilation ducts or outlets.

3.8 CABLE TRUNKING

- A. Installation: Secure trunking of all sizes at intervals not exceeding 1200 mm. Joints are not to overhang a fixing by more than 500 mm.
- B. Trunking passing through walls and ceilings is to have the cover fixed solidly for 25 mm either side of walls and for 150 mm either side of floors and ceilings.
- C. Vertical sections of trunking over 900 mm long are to have staggered insulated tie-off studs to support weight of cables.
- D. Cabling Provisions: Separation of power, low current and control circuits is to be by two channel trunking or by barriers inserted in trunking before installation of cables. Cable retaining straps are to be provided at not more than 600 mm centers. Openings in front of trunking are to facilitate drawing-in cables.
- E. Coupling: Trunking parts are to be mechanically and electrically coupled without causing abrasion to wiring.
- F. Earthing: Do not use metal trunking as earth continuity conductor. Provide protective conductor in accordance with Division 26 Section "Grounding and Bonding" of the Specification.

3.9 LABELING

- A. All metal conduits and metal trunking to be labeled with type of service

3.10 UNDERGROUND DUCTS

- A. Lay and assemble ducts in accordance with Division 2 Section "Underground Ducts and Utility Structures".

3.11 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure coatings and finishes are without damage or deterioration at the 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.

3.12 CLEANING

- A. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 26 05 33

SECTION 26 05 36 - CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes cable trays, cable ladders and related installations and accessories necessary to support and protect cables, feeders, sub-feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.
- B. Related Sections include the following:
 - 1. Division 7 Section "Through-Penetration Firestop Systems" for fire stopping materials and installation requirements.
 - 2. Division 26 Section "Basic Electrical Materials and Methods" for cable tray / ladder supports not specified in this Section. 26 Section "Low Voltage Power Conductors and Cables".

1.3 SUBMITTALS

- A. Technical Data: Submit data for approval including, but not limited to, the following:
 - 1. Manufacturers' catalogues with specifications of cable trays / ladders and related accessories.
 - 2. Samples of each type of tray / ladder and complete with its accessories and fittings.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Detail fabrication and installation of cable tray / ladder, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, fittings and earthing connections.
- C. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
 - 2. Vertical and horizontal offsets and transitions.
 - 3. Clearances for access above and to side of cable trays.
 - 4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.
- D. Design Calculations: Verify loading capacities for supports.
- E. Maintenance Data: For cable trays to include in the maintenance manuals.

- F. As-Built (Record) Drawings: At Project close-out, submit Record Drawings of installed cable trays in accordance with requirements of the Specification, Division 1.
- G. QUALITY ASSURANCE
- H. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
- I. Comply with the following standards:
 - 1. IEC 61537 “Cable management - Cable tray systems and cable ladder systems”.
 - 2. BS EN 10346 “Continuously hot-dip coated steel flat products for cold forming. Technical delivery conditions”.
 - 3. BS EN ISO 9227 “Corrosion tests in artificial atmospheres .Salt spray tests”.
 - 4. BS EN ISO 2081 “Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel”.
 - 5. BS EN ISO 1461 “Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods”.
 - 6. IEC 60529 “Degrees of protection provided by enclosures (IP Code)”.
 - 7. IEC 62262 “Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)”.
 - 8. TIA-569-D “Telecommunications Pathways and Spaces”.

1.4 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.
 - 1. Notify Engineer not less than 2 days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Engineer's written permission.

1.5 COORDINATION

- A. Coordinate layout and installation of cable tray / ladder with other installations.
 - 1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- | | | |
|----|-------------------|----------|
| 1. | El Sewedy | (Egypt) |
| 2. | EMECO | (Egypt) |
| 3. | Novo | (Egypt) |
| 4. | Wibe by Schneider | (Sweden) |

2.2 CABLE TRAYS AND LADDERS

- A. Components: To include cable trays or ladders (as shown on the Drawings), bends, elbows, tees, couplings and plates, rubber grommets, hangers, bracket supports and other system accessories required for safety and protection of the cable installations.
- B. SAFETY FACTOR
1. Cable Tray at 2.5 meters Span: Capable of sustaining a working (allowable) load of 68 kg per linear 30 cm with a safety factor of when tested as a simple beam and in accordance with approved load test method; test specimen to be a single section of cable tray.
 2. In addition to and concurrent with the above working load, a 90 kg concentrated load applied at mid span to result in no permanent deformation of the tray.
 3. Design to be such that all like parts are interchangeable and that trays may be readily assembled and joined without the use of special tools.
- C. Trays: Heavy gauge perforated sheet steel, hot-dip galvanized after manufacture, minimum 1.5 mm thick, with sides not less than 45 mm deep, and as shown on drawings. Fittings are to be same material as tray. Covers, where shown on the Drawings, are to be minimum 1.5 mm thick galvanized sheet steel for cable tray equal or lower than 300mm and 2 mm thick galvanized sheet steel for cable tray equal or greater than 450mm, Snap-On, forming a rigid assembly with the tray.
- D. Ladders: to be hot-dip galvanized after manufacture, fabricated from 2mm mild carbon steel. Ladder side channels are to be minimum 127 x 32 mm, strengthened by reinforcing inserts for torsional rigidity. Rungs are to be slotted to take cable cleats or ties and conduit clamps. Rungs are to be minimum 50 x 25 mm channels, spaced at 300 mm centers.
- E. Galvanizing to be in accordance with BS EN ISO 1461 (395 g/m²) applied after fabrication.
- F. Bolts and Screws: Cadmium plated or electrolytically galvanized.
- G. Coating applied to cable tray or cable ladder is to be applied after priming coat.
- H. Sizes: Trays and ladders are to be standard metric sizes, 150, 300, 450, 600 and 900 mm wide, and at least 2.4 m length of section. Size of tray or ladder is to be determined by number and sizes of cables in accordance with the Regulations and / or as shown on the Drawings. Tray or ladder is to have strength and rigidity to provide support for cables contained within. Deflection between supports is not to exceed 1/350 under full loading capacity.
- I. Cable tray width shall be chosen according to the number and diameter of cables laid on the tray. All feeders and sub feeders shall be laid such that their outer radius are spaced a distance equal to the diameter of the largest cable.
- J. All Cable trays installed in mechanical rooms, all plenum rated areas, parking areas, open space and on roof shall be covered with cover.
- K. Earthing connector for plastic coated trays or ladders is to be provided on each coupling between adjacent sections.
- L. Products to be provided with stamped markings by manufacturers.

- M. Cable trays and ladders to be provided with galvanized ventilated sun shade arrangements when installed in outdoor locations. Sun shade and fixings shall be from the same manufacturer of cable tray/ladder.
- N. All components and accessories shall be hot-dip galvanized steel after manufacture to give resistance to corrosion.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cable tray / ladder level and plumb according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.
- B. Each run is to be completed before installation of cables.
- C. Remove burrs and sharp edges from cable trays / ladders. Fix trays / ladders using approved suspension rods or steel angle brackets at spacing not exceeding 1.5 m and generally as shown on the Drawings.
- D. Cables: Secure to tray / ladder with purpose made straps or saddles and arrange in one layer only, evenly spaced, or as shown on the Drawings, with minimum spacing of one diameter of the larger of the two adjacent cables or of a trefoil formation of single core cable circuit.
- E. Fasten cable tray / ladder supports securely to building structure as specified in Division 26 Section "Basic Electrical Materials and Methods," unless otherwise indicated.
 - 1. Design supports, including fastenings to the structure, to carry the greater of the calculated load multiplied by a safety factor of 4. Submit calculations for approval.
- F. Make connections to equipment with flanged fittings fastened to cable tray / ladder and to equipment. Support cable tray / ladder independently of fittings. Do not carry weight of cable tray / ladder on equipment enclosure.
- G. Install expansion connectors where cable tray / ladder crosses a building expansion joint and in cable tray / ladder runs that exceed 27 m. Make changes in direction and elevation using standard fittings.
- H. Make cable tray / ladder connections using standard fittings.
- I. Locate cable tray / ladder above piping, unless accessibility to cable tray / ladder is required or unless otherwise indicated.
- J. At floor openings provide concrete curb, 10 cm wide and 10 cm high, around cable trays and seal with non-combustible material.
- K. Seal penetrations through fire and smoke barriers according to Division 7 Section "Through-Penetration Firestop Systems."
- L. Sleeves for Future Cables: Install capped sleeves for future cables through fire stopping-sealed cable tray / ladder penetrations of fire and smoke barriers.
- M. Workspace: Install cable trays / ladders with sufficient space to permit access for installing cables. Minimum clearance of 250 mm is to be maintained between top of tray / ladder and ceiling, beams and other services and between tray / ladders in multi-tier formation.

- N. Barriers: Where tray / ladders carry conductors of different systems, such as power, communications and data processing, or different insulation levels, such as 600V, 5000V, and 20, 000 V use separate cable tray / ladders. In case of absolute necessity, install insulating barriers to separate the systems after obtaining the Engineer's approval.
- O. Install covers after installation of cable is completed.
- P. Labeling of trays shall be as per IEC codes; size of letters and color of labels, marking and references shall be as per the relevant standard regulations at every change in direction an ID is required and on straight runs at every 12 meters an ID is required.

3.2 CONNECTIONS

- A. Ground cable trays / ladders according to manufacturer's instructions.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.3 WARNING SIGNS

- A. After installation of cable trays / ladders is completed, install warning signs in visible locations on or near cable trays / ladders.

3.4 FIELD QUALITY CONTROL

- A. Grounding: Test cable trays / ladders to ensure electrical continuity of bonding and grounding connections.
- B. Grounding: Do not use metal trays / ladders as earth continuity conductor. Connect trays / ladders by flexible tinned copper straps to nearest bare earthing conductor and at maximum 30-m spacing.
- C. Anchorage: Test pullout resistance for toggle bolts and powder-driven threaded studs for each type and size of anchorage material.
 - 1. Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales, required for reliable testing.
 - 2. Obtain Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener.
- D. Replace malfunctioning units.

3.5 CLEANING

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

3.6 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure cable tray / ladder is without damage or deterioration at the time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray / ladder manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray / ladder manufacturer.

END OF SECTION 26 05 36

SECTION 260539 - UNDERFLOOR RACEWAY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Description of Work: Raceways including wireways and related installations and accessories necessary to support and protect feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.
- B. Related Sections include the following:
 - 1. Division 3 " Concrete " for precast concrete units used as cellular concrete floor raceway.
 - 2. Division "Metal".
 - 3. Division 7 "Thermal and Moisture Protection" .
 - 4. Division 26 Section "Basic Electrical Materials and Methods".
 - 5. Division 26 Section "Wiring Devices" for receptacles installed in service fittings.

1.3 SUBMITTALS

- A. Technical Data: Submit data for approval including, but not limited to, the following:
 - 1. Manufacturers' catalogues with specifications of raceways and related accessories.
 - 2. Samples of each type of raceway and accessory.
 - 3. Samples: Service fittings and flush outlet covers with required finish, for approval.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Exact routing with indication of boxes, accessories and expansion joints, size and type of boxes.
 - 2. Typical assembly details of installation etc.
 - 3. Construction details of pull boxes.
 - 4. Typical installation details including connection enclosure, connection of flexible conduits, and earthing connections.
- C. Coordination Drawings: Include floor plans and sections drawn to scale. Identify components and accessories such as expansion-joint assemblies, straight raceway lengths, inserts, outlets, and fittings. Show underfloor raceway layout, connections between raceway elements, and relationships between components and adjacent structural elements.
- D. Record (As-Built) Documents: Show dimensioned locations of underfloor raceways, junction boxes, and preset and after-set inserts. Include locations, types, and circuiting of service-outlet fittings.

E. Maintenance Data: For underfloor raceways to include in maintenance manuals specified in Division 1.

1. Include detailed manufacturer's written instructions on locating preset inserts and on installing after-set inserts.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain underfloor raceway components through one source from a single manufacturer.
- B. Comply with related BS Standards such as BS EN 10142 or equivalent IEC/VDE.

1.5 COORDINATION

- A. Coordinate layout and installation of underfloor raceway products with structural work, including slab reinforcement, and with floor finish work.
 1. Coordinate height of preset inserts, junction boxes, access units, and raceways with depth of concrete slab and floor fill.
 2. Coordinate thickening of slabs where required for adequate encasement of raceway components.
 3. Coordinate exposed components with floor-covering materials to ensure fittings and trim are suitable for floor-covering material furnished.
 4. Revise locations from those indicated as required to suit field conditions and ensure functioning layout, and as approved by Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal as per project approved Vendor List:
 1. Dietzel GES (Austria)
 2. EGA Tubes (England)
 3. Square D Co. (USA)
 4. Thomas & Betts Corp. (USA)
 5. MK. (UK)
 6. Honeywell, Ackerman (UK)

2.2 UNDERFLOOR TRUNKING

- A. Type: For installation in floor screed, laid on unfinished concrete floor, secured and grouted flush with screed.
- B. Material: 3.3 m lengths of 2 mm thick (14 gauge) galvanized sheet steel, protected by corrosion resistant coating on inside and outside surfaces. Single, double or triple systems, as required, are to be as shown on the Drawings. Dimensions are to be as indicated.
- C. Openings: Ducts are to have 32 mm openings spaced at 600 mm with screw plugs for receiving initial or future installation of outlet boxes. Screw plugs are to be replaced by brass ferrules, inserted and securely fastened by crimping tool, for installation of pedestal type outlet boxes.

- D. Fittings: Ducts are to be supplied with approved standard manufacturer's fittings, couplings, adjustable duct supports, duct to conduit adapters, horizontal 45 and 90 degree bends, vertical 90 degree bends, terminal bushings to cabinets, cross-unders, offsets, plugs, ferrules and complete set of tools for installation and maintenance after installation.
- E. Junction Boxes: Flush, cast iron, or galvanized sheet steel or die-cast metal protected by corrosion resistant coating and suitable for double or triple duct systems, as required, and shown on the Drawings. Openings are to be provided for ducts and conduits. Interior of boxes is to be partitioned for two or three services; completely isolating each duct system and providing straight cross-junctions. Leveling and anchoring of boxes is to be by adjusting screws at four corners. Flush cover plates are to form smooth surface with flooring.
- F. Flush Outlet Boxes: Factory designed, with accessories necessary to accommodate specific outlets shown on the Drawings or cable outlets as required for signal or control services, with cord-grip nipples.
- G. Supports are to be capable of adjustment for height and arranged for maintenance of alignment and spacing of raceways during concreting.
- H. Recessed Service Fittings: Modular fittings that match with preset inserts and include covers/ receptacles, outlets and associated device plates to provide service indicated at each location. Covers are to be flush with floor and have a recess to match floor finish and level with the area. Boxes' covers are to be firmly held in place and non-rocking. Coordinate with architectural designs and materials approved for finishes and for electrical devices. Internally mounted receptacle / outlets are to be as shown on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrate for compliance with requirements for installation tolerances and other conditions affecting performance of underfloor raceways. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install underfloor raceways as indicated on the Drawings, in compliance with the Specification and according to manufacturer's written instructions.
- B. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to building walls.
- C. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Install supports securely at ends and at intervals not to exceed 1500 mm to prevent movement during concrete pour.
- D. Seal raceways, cells, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill. Provide tape or sealing compound at joints as recommended by raceway manufacturer.
- E. Remove burrs, sharp edges, dents, and mechanical defects.
- F. Cap or plug boxes, openings, and open raceway ends.
- G. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Install boxes in place with grout to prevent

movement during construction. Install supports, couplings and locking and grounding devices with screws tightened in accordance with raceway manufacturer's torquing values. Remove burs, which may cause damage to insulation. Place top covers in inverted position to prevent damage to surface of cover.

- H. Install devices and service fittings at points of use indicated.
 - 1. Cut; hole saw, and drill slab and raceways to allow wiring installation.
- I. Install markers at each cell to identify service. Install markers flush at screed line before pouring slab or placing fill. Extend marker with grommited screw when floor covering is placed. Do not extend through carpet. Install markers at inserts adjacent to junction boxes, on both sides of permanent walls, and at end of each raceway run. Use slotted-head screw to identify electrical power and Phillips-head screw to identify telephone.
- J. Installation to be inspected and certified by manufacturer/supplier/authorized representative.
- K. Labeling of raceways shall be as per DCA standards; size of letters and color of labels, marking and references shall be as per the relevant standard regulations.

3.3 CONNECTIONS

- A. Ground underfloor raceways and components.
 - 1. Tighten connectors and terminals according to manufacturer's published torque-tightening values.

3.4 CLEANING

- A. After installation, clean underfloor raceways, including outlet fittings and devices, and inspect exposed finish.

3.5 ADJUSTING

- A. Level raceway components with finished slab and make adjustments for floor finishes.

END OF SECTION 260539

SECTION 260923- LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 SUBMITTALS

- A. Product Data: Include dimensions and data on features, components, and ratings for lighting control devices.
- B. Samples: Occupancy sensors for color selection and evaluation of technical features.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- D. Maintenance Data: For lighting control devices to include in maintenance manuals .

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain lighting control devices from a single source with total responsibility for compatibility of lighting control system components specified in this Section,

1.5 COORDINATION

- A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:
 - 1. Division 26 Section "Panelboards"
 - 2. Division 26 Section "Lighting Control System"

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Contactors and Relays:
 - a. Automatic Switch Co.
 - b. Challenger Electrical Equipment Corp.
 - c. Cutler-Hammer Products; Eaton Corporation.
 - d. Furnas Electric Co.
 - e. GE Lighting Controls.
 - f. Hubbell Lighting, Inc.
 - g. Siemens Energy and Automation, Inc.
 - h. Square D Co.; Power Management Organization.
 - i. Zenith Controls, Inc.
2. Time Switches:
 - a. Diversified Electronics, Inc.
 - b. Grasslin Controls Corp.
 - c. Intermatic, Inc.
 - d. Leviton Manufacturing.
 - e. Paragon Electric Co., Inc.
 - f. Tork, Inc.
 - g. Zenith Controls, Inc.
3. Photoelectric Relays:
 - a. Allen-Bradley/Rockwell Automation.
 - b. Area Lighting Research, Inc.
 - c. Fisher Pierce.
 - d. Grasslin Controls, Corp.
 - e. Intermatic, Inc.
 - f. Paragon Electric Co., Inc.
 - g. Rhodes: M H Rhodes, Inc.
 - h. SSAC, Inc.
 - i. Tork, Inc.
4. Occupancy motion Sensors:
 - a. Arrow Hart Wiring Devices.
 - b. BRK Electronics.
 - c. Bryant Electric.
 - d. Honeywell, Inc.; Home and Building Controls.
 - e. Hubbell Lighting, Inc.
 - f. Lightolier.
 - g. Lithonia Control Systems.
 - h. MyTech Corporation.
 - i. Novitas, Inc.
 - j. RAB Electric Manufacturing Co., Inc.

- k. SenTec, Inc.
- l. Sterner Lighting Systems, Inc.
- m. Tork, Inc.
- n. Touchplate.
- o. Unenco Electronics (A Hubbell Co.).
- p. Legrand.

2.2 Watt Stopper, Inc. (The).GENERAL LIGHTING CONTROL DEVICE REQUIREMENTS

- A. Line-Voltage Surge Protection: Include in all line voltage solid-state equipment.

2.3 TIME SWITCHES

- A. Description: Solid-state programmable units with alphanumeric display.
- B. Description: Electromechanical-dial type.
 - 1. Astronomic dial.
 - 2. Two contacts, rated 30-A unless otherwise indicated.
 - 3. Two pilot-duty contacts, rated 2-A unless otherwise indicated.
 - 4. Eight-day program uniquely programmable for each weekday and holidays.
 - 5. Skip-day mode.

2.4 PHOTOELECTRIC RELAYS

- A. Description: Solid state, with single-pole, double-throw dry contacts rated to operate connected relay or contactor coils or microprocessor input.
- B. Light-Level Monitoring Range: 1.5 to 10 fc [16.14 to 108 lx], with an adjustment for turn-on/turn-off levels.
- C. Time Delay: Prevents false operation.
- D. Indoor Ceiling- or Wall-Mounting Units: Adjustable for turn-on/turn-off levels, semiflush, calibrated to detect adequacy of daylighting in perimeter locations, and arranged to turn artificial illumination on and off to suit varying intensities of available daylighting.
- E. Indoor Skylight Units: Housed in a threaded plastic fitting for mounting under skylight.
- F. Outdoor Sealed Units: Weathertight housing, resistant to high temperatures and equipped with sun-glare shield and ice preventer.

2.5 OCCUPANCY MOTION SENSORS

- A. Ceiling-Mounting Units: Unit receives control power from a separately mounted auxiliary power and control unit, and operates power-switching contacts in that unit.

- B. Ceiling-Mounting Units: Unit receives power from a remote source and, on sensing occupancy, closes contacts that provide signal input to a remote lighting control system.
- C. Switch-Box-Mounting Units: Unit receives power directly from switch leg of the live ac circuit it controls and operates integral power switching contacts rated 1000 W at ac, minimum.
- D. Operation: Turns lights on when room or covered area is occupied and off when unoccupied, unless otherwise indicated.
 - 1. Time Delay for Turning Lights Off: Adjustable over a range from 1 to 15 minutes, minimum.
 - 2. Manual Override Switch: Turns lights off manually regardless of elapsed time delay.
 - 3. Ambient-Light-Level Control: Adjustable for setting a level of ambient illumination above which sensor will not turn lights on when occupancy is sensed.
 - 4. Isolated Relay Contact: Operates on detection of occupancy or vacancy, as indicated, to activate an independent function.
- E. Auxiliary Power and Control Units: As follows:
 - 1. Relays rated for a minimum of 20-A normal ballast load or 13-A tungsten filament or high-inrush ballast load.
 - 2. Sensor Power Supply: Rated to supply the number of connected sensors.
- F. Passive-Infrared Type: Detects occupancy by a combination of heat and movement in zone of coverage. Each sensor detects occupancy anywhere in an area of 93 sq. m by detecting occurrence of 150-mm minimum movement of any portion of a human body that presents a minimum target of 232 sq. cm to the sensor.
- G. Ultrasonic Type: Emits a beam of ultrasonic energy and detects occupancy through use of Doppler's principle in discerning movement in zone of coverage by sensing a change in pattern of reflected ultrasonic energy.
- H. Dual-Technology Type: Uses a combination of passive-infrared and ultrasonic detection methods to distinguish between occupied and unoccupied conditions for area covered. Particular technology or combination of technologies that controls each function (on or off) is selectable in the field by operating controls on unit.

2.6 MULTIPOLE CONTACTORS AND RELAYS

- A. Description: Electrically operated and mechanically held.
 - 1. Current Rating for Switching: Consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballasts with 15 percent or less total harmonic distortion of normal load current).
 - 2. Control Coil Voltage: Match control power source.

B. Contactor Control Panels In Connection With BMS

1. General: Control panels are to be of equivalent construction to panel boards with respect to cabinet and interior standards of manufacture, and are to be surface mounted with see-through door and lock.
2. Construction: Non-standard modular, factory assembled cabinets, designed to receive appropriate contactors, measuring devices, terminals, relays and the like as required in conformity with the Drawings for operation of system locally and remotely from Building Management System (BMS) console.
3. Control: Switching relays controlled remotely by the BMS are to be provided with over-riding manual local individual controls. Appropriate interface components are to be provided and coordinated with the BMS described elsewhere in the Specification.
4. Relays, switching components, pilot lights, control transformers, fuses etc. are to be neatly arranged and mounted inside dust-tight and, where necessary, watertight cabinets. Control and indication devices are to be continuously visible and accessible for monitoring and control.
5. Equipment is to be electrically front shielded and enclosed by sheet metal barriers, readily accessible and demountable. Wiring is to be neatly arranged, clipped and terminated in pressure type terminals. Hardware is to be non-corroding and robust material, approved by the Engineer.
6. Control panels are to incorporate 3 ammeters, 1 per phase for local readings.
7. Current transformers are to have auxiliaries to enable connection to BMS.
8. Contactors are to be class AC-2 and AC-3 to IEC 60947-4-1. Each contactor is to be protected by an equally rated or circuit breaker of suitable short-circuit capacity at point of application.
9. Overcurrent relay is to be provided with all other accessories. Upon detecting fault on monitored control panel, corresponding plug-in breaker unit is to trip, and fault signal is to be sent to BMS.
10. Instrument and instrument transformers are to be provided as required and/or as indicated on the Drawings.
11. Current Transformers: Bar primary type to IEC 60044-1 class 0.5 for metering. Current rating is to be the next higher standard value above maximum demand load current.
12. Ammeters and Voltmeters: Long scale, switchboard type, with shadow proof covers for semi-flush mounting. Meters are to be approximately 100 mm square with scale covering approximately 250 degrees.
13. Voltmeter Selector Switches: Rotary type with cam operated contacts, and having 7 positions (off, R-Y, Y-B, B-R, R-N, Y-N, B-N).
14. Test blocks and plugs are to be provided for testing all instruments and instrument transformers.

15. All wiring to use heat resistant insulation and having all wire ends crimped with lugs and identification ferrules.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install equipment level and plumb and according to manufacturer's written instructions.
- B. Mount lighting control devices according to manufacturer's written instructions and requirements in Division 26 Section "Basic Electrical Materials and Methods."
- C. Mounting heights indicated are to bottom of unit for suspended devices and to center of unit for wall-mounting devices.

3.2 CONTROL WIRING INSTALLATION

- A. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in Division 26 Section "Conductors and Cables" for low-voltage connections and Division 26 Section "Voice and Data Systems" for digital circuits.
- B. Wiring Method: Install all wiring in raceway as specified in Division 26 Section "Raceways and Boxes."
- C. Wiring Method: Install all wiring in raceway as specified in Division 26 Section "Raceways and Boxes," unless run in accessible ceiling space and gypsum board partitions.
- D. Bundle, train, and support wiring in enclosures.
- E. Ground equipment.
- F. Connections: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.3 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Basic Electrical Materials and Methods."

3.4 FIELD QUALITY CONTROL

- A. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
- B. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.

- C. Verify settings of photoelectric devices with photometer calibrated within previous six months.
 - D. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:
 - 1. Continuity tests of circuits.
 - 2. Operational Tests: Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
 - a. Include testing of devices under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
 - E. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.
 - F. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.
- 3.5 CLEANING
- A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.
- 3.6 DEMONSTRATION
- A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.
- 3.7 ON-SITE ASSISTANCE
- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested, to adjust light levels, make program changes, and adjust sensors and controls to suit actual conditions.

END OF SECTION 260923

SECTION 26 12 16 - MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes distribution power transformers with medium-voltage primaries.
- B. Related Sections as the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Busways" for busway connections between transformers and secondary distribution equipment.
 - 3. Division 26 Section "Medium-Voltage Cables" for cable terminations at transformers.
 - 4. Connection to BMS system, including interface elements such as relays, transducers, etc. as detailed in Division 23 Specifications, BMS schedules and /or shown on the Drawings.

1.3 SUBMITTALS

- A. Product Data: Include full technical data on features, components, ratings, and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features. Submit Manufacturers' catalogues.
- B. Wiring Diagrams: Detail wiring and identify terminals for tap changing and connecting field-installed wiring.
- C. Product Certificates: Signed by manufacturers of transformers certifying that the products furnished comply with requirements.
- D. Type Test Certificates: Submit to verify compliance of main equipment with the relevant IEC Standards. Type test and special test certificates for transformers in general are to be as per IEC 60076-11 and include measurement of noise level, lightning impulse withstand, partial discharge measurement, temperature rise, short circuit test and enclosure protection to IEC 60529 for all main equipment. Type tests or Special tests will not be required if the Contractor can provide evidence / substantiation, in a form acceptable to the Engineer, which demonstrates that the required tests were successfully conducted on identical units in the previous twelve months.
- E. Routine Tests:
- F. Each transformer unit is to undergo routine tests at the manufacturer's works in accordance with the relevant standards. Submit routine test reports, prior to shipping equipment, indicating ambient test conditions and guaranteed rating of equipment under site conditions. Routine tests for power transformers are to include measurement of winding resistance, voltage ratio, check of polarity/vector group, impedance voltage, load loss, no-load loss, no-load current, induced over voltage withstand test and separate source voltage withstand test. The following routine tests specified in IEC 60076-11 shall be carried out at the

manufacturer's works on each and every transformer shall necessarily including but not be limited to the following:-

- a. Measurement of short-circuit impedance and load loss (routine test).
 - b. Partial discharge measurement as per IEC 60076-11 (routine and special test).
 - c. Routine Tests on Magnetic Circuit.
 - d. Measurement of no-load loss and current.
 - e. Measurement of sound level (special test).
 - f. Short-circuit test (special test).
- G. Acceptance test certificate of each transformer shall necessarily including but not be limited to the following:-
- a. All the routine tests conducted on the transformer and the measurements made.
 - b. Guaranteed values of losses, impedance etc.
 - c. Calculated values of losses, impedance etc. at reference temperature where applicable, based on measurements.
- H. All routine/Acceptance tests to be witnessed by the Employer and Consultant at factory.
- I. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
1. Plans and elevations, with dimensions and weights.
 2. Arrangement of equipment and general layouts.
 3. One-line diagram of power system.
 4. Foundation details, grouting holes and installation details.
- J. Sound-Level Test Reports: Certified copies of manufacturer's sound-level tests applicable to equipment for this Project.
- K. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- L. Maintenance Data: For transformers to include in the maintenance manuals specified in Division 1.
- M. List of commissioning spares and recommended spare parts for the next 5 years.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Engage a firm experienced in manufacturing transformers similar to those indicated for this Project and with a record of successful in-service performance.
- B. Standards: Equipment and component parts are to comply with the following Standards:
1. IEC 62271-1: Common clauses for HV switchgear and control gear standards.
 2. IEC 60076, IEC 60076-11, IEC 60076-12: Power transformers.
 4. IEC 60076-11: Dry type die cast resin.
 5. IEC 60076-8: Application guide for Power Transformers.
 6. IEC 60137: Insulated bushings for alternating voltages above 1 000 V Transformers.
 7. IEC 60529: Degrees of protection provided by enclosures (IP Code).
 8. IEC 61869: Instrument transformers.
 9. BS 2562: Cable Boxes for Transformers and reactors.
 10. BS 6121: Mechanical cable glands.
 11. BS EN 62444 cable glands for electrical installations.

12. Local Egyptian Codes.
 13. Local Power Authorities
- C. All transformers shall be suitable for normal operation at 45 deg.C (113 deg. F) Max ambient temperature and withstand surrounding humidity up to 93%.
- D. All transformers shall have an average sound pressure level lower than 63 dB at 1 meter.

1.5 WARRANTY

- A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period
1. Warranty Period: 1 year from date of substantial completion and the transformer energizing by the electrical distribution company.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: For indoor, dry-type transformers, apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit throughout periods during which equipment is not energized and is not in a space that is continuously under normal control of temperature and humidity.
- B. The transformer shall be covered with suitable transparent polythene sheets fused together with necessary desiccant inside before crating/casting.

1.7 COORDINATION

- A. Coordinate layout and installation of transformers with other construction.
- B. Coordinate size and location of concrete or mounting bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB. (Egypt)
 2. El Sewedy. (Egypt)
 3. Schneider France Transfo/ Trihal/ Tricast (France)
 4. G.E. (U.S.A.)
 5. Siemens (Germany)

2.2 DRY TYPE CAST RESIN POWER TRANSFORMER

- A. Type: 3-phase, indoor type, two winding, solventless cast resin, , with minimum class B insulation on inner LV cores and class B on outer MV cores, rated for continuous operation under worst site ambient conditions at full load, and complying with. IEC 60076-11
1. Core Construction:
 - a. The core shall be constructed from laminations of cold rolled, grain oriented sheet steel which is insulated on both sides. To protect the core against corrosion and improve noise levels the core assembly shall be coated after assembly with resin based paint.
 - b. All parts of the core shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transportation, installation and service.
 - c. The magnetic circuit shall be earthed through a link as specified in clause Internal Earthing.
 - d. The lamination shall be clamped at top and bottom by steel channels, which are interconnected by vertical steel bolts. The bottom steel channels shall be used to support the transformer and the top steel channel shall incorporate lifting lugs.
 - e. Wheels shall be fitted to the cross-channels which shall be bi-directional or steerable.
 - f. The supporting cross-channels shall be insulated from the core- clamping channels by anti-vibration pads.
 - g. The core-clamping and supporting steel work after all forming, drilling and shaping operations shall be thoroughly digressed and rinsed prior to application of a zinc phosphate primer, rinsed again and finally coated with an oven baked epoxy paint.
 2. Coil construction:
 - a. The high voltage winding shall be wound with Aluminum conductor material and encapsulated in epoxy-resin/fiber glass or quartz reinforced. The high voltage windings shall be interconnected by interconnection pieces with similar insulation or by other approved method.
 - b. Tappings shall be arranged at such positions on the MV Winding as will preserve, as far as possible, the electromagnetic balance of the transformer at all voltage ratios, but shall also be positioned with due regard to the impulse voltages which may be impressed on the windings.
 - c. The low voltage windings: The low voltage windings shall be wound with Aluminum conductor material, encapsulated in epoxy-resin and provided with appropriate terminals for direct connection to the cable box.
- B. Insulation and Encapsulation: Humidity resistant, explosion and fire-resistant, self-extinguishing, tropicalized, giving non-toxic gases in the event of fire to be as per IEC 60076-11.
- C. Tapping is to be provided on MV side by means of re-connectable links (off-circuit), giving $\pm 5\%$ [$+2 \times 2.5\%$ $-2 \times 2.5\%$] tapping on transformers.
- D. Rubber sound isolation pads are to be provided between core and coil assemblies, and between base and housing.
- E. Cooling fans, where specified, are to permit 25% increase in rated power.
- F. Mounting and Handling: Transformer base and structure are to have lifting hooks or lugs, towing and lashing eyes or lugs and provision for roller wheels.

- G. Temperature monitoring is to be provided by externally mounted tripping units giving alarm and trip at two stages with about 20 deg. C temperature difference, actuated by three embedded thermistor sensors in LV windings (hot-spot). Additional thermal monitoring/control is to be provided for cooling fan operation.
- H. High temperature alarm monitoring is to have a built-in digital display unit.
- I. Temperature is to be monitored by the BMS System.
- J. Terminals: Arranged as described in the Specification or as shown on the Drawings, and are to be compatible for copper cable termination.
- K. Earthing bolts or copper pads are to be provided on main frame of transformer.
- L. Earthing busbars are to be provided on LV and MV sides of housing.
- M. Housing: Sheet steel construction, IP 21 with provision for roof fans for indoor installation.
 - 1. Openings shall be provided on the enclosure for access to the voltage selection links and tap selection links. These openings shall be provided with sliding or hinged or removable type covers made from the same material as of enclosure. It shall be possible to lock the covers by means of Allen Head Screws or other suitable means. Number of screws shall be a minimum, preferably not more than 2.
 - 2. Each transformer shall be provided with one Allen Head Screw or special tool required to open these access covers.
 - 3. A skid underbase shall be provided for the complete unit (i.e. transformer and enclosure). The skids shall be parallel to the long sides of the enclosure.
- N. Characteristics:
 - 1. Rated (**net without fans**): Refer to Drawings.
 - 2. Frequency: 50 Hz.
 - 3. Rated Voltage:
 - a. MV Side (primary): 22 kV.
 - b. LV Side (secondary): 400 V.
 - 4. Winding Connections: Dy11 neutral insulated and brought out.
 - 5. Impedance Voltage at Rated Current: 6 %.
 - 6. Rated Power Frequency Withstand-Voltage: 50 KV.
 - 7. Lightning Impulse Withstand-Voltage: 125 kV.
 - 8. Resistant to overload variation and overloads : C2
 - 9. Resistant to pollution and to condensation : E2
 - 10. Self-extinguishing when exposed to fire: F1
 - 11. Short-Circuit Apparent Power of the System at Location: 750 MVA.
 - 12. Duration of Short-Circuit-Withstand: 2 seconds.
 - 13. Terminal Connection System:
 - a. MV Side: cable sealing ends, bolted, from above.
 - b. LV Side: cable glands and fittings, bolted, from above.
 - 14. Power capacity in case of forced ventilation increased by 40%.
- O. Accessories are to include the following:
 - 1. Earthing switch, fault-making type, on MV side of housing, interlocked with door, visible from outside the enclosure, with trip contact for tripping MV circuit breaker before closing earthing switch.
 - 2. Fans and fans control for extra rating of transformer.
 - 3. Four re-orientable roller rim wheels and attachment accessories.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Locations and Layout: Exact locations and physical layout of equipment and components may be varied as required to suit manufacturer's design and as approved, provided the required functions and operations are accomplished; follow the identification of the units indicated on Drawings exactly to ease checking and building maintenance procedures.
- B. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
- C. Cable Trenches: Ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.
- D. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.
- E. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.
- F. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for MV, LV and control cables.
- G. Relays: Set in accordance with manufacturer's instructions and the Local Power Authorities requirements.
- H. Earthing: Ensure that earthing installation is as described in Division 26 Section "Grounding and Bonding" of the Specification and/or as shown on the Drawings.

3.2 IDENTIFICATION

- A. Identify transformers and install warning signs according to Division 26 Section "Basic Electrical Materials and Methods."

3.3 CONNECTIONS

- A. Tighten bus joint, connector, and terminal bolts according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.4 FIELD QUALITY CONTROL

- A. Equipment: Inspect equipment upon delivery to site and report any damage to Engineer.
- B. Components: Check component ratings, types, sizes and wiring connections, including current and voltage transformers, fuses, switches, instruments and relays.
- C. Manufacturer's instructions are to be followed under all circumstances. Carry out and record measurement and tests recommended by the manufacturer.

- D. Test Objectives: To ensure transformer is operational within industry and manufacturer's tolerances, is installed according to the Contract Documents, and is suitable for energizing.
- E. Test Labeling: On satisfactory completion of tests for each transformer, attach a dated and signed "Satisfactory Test" label to tested component.
- F. Schedule tests and provide notification at least 7 days in advance of test commencement.
- G. Report: Submit a written report of observations and tests. Report defective materials and installation.
- H. Tests: Include the following minimum inspections and tests according to manufacturer's written instructions.
 - 1. Inspect accessible components for cleanliness, mechanical and electrical integrity, and damage or deterioration. Verify that temporary shipping bracing has been removed. Include internal inspection through access panels and covers for dry-type transformers.
 - 2. Inspect bolted electrical connections for tightness according to manufacturer's published torque values.
 - 3. Insulation Resistance: Perform meg-ohmmeter tests of primary and secondary winding to winding and winding to ground Duration of Each Test: 10 minutes.
 - 4. Temperature Correction: Correct results for test temperature deviation from 20 deg C standard.
 - 5. Turns Ratio: Measure between windings at each tap setting. Measured ratios deviating more than 0.5 percent from calculated or measured ratio for an adjacent coil is not acceptable.
 - 6. Winding Resistance: Measure for windings at nominal tap setting. Measured resistance, deviating more than 1 percent, from that of adjacent windings, is not acceptable.
- I. Test Failures: Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

3.5 GROUNDING

- A. Comply with Division 26 Section "Grounding and Bonding" for materials and installation requirements.

3.6 CLEANING

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

3.7 ADJUSTING

- A. After installing and cleaning, touch up scratches and mars on finish to match original finish.
- B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout normal operating cycle of facility. Record primary and secondary voltages and tap settings and submit with test results.

3.8 DEMONSTRATION

- A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.
- B. Provide both classroom training and hands-on equipment operation covering the following:
 - 1. Safety precautions.
 - 2. Features and construction of project transformers and accessories.
 - 3. Routine inspection, test, and maintenance procedures.
 - 4. Routine cleaning.
 - 5. Features, operation, and maintenance of integral disconnect switches and protective devices.
 - 6. Interpretation of readings of indicating and alarm devices.
 - 7. Fuse selection.
 - 8. Protective-relay setting considerations.
 - 9. Features, operation, and maintenance of separable, insulated, connector system.
 - 10. Tap-changing procedures.
- C. Schedule training with the Employer with at least 7 days' advance notice.

END OF SECTION 26 12 16

SECTION 26 13 00 - MEDIUM-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes medium-voltage switchgear and associated auxiliary equipment.
- B. Description Of Work: medium voltage (MV) switchgear installations comprise the following:
 - 1. Indoor withdrawable-metal enclosed switchgear
 - 2. Ring main unit type switchgear.
 - 3. Control power supply.
 - 4. Equipment supports.
 - 5. Earthing of switchgear.
 - 6. Ancillary work.
 - 7. Connection to BMS system, including interface elements such as relays, transducers, etc. as detailed in Division 23 Specification Sections BMS schedules and /or shown on the Drawings.
- C. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Grounding and Bonding".
 - 3. Division 26 Section "Medium-Voltage Cables" for cable terminations at switchgear.

1.3 SUBMITTALS

- A. Product Data: Submit full technical data of equipment for approval including, but not limited to, the following:
 - 1. Manufacturers' catalogues, detailed description of construction, provisions for extension, compliance with the Standards, dimensions and weights, operating characteristics, operating curves and error curves (VT, CT) for all switchgear, control gear, protective gear, metering gear etc.
 - 2. Details of miscellaneous items including pilot lights, cabling or wiring, incoming and outgoing feeder terminal fittings, supports, labels, interlocks, bracing etc.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Plans and elevations, with indication of switchgear mounted components, dimensions and weights.
 - 2. Arrangement of equipment and general layouts.
 - 3. One-line diagram of power system showing current ratings of switchgear and busbars and types and locations of protective gear (relays, metering instruments, CTs, VTs) etc.
 - 4. Schematic and elementary diagrams of control circuits.

5. Foundation details, grouting holes and installation details.
 6. Physical arrangement of incoming and outgoing feeders, instrument transformers, busbars, connections etc.
 7. Dimensions and weights of control power supply and other auxiliary equipment or components.
- C. Technical Literature: Submit the following for approval prior to equipment manufacture:
1. Schedule of selected circuit breakers, relays and control gear, with complete identification of each component and its characteristics.
 2. Protection coordination scheme, including pick-up settings and time-grading, together with time-current curves and range of adjustments etc. as required to coordinate with upstream and downstream protective devices of the complete system.
- D. Type Test Certificates: Submit to verify compliance of main equipment with the relevant IEC Standards, including the following:
1. Impulse withstand-voltage tests
 2. Power frequency withstand-voltage tests.
 3. Temperature-rise tests.
 4. Short time current tests.
 5. Verification of making and breaking capacity.
 6. Mechanical endurance/operation tests.
 7. Verification of degrees of protection for persons against contact with live and moving parts.
 8. Internal arc tests.
 9. Protection degree test to IEC 60529.
- E. Type Tests for Ring Main Units:
1. Each type and design of ring main equipment shall be subjected to the Type Tests specified in relevant IEC Standards, as applicable to the particular switchgear which shall include but not be limited to the following:
 - a. Dielectric tests
 - b. Measurement of the resistance of the main circuit
 2. Type tests or Special tests will not be required if the Contractor can provide evidence / substantiation, in a form acceptable to the Engineer, which demonstrates that the required tests were successfully conducted on identical units in the previous twelve months.
 - 3.
- F. Routine Tests: Each complete switchgear unit is to undergo routine tests at the manufacturer's works in accordance with the relevant standards. Submit routine test reports, prior to shipping equipment, indicating ambient test conditions and guaranteed rating of equipment under site conditions.
- G. Routine Tests
1. Each unit of SF6 insulated switchgear or ring main equipment shall be subjected to the routine tests specified in relevant IEC Standards which shall include the following, as applicable:
 - a. Power frequency voltage withstand dry tests on the main circuit.
 - b. Voltage withstand test on auxiliary and control circuits.
 - c. Measurement of the resistance of the main circuit.
 - d. Partial discharge measurements.
 - e. Mechanical operation tests.

- f. Gas tightness tests of gas filled compartments.
 - g. Design and visual tests.
2. 2 sets of test report on each unit shall be submitted to the Engineer.

- H. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- I. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- J. Maintenance Data: For switchgear to include in the maintenance manuals.
- K. As-Built (Record) Drawings: At Project close-out, submit Record Drawings of installed electrical substations, in accordance with requirements of the Specification, Division 1.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Engage a firm experienced in manufacturing switchgear similar to those indicated for this Project and with a record of successful in-service performance.
- B. Standards: Equipment and component parts are to comply with the following Standards:
 - 1. Common clauses for HV switchgear and control gear standards: IEC 62271.
 - 2. A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 72.5 kV: IEC 62271-200.
 - 3. HV a.c. circuit breakers: IEC 62271-100.
 - 4. Insulation coordination: IEC 60071.
 - 5. HV a.c. fuse-switch combinations and fuse-circuit-breaker combinations: IEC 62271-105.
 - 6. A.C. disconnectors (isolators) and earthing switches: IEC 62271-102.
 - 7. HV switches.
 - 8. Surge arrestors: IEC 60099-1.
 - 9. Metering and protective current transformers (CTs): IEC 61869-2.
 - 10. Metering and protective voltage transformers (VTs): IEC 61869-3.
 - 11. Relays: IEC 61260.
 - 12. Reading instruments: IEC 60051.
 - 13. Watt-hour meters: IEC 62052-11.
 - 14. Power transformers: IEC 60076, 60076-11, 60076-7.
 - 15. Insulating oil: IEC 60296.
 - 16. Sulfur hexafluoride: IEC 60376.
 - 17. Fuses: IEC 60947.
 - 18. IEC 60060: High voltage test technique.
 - 19. IEC 60085: Thermal evaluation and classification of electrical installation.
 - 20. IEC 60529: Degree of protection provided by enclosures (IP Code).
- C. Test Standards
 - 1. Type and Routine tests shall be carried out in accordance with the requirements of the IEC Publication 62271 as applicable:

1.5 WARRANTY

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

1. Warranty Period: 1 year from date of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store so condensation will not form on or in switchgear.
- C. Apply temporary heat where required to obtain suitable service conditions.
- D. Handle switchgear using factory-installed lifting provisions.

1.7 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 1. Notify Engineer not less than two days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Engineer's written permission.

1.8 COORDINATION

- A. Coordinate layout and installation of switchgear with other construction and room dimensions. Advise the Engineer in case of conflict.
- B. Coordinate size and location of concrete or mounting 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."

1.9 EXTRA MATERIALS

- A. Spare Parts: Provide spare parts, as recommended by the manufacturer, for one year maintenance as expected under local conditions, and to allow for emergency replacement due to accidental breakage or failure. Spare parts are to include, but are not limited to, the following:
 1. Two sets of each type of lamp, fuse, auxiliary switch, trip coil, control switch, selector switch, neon indicator and the like.
- B. Tools and Instruments: Provide tools and instruments required for normal routine inspection, testing, operation and maintenance including levering crank, manual charging handle, manual shutter operator, testing jumpers and HV test bushings, set of rail extensions, digital micro ohm-meter, set of mobile lifting and handling equipment etc. as necessary for the type of switchgear.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Schneider (Egypt)
2. ABB (Egypt)

2.2 GENERAL REQUIREMENTS

- A. Busbars: Air-insulated, high conductivity, electrolytic copper, modular, designed to withstand worst short-circuit conditions without allowing permissible temperature rise at ambient conditions to be exceeded, in accordance with the Standards. Busbar connection from one unit of switchgear to another is to be expansion/contraction compensated, plated and bolted. Busbar supports are to be flame-retardant, track-resistant, glass polyester, porcelain or equally reliable fiberglass reinforced epoxy to approved standards.
- B. Earth Bus: Copper of not less than minimum size required by the Standards, designed to withstand worst earth- fault current of power system without showing any signs of thermal or mechanical damage or degradation. Earth bus is to extend full length of switchgear.
- C. Power Cable Terminations: Fixed bolted type, unless otherwise specified, complete with standard fittings and accessories for connection of incoming and outgoing cables. Cable compartment is to be designed to permit cables to enter enclosure and connect at respective terminals from below, or as shown on the Drawings. Terminations are to include appropriate sealing ends, fittings and accessories for type of cable used, including stress cones or other stress relieving accessories, heat shrinkable sleeving, end boxes or end bushings and fittings of any kind necessary to support and protect specified cable ends.
- D. Potential Indicators: Neon indicators are to be provided at front of each switchgear unit, one per phase, using capacitive potential divider to indicate voltage state on cable terminals.
- E. Interlocks are to be provided on switchgear so that:
1. Circuit breaker cannot be isolated, earthed or put into service position when closed.
 2. Access to cable compartments cannot be made unless earthing switch is closed.
 3. Earthing switch cannot be opened unless cable compartment is closed.
- F. Keys and padlocks are to be provided for manually interlocking two or more units if required. Electrical and mechanical interlocks are to be provided for automatic safe and functional operation of the system as shown on the Drawings/Schedules.
- G. Earthing facilities are to be provided for earthing and/or short-circuiting the feeder at its terminals through built-in, safety-interlocked, quick-make earthing switch, without use of loose attachments.
- H. Metal cases of instruments and control devices are to be connected by bare copper conductors of not less than 2.5mm² cross-section to nearest earth bar.
- I. Ferrules: Cable and wire ends are to be fitted with numbered ferrules of approved type at each termination. Colour coding is to be as required by the Regulations and the applicable Section of the Specification.

- J. Test terminal blocks are to be provided inside insulating covered bases for instruments, instrument transformers, relays etc. in LV compartments.
- K. Components are to be interchangeable when of same rating and function.
- L. Finish: Inner and outer surfaces of steel enclosures and structure are to be cleaned, phosphatized, primed with rust inhibiting primer and finished with two coats of baked enamel, color standard gray (RAL 7033) unless otherwise approved. Finish is to be vermin and fungus proof and suitable for worst climatic conditions on site.
- M. MV Switchgear Ratings:
 - 1. Rated Voltage: **24 kV**.
 - 2. Nominal Service Voltage: **22 kV**.
 - 3. Rated Frequency: **50 Hz**.
 - 4. Rated One Minute Power Frequency Withstand Voltage (rms) to Earth and Between Phases: **50 kV**.
 - 5. Rated Impulse Withstand-Voltage (1.2/50 micro-sec) (peak): **125 kV**.
 - 6. Rated Normal Current of Busbars: **630 A** as shown on the Drawings or specified in article **Error! Reference source not found.** "MV Switchgear Assemblies" hereof.
 - 7. **Rated Short Time Withstand-Current: 25 kA for 1 seconds.**
- N. Auxiliary Power Supply Rating:
 - 1. Rated Supply Voltage of Closing and Opening Devices and Auxiliary Circuits: **110d.c. V**.

2.3 WITHDRAWABLE METAL-ENCLOSED SWITCHGEAR

- A. Type: For installation **indoors** comprising air insulated **single busbar** system, horizontally isolated, withdrawable circuit breakers, floor mounted, free standing, modular design of matching units to form a continuous integral metal-clad switchgear assembly extendable at either end.
- B. Degree of Protection: Switchgear is to have a degree of protection against contact with live parts or contact with movable parts and against external effects of **IP 4X**, in connected position according to IEC 271 and IEC 529, when in the service position.
- C. Construction: Each switchgear unit is to be divided into main switchgear compartment, busbar compartment, cable compartment and LV compartment and is to comprise withdrawable part and stationary part. Compartments are to have bolted, interconnected and earthed metal partitions. Enclosures, structure and partitions are to be galvanized steel.
- D. Withdrawable part is to comprise circuit breaker with operating and control mechanism, isolating contacts and front shield completing the compartment enclosure, all mounted on one metal truck. Isolating contacts are to be self-aligning, pressure type, silver plated copper, fully shrouded, and visible when in disconnected position.
- E. Stationary part is to comprise the various compartments and required fixed components of the unit, with all operating, monitoring, setting and adjusting devices, protective relays, key interlocking and padlocking devices accessible to operator at front panel.
- F. Front panel is to include open and closed indicating lamps, on and off circuit breaker control switch, mimic diagram, pad lockable earthing switch handle with indications of position and direction of rotation, and potential indicators, as a general requirement for all units. Particulars of additional components, relays and indicating instruments are specified under article **Error! Reference source not found.** Switchgear Assemblies hereof or are shown on the Drawings.
- G. Metal safety shutters are to automatically close isolator spouts in fixed compartment when

- G. Metal safety shutters are to automatically close isolator spouts in fixed compartment when withdrawable part is in disconnected position. Shutters are to be double latched for extra safety, pad lockable, painted red and with the word BUSBARS marked in white on front of busbar shutters and painted yellow with the word CABLE marked in white on cable end shutters.
- H. Metal Truck: 4-wheel type, with handle for racking and locking breaker into in-service or disconnected positions. Truck is to be of self-aligning design running on fixed steel rails, continuously earthed.
- I. Interlocks: In addition to those specified in Paragraph "General Requirements" Subparagraph 6 hereof, interlocks are also to be provided to:
 - 1. Discharge the stored energy mechanism of a circuit breaker upon insertion or withdrawal from service position.
 - 2. Prevent disconnecting auxiliary circuits while circuit breaker is in service position.
 - 3. Prevent moving breaker into service position whilst auxiliary circuits are not connected and/or earthing switch closed.
 - 4. Prevent complete withdrawal of circuit breaker whilst auxiliary circuits are connected.
 - 5. Prevent closing of earthing switch when circuit breaker is between disconnected and service position.
- J. Access to LV and auxiliary wiring is to be from front of unit for control, protection, test terminal blocks and associated connections. Multi-pin, disconnectable, lock-in type plug and socket arrangement is to be provided between withdrawable and fixed parts of switchgear.
- K. Anti-Condensation heaters with thermostat, switch and pilot lamp, and of rating recommended by manufacturer are to be provided in each section of switchgear assembly.
- L. Wiring diagram, suitably protected and located inside LV compartment of each unit, is to indicate all data and components related to the particular unit and its external circuitry.
- M. Insulating Mat: Anti-slip, synthetic, insulating, rubber mat, minimum 5 mm thick and 900 mm wide, with heavy canvas lining on lower face, is to be provided for full length in front of switchgear assembly.
- N. Busbar earthing is to be provided by means of manufacturer's pre-designed, truck-mounted transferable unit.
- O. Voltage transformers and auxiliary control power transformers with current limiting fuses are to be provided on withdrawable trucks, unless otherwise specified or shown on the Drawings.

2.4 RING MAIN UNIT TYPE SWITCHGEAR

- A. Type: **Indoor** metal-enclosed type, factory built and dispatched as a complete assembly.
- B. Insulation type: SF6 switching and insulated copper busbars.
- C. Components: Unit is to consist of two metal enclosed network ring main switch-disconnectors and outgoing fuse- switch combination(s), as shown on the Drawings, with cable terminal fittings behind dead-front panels, and front- mounted switchgear operation, control, indication and metering devices.
- D. Degree of Protection: IP 65 to IEC 271 and IEC 529 for MV switchgear and parts and **IP 3X** for enclosure.

- E. Ring Main Switch-Disconnecter: General purpose, 3-pole, load-break, short-circuit make, category B to IEC 271.
- F. Switch-Disconnecter Rating:
 - 1. Rated Normal Current: **630 A**.
 - 2. Rated Short-Circuit (peak) Making Current: **50 kA**.
 - 3. Rated Short Time Current: **25 kA** for **3 sec**.
 - 4. Rated Transformer Off-Load Breaking Current: Same as rated short time in previous subparagraph.
- G. Switch-disconnector operation is to be by removable handles at front of unit. Switching mechanisms are to be manual, spring charged, quick-make, quick-break, with speed of make and break switching independent of operator. Main switch and earth switch operations are to be separated and safety interlocked with the manual handle inserted in separate access holes to give on/off operation of main switch and earth on/earth off operation of earthing switch. Handle design is to ensure delay between closing and re- opening of main switch or earthing switch, to prevent re- opening of switch immediately. It is to be impossible to move earth switch into or from one position to another inadvertently and only when main switch is in open position. Indication of switch position is to be mechanical, directly connected to moving contacts. Each switch is to have padlocking device in the closed, open and earth positions.
- H. Fuse-Switch Combination: 3-pole, trip-free, of similar construction to switch-disconnector and consisting of load break, short-circuit make fuse-switch combination. Fuse is to be separately located in fuse chamber with interlocked earthing switches providing upstream and downstream earthing of the fuse assembly before allowing access to fuse live terminals. Automatic trip switching is to be by fuse striker pins which actuate common trip-bar in switch mechanism. Once operated, striker pins remain in ejected position, preventing re-closure of switch until fuse has been replaced. Single phasing is not to be possible. Fuses are to be totally enclosed, current limiting, cartridge type, with striker pins withdrawable from front of unit.
- I. Fuse-Switch Rating:
 - 1. Rated Normal Current: 630 A.
 - 2. Rated Prospective Short-Circuit: **25 kA**.
 - 3. (Peak) Making Current: **50 kA**.
- J. Accessories are to include the following:
 - 1. 2 N.O. and 2 N.C. auxiliary contacts on each switch.
 - 2. Shunt trip release on fuse-switch combination.
 - 3. Automatic reset earth fault indicator operated by core-balance type CT located near and outside cable terminals and visible from front.
 - 4. Insulating rubber gloves, earthing equipment, fuse tongs, schematic diagram with equivalent ratings and references, operating handle etc. placed inside compartment.

2.5 MV CIRCUIT BREAKERS

- A. Type: SF6 circuit breaker using rotating arc or puffer principle, with closed gas circuit, and with pressure detector to prevent operation of circuit breaker in case of loss of gas pressure within the sealed enclosure. Sealed enclosure is to be stainless steel.
- B. SF6 breakers, to be provided with gas filling valve and with pressure switches, one per pole, to initiate alarm in case the pressure of the SF6 gas drops below manufacturer set values.

- C. Particulars: In addition to the ratings specified in paragraph 2.2M "MV Switchgear Ratings" of Article 2.2 "General Requirements" hereof, circuit breakers are to have the following ratings:
1. Rated Normal Current: As shown on Drawings or as specified in Paragraph "MV Switchgear Assemblies" hereof.
 2. Rated Short-Circuit Breaking Current at Nominal Service Voltage and Percentage D.C. Component in Accordance with IEC 271: 25 kA.
 3. Rated Short-Circuit Making Current (peak): 50 kA.
 4. Rated Duty Operating Sequence: **0.03 sec - CO - 3 min - CO**.
 5. Rated Transient Recovery Voltage (TRV) for Terminal Faults (peak): 125 kV.
 6. Rated (single) Capacitor Breaking Current: To be stated by manufacturer (600 A minimum).
- D. Operating Mechanism: Mechanically and electrically trip- free, stored energy, spring loaded, manually charged by lever or hand-crank, electrically charged by suitably rated universal motor, and capable of one complete off-on-off cycle in case of loss of control power. Circuit breaker is to have electrical close solenoid and two trip coils, mechanical on and off push buttons, mechanical on/off/charged indicators, operation counter and auxiliary switches to satisfy all functions specified or shown on the Drawings. Five N.C. and five N.O. spare auxiliary switches for future use are to be provided in addition to those required. Insertion of manual spring charging lever or hand- crank is to automatically disconnect the motor. Slow closing of circuit breaker contacts for inspection and adjustment is to be possible whilst in the disconnected position.
- E. Automatic tripping is to be by indirect auxiliary power through CT operated protective relays.
- F. Interchangeability: Circuit breakers of different current ratings are not to be interchangeable. Circuit breakers of same current rating are to be wired alike and interchangeable.

2.6 PROTECTIVE RELAYS, DEVICES AND AUXILIARIES

- A. Protective Relays: Solid state, static, sealed type, having high immunity to electric field, with modular design, suitable for operation at 55 deg. C ambient temperature, mounted in dust-tight steel enclosures with cover, with self supervision system test buttons for testing without removing from case, and built in self regulated power supply unit and installed where shown on the Drawings. Adjustments and settings are to be accessible and visible from front of relay.
- B. Solid State Relay: Provide with D.C. power from the switchgear power supply, and to be provided with a pilot LED which is to be lit under healthy operating conditions. Relay is to be provided with a self supervision system which upon power supply interruption or a fault condition is to switch off the LED and to initiate an alarm. The rated current and voltage for current & voltage sensing relays are to match that of the corresponding current and voltage transformers of the switchgear respectively. The continuous output rating of the output contacts is not to be less than 10A.
- C. Interference and test voltages of the solid state relays are to be as follows:
1. Insulation test voltage, terminal groups between themselves and the relay frame work as per IEC 255-5: 2 kV, 50 Hz, 1 min.
 2. Impulse test voltage, terminal groups between themselves and the relay frame work as per IEC 255-4: 5 kV, 1.2/50 micro sec.
 3. High frequency test voltage, terminal groups between themselves and the relay framework as per IEC 255-6: 2.5 kV, 1MHZ.
 4. Spark interference test voltage, terminal groups between themselves and the relay framework as per SS346 15 03 class 3: 4-8 kV.

- D. Over Current Relay: 3 phase, non-directional, solid state type with two setting stages as follows:
1. Low setting stage for overload protection with current setting range of 50 % to 250 % of rated current and adjustable definite time and inverse time operation modes as per IEC 255-4.
 2. High setting stage (instantaneous) for short circuit protection with current setting range up to 4000% of rated current.
- E. Earth fault relay, non-directional, solid state type with two setting stages as follows:
1. Low setting stage of 10 % to 80 % of rated current and adjustable definite time and inverse time operation modes as per IEC 255-4.
 2. High setting stage (instantaneous) with current setting range up to 1000% of rated current.
- F. Restricted earth fault relay, on secondaries of distribution transformers and generators having a solidly grounded neutral and rated over 500 kVA, is to be high impedance, instantaneous differential type, current calibrated from 1% - 20% of phase current.
- G. Under-Voltage and Over Voltage Relays: Single phase, solid state definite time type with the following setting ranges:
1. Under Voltage Relay: 6 % to 9 % of rated voltage and 0.2 to 6 sec time delay.
 2. Over Voltage Relay: 80 % to 9 130 % of rated voltage and 0.2 to 6 sec time delay.
- H. Under-Voltage and Phase-Sequence Relays: Under-voltage relay is to be time-delay type, with selectable time/voltage characteristics 0.1 - 1.0 seconds for settings between 60% and 90% of normal voltage, sensed at VT secondaries. Combined under-voltage and phase-sequence relays are to be provided where specified or shown on the Drawings. Phase-sequence relay is to prevent operation (closing) of respective circuit breaker in case of non-conformance of phase rotation.
- I. Auxiliary Relay: Suitably rated with sufficient number of N.O. and N.C. contacts for operation in conjunction with protective relays or control/interlocking requirements. Relay is to have two N.O. and two N.C. spare contacts.
- J. Surge Arresters: Gap-less, metal oxide, heavy duty type, **silicon polymer** housing with the following characteristics:
1. Arrester Rated Voltage: 11.2 kV.
 2. Maximum Continuous Operating Voltage (Uc): 9 kV.
 3. Nominal Discharge Current (8/20 micro-sec peak): 10 kA.
 4. Energy Input Capacity: 3.5 kJ/kV.
- Surge arresters are to be vertical, free standing, explosion-proof type, with pressure-relief device and discharge counter. Submit complete data and characteristics in accordance with IEC 99 testing requirements and procedures.
- K. Control power supply is to be a complete system, including main LV switch, battery charger, batteries, racks and connectors, factory assembled and completely pre-wired to minimize field installation.
- L. Auxiliary LV power is to be obtained from a self-contained control power transformer unit supplied with the switchgear, when specified or shown on the Drawings. Where two alternate sources of LV power are shown/specified, an automatic transfer switch with manual over-ride and off- position is to be provided.
- M. Batteries: Nickel cadmium type, of capacity sufficient to supply all MV switchgear auxiliary loads, relays, coils, lamps, alarms etc. for 8 hours, to close all circuit breakers in rapid

succession, and trip all circuit breakers simultaneously with the charger off. Battery is to be heavy-duty type with transparent containers, maximum and minimum electrolyte level indicators and alarm initiating relay in case of D.C. output failure.

- N. Battery Racks: Generously dimensioned termite resistant hardware with electrolyte resistant paint finish, or square sectioned steel tubes treated with electrolyte resistant extruded coating. Fittings and connectors are to be approved and certified electrolyte resisting and corrosion proof materials.
- O. Battery Charger: Automatic voltage controlled, solid state type, suitable for float and boost charging, returning batteries to 90% full charge within 4 hours after full discharge, plus full duty cycle required of batteries. Charger is to operate from 380 V supply, 50 Hz, single-phase, giving specified D.C. output and having minimum range of adjustment of 100% - 125% float voltage and 110% - 135% boost voltage. Ripple is not to exceed 1% of nominal output voltage. Charger is to be rated 125% of its nominal full load and is to have its own automatic control against overcharging and overload protection. Charger is to have a.c. voltmeter, D.C. voltmeter, D.C. ammeter, main incoming circuit breaker, pilot lights on a.c. input and D.C. output, and earth fault detector with alarm indication.
- P. Battery Charger Type: Is to be Dual charger-type, parallel redundant, with each module capable of carrying the full load requirements of the system.

2.7 METERING INSTRUMENTS - INSTRUMENT TRANSFORMERS

- A. Instruments Generally: Housed in enameled, square steel cases for switchboard flush installation, size 96 x 96 mm with 5 mm frontal, protected and sealed white background dials with black pointers (in general) and anti- parallax shadow-proof glass covers. Accuracy of instruments is to be class 1.5 unless otherwise specified. Moving parts are to be damped, revolving on hard-stone bases, with zero adjustment screw.
- B. A.C. Voltmeters: Moving iron type, operating from VT secondaries, and with the following characteristics:
 - 1. Measuring Range: 27.5 kV with red line marked on nominal voltage, 250 degrees decimal scale.
 - 2. Overload Factor: 1.2 times rated voltage continuous and twice rated voltage for 1 minute.
- C. D.C. Voltmeters: Moving coil type, with the following characteristics:
 - 1. Measuring Range: 150 V.
 - 2. Overload Factor: 1.2 times rated voltage continuous and twice rated voltage for 1 minute.
- D. Voltmeter Selector Switch: 7-position, rotary type, with cam-operated contacts, permitting line-to-line and line- to-neutral voltage readings, and with off position.
- E. Ammeters: Moving iron type, operating from CT secondary, and with the following characteristics:
 - 1. Measuring Range :1.25 CT primary amps, 250 degrees decimal scale
 - 2. Overload Capacity: 1.2 times measuring range continuous, twice measuring range for 2 minutes, and fifty times measuring range for 1 second.
- F. D.C. Ammeters: Moving coil type, with the following characteristics:
 - 1. Measuring Range: 10 A.
 - 2. Overload Capacity: Ten times measuring range for 5 seconds.

- G. Power Factor Meters: Totally enclosed, 3-phase, electro- dynamic type, with cross-coil meter movement and accuracy of 1% from at least 20% - 100% rated current at rated voltage.
 - 1. Measuring Range: 0.1 conductive-unity-0.1 capacitive
- H. Wattmeters: Totally enclosed, 3-phase, electro-dynamic type, with overload factor of 1.2 times continuous.
- I. Watt-Hour Meters: 3-phase, to IEC 62052, unless otherwise required by the Local Power Authority, for operation from 5 A CT secondaries.
- J. Frequency Meters: Vibration (reed) type, rated frequency 50 Hz, class 1, rated frequency range 45-55 Hz, and unaffected by voltage variations of +/-20%.
- K. Current Transformers (CTs): Indoor dry type (cast- resin), with the following characteristics:
 - 1. Metering (general): Class 0.5, 5 A secondary.
 - 2. Protection: class 5P20
 - 3. Kilowatt-Hour-Metering: Class 0.5, 5 A secondary (check with power authority).
- L. Rated primary current, core size and accuracy limit factors are to be determined in accordance with nominal current of plant protected, short-circuit level and burden. CT is to perform under specified conditions without exceeding accuracy limit. Submit error curves for approval. Thermal short-circuit rating is to be 100 times rated primary current with dynamic short-circuit rating of 2.5 times thermal rating.
- M. Voltage Transformers (VTs): Magnetic, single-phase, indoor, dry type (cast-resin), with the following characteristics:
 - 1. Rated Voltage:
 - a. Primary: $22/\sqrt{3}$ kV.
 - b. Secondary: $110/\sqrt{3}$ V.
 - 2. Accuracy Class: 0.5.
 - 3. Rated Voltage Factor: 1.2 continuous, 1.9 for 30 seconds.
- N. Check associated burden and ensure VT can perform satisfactorily under specified conditions. Submit error curves for approval.

2.8 MICROPROCESSOR BASED METERING AND MONITORING UNIT

- A. General: A microprocessor based metering unit is to be provided on the incoming and/or outgoing feeder panels of the MV switchgear as specified in items of Paragraph "MV Switchgear assemblies" above and/or as shown on the drawings. Unit is to be capable of monitoring and displaying the functions listed below as well as providing the protection function indicated and the capability to municate data. Unit is to be similar to Cutler Hammer type IQ DP-4000 or other equal and approved.
- B. Direct reading metered values are to be displayed by the unit as follows:
 - 1. AC amperes in each phase, +/-0.5% accuracy
 - 2. AC voltage, phase to phase, phase to neutral, +/-0.5% accuracy
 - 3. Megawatts, +/-1% accuracy
 - 4. Megavars, +/-1% accuracy
 - 5. Megavoltamperes, +/-1% accuracy
 - 6. Power factor, +/-2% accuracy
 - 7. Frequency, +/-0.1 Hz accuracy

8. Megawatt demand (5,10,15,30 minute interval field programmable), +/-1% accuracy
 9. Megawatt , megavars and VA hours, +/-1% accuracy
 10. %THD , +/- 1%
- C. Trip and/or Alarm: Device is to trip and/or alarm on the following conditions as shown on the drawings.
1. Voltage phase loss, if any phase RMS is less than 50% of the nominal line voltage.
 2. Current phase loss, if the smallest phase is less than 1/16 of the largest phase value.
 3. Line voltage phase unbalance, programmable from 5 to 40% of nominal in 5% increments.
 4. Voltage phase reversal
 5. Over-voltage, programmable from 105 to 140% in 5% increments
 6. Under-voltage, programmable from 95 to 60% in 5% increments
- D. Device is to have a time delay for the trip and/or alarm settings for over-voltage, under-voltage and phase unbalance. Delay is to range from 0 to 8 seconds in 1-second intervals.
- E. Display screen and LEDs are to indicate both trip and alarm conditions. Cause of a trip or alarm is to be indicated on the display window. Device is also to signify reverse power flow, negative power factor and negative kVAR. Unit is to trip in the event of an internal malfunction.
- F. Control power is to be drawn from the monitored incoming AC line terminal connections. Device is to have non-volatile memory and not require battery backup. In the event of a power failure, the device is to retain preset parameters.
- G. Unit is to allow user to disable undesired values or functions and to later reactivate them if required. In the event of trip or alarm condition, a built-in reset button is to allow a manual reset of the unit. Unit is also to be capable of being remotely reset via its communication port.
- H. Addressable communication card is to be provided, capable of transmitting all data, including trip data, over a two wire local area network to the BACS (refer to Division 23 specifications).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Locations and Layout: Exact locations and physical layout of equipment and components may be varied as required to suit manufacturer's design and as approved, provided the required functions and operations are accomplished; follow the identification of the units indicated on Drawings exactly to ease checking and building maintenance procedures.
- B. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
- C. Cable Trenches: Ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.
- D. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

- E. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.
- F. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for MV, LV and control cables.
- G. Relays: Set in accordance with manufacturer's instructions and the Local Power A's requirements.
- H. Earthing: Ensure that earthing installation is as described in Division 26 Section "Grounding and Bonding" of the Specification and/or as shown on the Drawings.
- I. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.2 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Basic Electrical Materials and Methods."
- B. Diagram and Instructions: Frame under clear acrylic plastic on the front of switchgear.
 - 1. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
 - 2. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of the maintenance manual.
 - 3. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

3.3 CONNECTIONS

- A. Tighten bus joint, connector, and terminal bolts according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.4 FIELD QUALITY CONTROL

- A. Equipment: Inspect equipment upon delivery to site and report any damage to the Engineer.
- B. Switchgear: Inspect and check switchgear for completeness and as recommended by the manufacturer and check phasing of buses, contact alignment and clearances.
- C. Components: Check component ratings, types, sizes and wiring connections, including current and voltage transformers, fuses, switches, instruments and relays.
- D. Before energization carry out at least the following tests:
 - 1. Insulation resistance on busbars (with circuit breakers in disconnected position), circuit breakers, bushings and insulators, feeder terminals etc., using at least a 5 kV megger for MV circuits and a 1000 V megger on all control and protection circuits, with relays, lamps and the like components disconnected, to ensure satisfactory insulation resistance as recommended by the Standards and approved practices.
 - 2. High voltage tests on busbars, circuit breakers in disconnected position, switches, VTs and insulators, by applying HV a.c. test voltage between phases and phase to earth at 80% of the IEC voltage withstand test for 1- minute.

3. Resistance across closed contacts of circuit breakers using appropriate micro-ohm meter.
 4. Polarity check and ratio tests for CTs.
 5. Calibration checks and adjustment for ammeters and voltmeters.
 6. Primary and/or secondary injection tests to check relay operation, using appropriate test sets, followed by tripping of circuit-breaker once only, through its protective relay circuit.
- E. Cables: With circuit breaker in disconnected position, ensure that HV testing of feeder cable and respective termination is carried out as required under cable tests.
- F. After energization carry out inspection and checking as follows:
1. Breakers are to be closed, one at a time, with as little load on the feeder as possible; check meters as load is increased and any indication of overheating detected by appropriate instruments or sensors.
 2. Open and withdraw circuit breaker after a prolonged test run, inspect and check circuit breaker conditions, isolating contacts, contacts on all instruments and control switches, connections at terminal blocks etc., busbar connections and busbars for any indication of overheating; check for loose connections and bolts etc. and finally re-apply megger tests to ensure same quality of insulation as before energization.
 3. Close circuit breaker slowly, while in the disconnected position and inspect contacts and/or contact movement and compare with design figures.
- G. Manufacturer's instructions are to be followed under all circumstances. Carry out and record measurement and tests recommended by the manufacturer.
- H. Infrared Scanning: After Substantial Completion, but not more than two months after the end of the Defects Liability Period, perform an infrared scan of switchgear assembly. Make bus joints and connections accessible to a portable scanner and perform scanning during a period of normal working load as advised by Employer.
1. Follow-up Infrared Scanning: Perform one additional follow-up infrared scan at same locations as before, 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide calibration record for scanning device used for electrical distribution equipment.
 3. Record of Infrared Scanning: Prepare a certified report identifying all connections checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 CLEANING

- A. Inspect interior and exterior of installed switchgear. Remove paint-splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.6 DEMONSTRATION

Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.

END OF SECTION 26 13 00

SECTION 26 24 13 – SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes Main Distribution Board(s) work for low voltage (LV) distribution, ancillary mounting frames, fittings, cable termination accessories and supports.
- B. Connection to BMS system, including interface elements such as relays, transducers, etc. as detailed in Division 23 Specification Sections BMS schedules and /or shown on the Drawings.
- C. Requirements of the following Sections apply to this Section:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Grounding and Bonding".
 - 3. Division 26 Section "Low Voltage Power Conductors and Cables".

1.3 DEFINITIONS

- A. MDB: Main distribution board.
- B. CT: Current Transformer.
- C. VT: Voltage Transformer.
- D. EMI: Electromagnetic interference.
- E. RMS: Root mean square.
- F. The following terms used on the Drawings and in the Specification are synonymous and may be used interchangeably: "Switchboard" and "Main Distribution Board".

1.4 SUBMITTALS

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

2. The Current-time characteristics must be plotted on a log-log papers manually or by software program showing that the choice of the C.B. and relay settings are correct for coordination.
 3. If selectivity coordination study is failed for any reason, contractor is responsible to change or add any number of breakers, relays, related cables...etc. Such that the selectivity coordination shall be fully achieved with no extra cost to the owner.
 4. Short circuit and Voltage Drop Calculation Submit a comprehensive short circuit study as well as voltage drop calculation based on the actual impedance values of the electrical components such as supply short circuit level at the 22 KV (shall not be less than 750 MVA), transformer, bus bars and cables ... etc.
- C. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
1. Plans and elevations with indication of built-on equipment, exact dimensions, and weights.
 2. Arrangement of boards inside rooms allocated, indicating spaces and clearances.
 3. Arrangement of equipment inside board.
 4. One-line diagram of power system showing current ratings of switchgear and busbars and types and locations of protective gear (relays, instruments, CTs, VTs etc.)
 5. Schematics and wiring diagrams of control circuits. Differentiate between manufacturer-installed and field-installed wiring.
 6. Foundation details and grouting holes installation details.
 7. Arrangement of incoming and outgoing feeders, terminal fittings, instruments, busbar connections etc.
 8. Utility Company's metering provisions with indication of approval by utility company.
 9. Mimic-bus diagram.
- D. Technical Literature: Submit the following for approval prior to placing orders for equipment manufacture:
1. Schedule of circuit breakers application, indicating type, range, features and characteristics, short-circuit ratings, time-current curves etc.
 2. Method of setting of protective devices for overload, short-circuit and earth-fault currents as coordinated with upstream and downstream systems based on specific coordination curves of protective devices used and specific calculated prospective short-circuit currents at various points.
 3. Test methods on site and references, including testing equipment for microprocessor controlled trip units.
- E. Qualification Data: For firms and persons specified in "Quality Assurance" Article. Provide evidence of applicable registration or certification.
- F. Verification: Submit complete design verification documentations by the original manufacturer in accordance with the standard including test reports, test certificate, calculations, logs, records, etc. Manufacturer of the switchgear and controlgear assemblies shall not be permitted to provide any changes to the original manufacturer design but only to provide routine verification documentations. .
- G. Field Test Reports: Submit written test reports and include the following:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- H. Manufacturer's field service report.
- I. As-Built (record) Drawings: Submit hard and soft copies with labeling.

- J. Maintenance Data: For main distribution boards and components to include in maintenance manuals. In addition to requirements specified in Division 1 include the following:
1. Routine maintenance requirements for main distribution boards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current curves, including selectable ranges for each type of overcurrent protective device.
 4. List of recommended spare parts with price for 3 years and contacts number and addresses of nominated supplier.
- K. Coordination Study: Contractor is to submit a complete coordination and protection study for all the electrical system. The coordination shall be fully detailed to show the short circuit currents at each panel location. The study shall show that the protective devices provided do ensure the proper protection and coordination. Any breakers not satisfying the study shall be replaced by proper ones to ensure proper system operation and any related electrical items shall be updated accordingly. The coordination study has to be associated with a coordination study for earth fault currents throughout the system to ensure proper selection of earth fault setting for all breakers to ensure discrimination and proper protection of all system components.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer with minimum five years of successful installation experience on projects utilizing main distribution boards units similar to those required for this project.
- B. Manufacturer Qualification: A firm regularly engaged in the manufacture of main distribution boards, of types, sizes, and capacities required, and whose products have been in satisfactory use in similar service for not less than five years.
- C. Codes and Standards: Comply with the latest issue of:
1. IEC 61439 : Low Voltage Switchgear and Control Gear Assemblies
 2. IEC 60947-2 : "Molded case circuit breakers"
 3. IEC 60831-1 & 2: for power factor correction capacitors.
 4. IEC 61641 for internal arc faults.
 5. IEC 60529: Specification for degrees of protection provided by enclosures (IP code).
 6. IEC 62262: Protection against mechanical impact (IK code).
 7. Comply with IEC 61921 for PF correction capacitors.
 8. Other components where not specified are to comply with the relevant IEC standards
- D. Compliance with Local Requirements: Comply with applicable local regulations/code requirements of authorities having jurisdiction. These will have precedence over other codes/standards nominated for the project, unless otherwise approved in writing.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for main distribution boards, including clearances between main distribution boards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for main distribution boards, including clearances between main distribution boards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- G. Test certification for this range of switchboard from internationally recognized testing agency such as ASTA, KEMA etc.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in sections of lengths that can be moved past obstructions in delivery path. Deliver MDBs and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for MDBs and components to protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.
- 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 main distribution boards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside main distribution boards; install electric heating (250-W per section) to prevent condensation.
- D. Handle MDBs carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

1.7 PROJECT CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving main distribution boards into place.
- B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Engineer not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
 - 2. Indicate method of providing temporary utilities.
- C. Environmental Limitations: Rate equipment for continuous operation under the following, unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding [40] deg C.
 - 2. Altitude: Not exceeding [1000] m.

1.8 COORDINATION

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

1.9 EXTRA MATERIALS

- A. Spare Parts: Provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the following:

1. 1 set of fixed and moving contacts for every type of replaceable (consumable) contact set.
 2. 1 operating motor and/or coil for each type of electrically operated circuit breaker.
 3. 2 sets of each type of indicating lights, fuses, LEDs, control switches, and similar devices subject to failure or breakage at any time.
- B. Tools and Instruments: Provide tools and instruments required for normal routine inspection and maintenance and testing of circuit breakers and protective devices as appropriate for type of switchgear supplied.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. Schneider Electric (Egypt)
 2. ABB (Egypt)
 3. Siemens (Germany)

2.2 GENERAL REQUIREMENTS

- A. Generally: Main distribution boards are to be dead-front type, metal enclosed, multi-cubicle, floor mounted, free standing, with 1000V rated insulation voltage, and 600 V rated operational voltage, with fixed or draw-out switchgear, manually or manually and electrically operated, as shown on the Drawings, with matching vertical sections to form a continuous integral and rigid structure. Outgoing sections are to be of equal width.
- B. Generally: Coordinate with Building Management System (BMS) supplier (if BMS system is specified) and provide all necessary interfaces, relays, transducers, etc, necessary for the functions specified in the BMS schedules and/or shown on the Drawings.
- C. General Construction: Rigidly framed and bolted, with Electro-galvanized sheet steel enclosures, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating, gray colour (RAL 7035 ANSI 61) or standard manufacturer's colour subject to Engineer's approval. Switchgear shall be vermin, dust and rodent proof, IP 31 protection to IEC 60529 for indoor installations and IP 54 protection for installations in wet areas and IP55 degree of protection for outdoor installations, with adequate lifting means and base-frames and capable of being moved into position and directly bolted to floor without additional sills. For ratings up to 3200A, enclosures shall have mechanical impact resistance of IK10 to IEC 62262 for enclosures protection degree IP 54 and higher, and IK08 to IEC 62262 for enclosures protection degree lower than IP 54. Test certificates for mechanical impact shall be submitted for approval; otherwise enclosure thickness shall not be less than 1.5mm. For rating larger than 3200A, enclosures shall have minimum thickness of 2mm..
- D. Ventilation: Compartments are to be ventilated, by approved methods complying with the Standards.
- E. Main Distribution Boards are to have a short circuit withstand current as shown on the drawings for 1 sec. All boards shall comply with IEC 61641 for internal arcs.
- F. Fastenings between structural members are to be bolted.

- G. Extension of structure and busbars is to be possible at either end of switchboard for form 3 and form 4 type switchboards.
- H. Arrangement is to permit incoming and outgoing busbars and cables to enter enclosure as indicated on the Drawings and connect at respective terminals without inconvenience to installation or maintenance.
- I. Removing Circuit Breakers: Suitable arrangements and equipment are to be provided for extracting, lifting and unloading switchgear from enclosures as appropriate for type of switchgear.
- J. Spare and space positions are defined as follows:
 - 1. Spare position: Fully equipped enclosure with switchgear
 - 2. Space position: Fully equipped enclosure ready to receive switchgear.
- K. Busbars: Site rated for normal current as shown on the Drawings or at least site rated to same rating of main circuit breaker frame size, and braced for a symmetrical rms short-circuit duty as specified. Busbars are to be copper, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to maximum 90 deg C. Connections and buswork are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance unless otherwise recommended by the manufacturer and approved by Engineer. Contact surfaces are to be Electro-silver plated.
- L. Connections from busbar to switchgear are to be rated to carry full continuous current rating of switchgear frame and are to be insulated.
- M. Full size neutral is to be continuous through all sections. Neutral bus is to be insulated and separate from earth bus and connected to it with removable links, at every bus section. Links are to be of the same cross-section of the earth bus.
- N. Earth bus is to extend full length of board, firmly fixed to each section in accordance with the Regulations and Standards, complete with two main earthing lugs (one at each end), and required number of feeder protective earth connectors.
- O. Earth bus is to be half size of phase buses
- P. Switchboard Form: Switchboard(s) are to be of the following form(s):
 - 1. Form 3b.
 - 2. Incoming: Withdrawable type.
 - 3. Tie: Withdrawable type.
 - 4. Outgoing: Fixed or Withdrawable type.
- Q. Withdrawable metal enclosed circuit breaker section is to consist of compartmented unit(s), stationary part with rear busbar and cable connection compartments and front draw-out circuit breaker assembly. Partitions between sections are to be bolted steel plate and partitions between compartments are to be tough solid insulating removable bolted barriers. Each unit is to have hinged lockable front door with grip-handle and door mounted instrumentation.
- R. Draw-out circuit breaker assembly is to have disconnecting contacts, wheels and interlocks to prevent connecting or disconnecting circuit breaker unless in the open position, and to prevent closing circuit breaker while racking into any of the three positions (connect, test, disconnect). Racking mechanism and rail assembly are to be approved worm and lever mechanism. It is to be possible to close the unit door with breaker in any of the three positions and when removed. External position indicator is to be provided. Fixed disconnecting primary contacts are to be accessible and replaceable from front and are to be silver plated copper. Moving primary disconnect contacts are to consist of self-aligning,

silver plated, spring pressure, finger-cluster, copper contact fitted on line and load studs of circuit breaker.

- S. Fixed main circuit breaker section is to individually accommodate main circuit breaker, main cable entry with terminal fitting assembly and metering compartment. Where placed against a wall, accessibility is to be possible from front and sides or only from front of section.
- T. Pull Sections: An additional cable pull section is to be provided, depending on actual configuration shown on the Drawing, and subject to Engineer's approval.
- U. Front accessible fixed group-mounted feeder MCCB distribution sections for form 1 & form 2 switchboards are to rear align with main section(s) and be of uniform depth, with all devices removable from the front and mounted on a panelboard type base. Construction is to allow all connections and maintenance to be made without rear access. Cables are to be accommodated in extra wide vertical gutters. Sides, top and rear are to be covered with removable screw-on plates having formed edges all around. Front plates are to be sectionalized and removable, covered by trims, and secured by self-tapping screws.
- V. Front and rear accessible fixed group-mounted MCCB distribution sections for form 1 & form 2 switchboards are to front and rear align with main section(s). All devices are to be mounted on panelboard type base. All necessary line and load connections are to be accessible from the front. Main circuit breaker connections, busbars and cable connections are to be front accessible. Sides, top and front are to be covered with removable screw-on plates having formed edges all around. Front plates are to be sectionalized and removable, covered by trims, and secured by self-tapping screws.
- W. Front and rear accessible, front and rear aligned, individually mounted fixed MCCB distribution sections as basic construction for form 3 and form 4 switchboards, are to be compartmentalized construction, consisting of front modular circuit breaker compartments, busbar system compartments and rear cable termination compartments (as per the form type selected), with insulating barriers between front compartments and busbar compartments and between rear compartments and busbar compartment (removable for maintenance). MCCBs are to be closely coupled to busbars (to minimize chances of bus-side faults), and to rear cable terminals, through compatibly frame-sized insulated connectors. MCCB modules are to be covered on the front, by recessed frame-type bolted covers, 1.5 mm minimum thickness, to protect circuit breaker handles. Top, sides and rear are to be covered with removable screw-on plates having formed edges all around.
- X. THDi and THDv at the main distribution board section of each transformer (Point of Common Coupling) shall not exceed 10% with 8% individual harmonic order and 5% with 3% individual harmonic order respectively. Necessary supporting calculations based on actual nonlinear loads including VFD, UPS, lighting ballasts, etc. and all other linear loads on the same transformer shall be submitted for Engineer's approval. In case the specified harmonic limits cannot be achieved, the contractor is responsible for achieving the specified limits by providing necessary filters on MDB bus. Adopted solution shall be submitted for Engineer's approval prior to implementation.
- Y. All main distribution boards shall be equipped with combined Class I + II surge protective devices. SPDs along with their fused-disconnect switch shall be integrated within or adjacent to the MDB's enclosure.

2.3 POWER AIR CIRCUIT BREAKERS (PACBs)

- A. Type: Encased in high strength, high temperature resistant, molded plastic insulating materials, for normal operation at maximum temperature within enclosure at point of application, tested to approved standards, manually operated for normal functions, and automatically tripped under over-current conditions. Trip power is to be derived from main

power circuit, with sufficient tripping energy to reliably trip circuit breaker. Fixed mounted circuit breaker is to be rear connected.

- B. Construction: Manually or manually and electrically operated, as shown on the Drawings, with two-step, spring charged, stored energy mechanism, quick-make, quick-break type, electrically and mechanically trip-free, to prevent maintaining circuit breaker closed against over-current condition whether under manual or automatic operation. Electrically operated circuit breakers are to have integrally mounted, spring charging motor mechanism automatically recharged upon closing. Both manually or manually and electrically operated circuit breakers are to have mechanical built-in charging lever and are to include open and close direct acting push buttons. Stored energy provision is to allow open/close/open sequence of operation without use of external energy. Circuit breaker is to have arc-quenching device on each pole and replaceable arcing contacts.
- C. Control Power: For electrically charged circuit breaker and/or for shunt trip device, where required, control power is to be 120V ac obtained from in-built MDB control power transformer connected and fused on line-side of circuit breaker. Where shunt trip and/or under voltage release are required, a sufficient capacitor trip device is to be provided. Control power “healthy” indication lamp is to be provided with alarm on BMS if the system is “unhealthy.”
- D. Rating: **[3-pole] [4-pole]**, unless otherwise shown on the drawings. 600 V class, with continuous current rating (frame size) as shown on the Drawings, ranging between 400 A and 4000 A (400, 800, 1200, 1600, 2000, 2500, 3000, and 4000 A), fully rated (100%) for service under worst site conditions. Breakers are to be rated for a symmetrical rms service short-circuit breaking capacity as shown on the Drawings, to IEC 60947-2 sequence II (rated service short-circuit breaking capacity) at specified voltage and frequency, meeting IEC 60947-2, sequence I, II, III and IV tests (for circuit breakers of utilization category B), tested in an enclosure substantially the same as the enclosure in which they are to be installed.
- E. Trip Unit: Totally enclosed, programmable, solid state device, interchangeable for compatible frame sizes, pluggable into front of circuit breaker, tamper-proof and with transparent, sealable cover. Trip unit is to measure sinusoidal and non-sinusoidal current wave forms (fundamental to thirteenth harmonic) by continuously sampling each phase through out every cycle. Trip unit is to be direct acting trip device, current transformer operated, with flux transfer shunt trip that requires no external power. It is to have adjustable current setting (0.5 - 1.0 times trip unit rating) with adjustable long-time delay, short-time pick-up and short-time delay, earth-fault pick-up and time delay instantaneous over current pickup. Current setting range is to be by means of replaceable trip-units within the maximum frame size rating. Once removed, circuit breaker is to remain in the trip-free position. Earth-fault trip is to be adjustable, range 10% to 60% of normal current rating of the circuit breaker and a maximum of 1200A, with adjustable time delay between 0.1 and 0.5 seconds. Short time delay is to be adjustable in steps, 2 - 9 times current setting, with pre-settable or adjustable time band having maximum delay of 0.3 to 0.5 seconds. Instantaneous trip is to be adjustable in steps at least 2 – 13 times the trip unit rating. Over-ride protection is to allow full sensitivity up to interrupting capacity of Circuit Breaker.
- F. Trip Unit shall have the metering functions for each phase comprising:
 1. Voltage.
 2. Frequency.
 3. Energy.
 4. Total power.
 5. Peak power demand.
- G. Trip Unit shall have protective relays including:
 1. Over-voltage
 2. Voltage unbalance.
 3. Current unbalance

4. Reverse power.
-
- H. Trip Unit Status Display: Shall indicate in words the status of normal breaker operation, long time over current pick up, instantaneous time over current trip, short time over current trip, ground fault trip. Unit shall have integral resettable counter to count long time, short time, instantaneous and ground fault trips.
 - I. Position Indicators: Positive with trip indication target. Target indicator is to be mechanical and is to give indication even when control power has been lost.
 - J. Trip unit shall have inputs from conventional potential transformers for every phase. Current sensors transformers for every phase. Current sensors shall be encased in epoxy filled plastic housing to protect against damage and moisture and shall be integrally mounted in breakers.
 - K. Neutral Current Transformer: Provide on the neutral conductor of each main, tie or outgoing circuit having earth fault protection. Rating and characteristics of the neutral current transformer are to be suitable for proper operation of the earth fault protection system.
 - L. Circuit breaker accessories are to include the following:
 1. Padlocking or key-locking provisions for all positions (disconnected, test, connected, closing blocking, open)
 2. Overload, short-circuit, and ground fault trip LEDS
 3. Trip indicator and reset button
 4. Operations counter.
 5. On/off pilot lights.
 6. Shunt-trip coil and closing solenoid for remote control.
 7. Bell alarm for remote over-current trip indication.
 - M. Auxiliary Contacts: Include N.O. and N.C. contacts on switchgear as required for remote monitoring and control, plus 2 N.O. and 2 N.C. spare contacts.
 - N. Electrical Interlock: If electrical interlock is required between power air circuit breakers (as shown on the drawings), the mechanical closing button of the circuit breaker is to be disabled in the connect position and an additional electrical push button is to be provided for the closing of the circuit breaker through the breaker's shunt close coil. The electrical interlock is to be provided on both shunt trip and close coils of the circuit breaker in order to perform simultaneous tripping and inhibit closing functions on the interlocked breaker.

2.4 MOLDED CASE CIRCUIT BREAKERS (MCCBs)

- A. MCCBs generally are to be thermal-magnetic type for ratings below 400 A frame size, unless otherwise shown on the Drawings. MCCBs 400 A and larger are to be electronic solid-state trip type. All circuit breakers are to be 3-pole unless otherwise shown on drawings.
- B. Construction: Totally enclosed, molded case, constructed from high quality, high temperature resistant, tropicalized, molded insulating materials, for normal operation at 70 deg. C within enclosures, to approved standards, provided with quick-make, quick-break, trip-free switching mechanism manually operated by front toggle type handle and automatically tripped under over-current conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Contacts are to be non-welding silver alloy with arc quenching metallic devices of approved construction. Cable terminals are to be solder-less anti-turn box lug or clamp type with set screws suitable for copper or aluminum cables.

- C. Thermal magnetic circuit breakers are to include, on each pole, a bi-metallic inverse time-delay over current trip element for small overloads and instant magnetic over current trip elements for operation under short-circuit conditions. Circuit breakers 250 A frame size and larger are to have adjustable instantaneous trips.
- D. Thermal over-current trips are to be compensated to allow for ambient temperature higher at breaker than at protected circuit or device. Compensation is to be applicable between 25 and 50 deg. C. In case of adjustable thermal settings, range of adjustment is not to exceed maximum trip rating shown on the Drawings.
- E. Electronic trip circuit breakers are to have solid state trip units with long time delay setting range at least between 0.5 and 1.0 times maximum trip rating, short time delay range 3 to 10 times maximum trip rating with maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified, and is to be adjustable between 0.2 and 0.6 normal phase current pick-up with maximum time delay of 0.2 seconds, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.
- F. Tripped Position: When tripped automatically by over current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.
- G. Interchangeable Trips: Circuit breakers 250 A to 400 A frame size are to have interchangeable thermal and electronic trip units.
- H. Sealing: Non-interchangeable trip circuit breakers are to have sealed covers. Circuit breakers with interchangeable trips are to have trip unit covers sealed to prevent tampering.
- I. Circuit breaker ratings are to be non-current limiting, fully rated (100%) with continuous duty at site conditions, and with frame size and interrupting capacity to IEC 60947-2, sequence II (rated service short-circuit breaking capacity), and maximum trip rating as shown on the Drawings. Interrupting capacities at specified voltage and frequency are to meet IEC 60947-2 test sequence I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability).
- J. Accessories: Circuit breaker design is to allow addition of open/close electrical motor operator, control and interlocking functions, under-voltage release, shunt-trip coils, alarm and auxiliary switches, padlocking devices, key-lock devices, and the like.

2.5 METERING INSTRUMENTS

- A. Generally: Instruments are to be housed in enameled, square, metal cases for flush installation. Scales and markings are to be protected and sealed. Accuracy of instruments is to be within 2% unless otherwise specified.
- B. Voltmeters: Digital Type, range 1.25 times nominal system voltage, with "400 V voltage" indicator LED.
- C. Voltmeter Selector Switch: enabling measurement between phases and between phase and neutral.
- D. Ammeters: Digital Type, range 2 times nominal circuit amperage.
- E. Provide ammeters and pilot lights for each phase.
- F. Provide P. F meter moving iron type with center zero adjuster, size 76 x76mm.

- G. Current Transformer (CT): Indoor dry type, rated secondary current 5 A. Rated primary current, core size and accuracy are to be determined in accordance with nominal current of plant protected, short-circuit level and burden.
- H. Voltage Transformer (VT): Provide where required, complete with primary and secondary fuses and disconnecting device.

2.6 DIGITAL METERING UNITS

A. Metering unit shall be provided on the incoming and outgoing feeders having the following functions for each phase:

- 1. Voltage.
- 2. Current.
- 3. Frequency.
- 4. Energy.
- 5. Total power.
- 6. Peak power demand.

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

2.7 POWER FACTOR (PF) CORRECTION

- A. Generally: Multi step automatic PF correction system is required to bring up power factor of LV system to better than 0.90.
- B. Location of capacitor bank is to be indoors, as close as possible to nominated switchboard requiring PF improvement, and to be totally enclosed in sheet metal cabinets with appropriate ventilation.
- C. Capacitor bank is to be prefabricated, complete with capacitors, contactors, busbars and power factor regulator, to effect automatic control and sensing of power factor for switching in and out the number of steps required to improve PF to at least the figure indicated above, and discharge resistors to enable discharge of capacitors after disconnection.
- D. Steps are to be rated at maximum 40 kVAR, 3-phase, operating for loads between 100 kVA and 1250 kVA having PF below 0.85 (refer to the Drawings for total rating and configuration).
- E. Capacitors are to be dry-type, operating on rated low voltage, made of metalized polypropylene (self-healing dielectric) foils coated with thermosetting resin, or equal construction, proved in operation for at least 5 years, under prevailing ambient conditions. , with a loss factor not exceeding 0.3×10^{-3} (a consumption of about 0.4 watts per kVAR).
- F. Switching of capacitors is only to be performed by the fast closing contactors on capacitor bank units (with surge limiting reactors as necessary). Switching arrangement of capacitors is not to allow excessive transient capacitive switching at source, i.e. circuit breaker feeding the bank.

- G. Anti-harmonic reactors are to be provided in series with the capacitors and properly tuned to limit the harmonic currents in order to avoid over loading the capacitors. The reactor rating at 50 Hz is not to be less than 7% of the capacitors to be protected.
- H. Accessories: Each capacitor is to have its own connection terminals, HRC fuses, contactor, indicator lamp and set of discharge resistors.
- I. Regulator is to be housed in front door of one cubicle, and is to have setting knob for PF selection between 0.8 and 1.0, manual control position, and signal lights.
- J. Instrument transformers are to be provided at incoming circuit breaker(s) of MDB.

2.8 DIGITAL VOLTAGE RELAY

A. This unit shall be provided on the incoming and coupler section to perform the following functions, for connection to the automatic transfer system and monitoring by BMS system:

- 1. Over-voltage (adjustable from 90 to 120%, with time delay adjustable from 0.5-5 Sec).
- 2. Under-voltage (adjustable from 75 to 95%, with time delay adjustable from 0.5-5 Sec).
- 3. Phase Voltage unbalance (detect voltage unbalances over 10%).
- 4. Phase reversal.

2.9 WIRING

- A. Arrangement: Wiring is to be modularly and neatly arranged on master terminal boards with suitable numbering strips and appropriate cartridge type fuses where required.
- B. Connections are to be made at front of terminal board and with no live metal exposed.
- C. Metal cases of instruments, control switches, relays etc. are to be connected, by bare copper conductors not less than 2.5 mm² section, to nearest earthing bar.
- D. Control Wiring: Copper, PVC insulated, 85 deg. C, 600 V grade, and PVC sheathed for multi-core cables. Finely stranded copper conductor, silicon rubber insulated cables are to be used in proximity to higher temperature components and as flexible cable.
- E. Ferrules: Wires are to be fitted with numbered ferrules of approved type at each termination.

2.10 MISCELLANEOUS

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

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive main distribution boards for compliance with installation tolerances and other conditions affecting performance. Notify Engineer in writing of conditions detrimental to proper completion of the work.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install main distribution boards as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable requirements of applicable standards or codes approved.
- B. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from main distribution board units and components.
- D. Cable Trenches: Ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.
- E. Built-in Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.
- F. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.
- G. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.
- H. Relays: Set in accordance with manufacturer's instructions and in accordance with an approved scheme.
- I. Make Good damage painted surfaces, clean and apply rust-inhibiting prime coat and two finishing coats of approved enamel upon delivery of equipment to site, or as required by Engineer.
- J. Operating Instructions: Frame and mount the printed basic operating instructions for main distribution boards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of main distribution boards.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Basic Electrical Materials and Methods."
- B. Main Distribution Board Nameplates: Label each main distribution board compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

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

3.5 FIELD QUALITY CONTROL

- A. Equipment: Inspect equipment upon delivery to Site and report any damage to Engineer.
- B. Switchgear: Inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.
- C. Prior to energization of circuitry, check all accessible connections to manufacturer's torque tightening specification.
- D. Tests: After installation and before hand-over, carry out all visual and mechanical inspection and electrical tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including, but not limited to, the following. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 1. Insulation resistance tests for each main distribution board bus, component, connecting supply, feeder, and control circuit.
 - 2. Continuity tests of each circuit.
 - 3. Operational tests.
- E. Main and Control Circuits: Using 1000 V megger (2000 Megohm range), check insulation resistance between phases, between phases and earth/enclosure and between neutral and earth.
- F. Primary Injection Tests: Provide portable test equipment to test time-delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.
- G. Instantaneous Trip Elements: Test by high current primary injection, using high-current primary injection test-sets and reports all readings.

3.6 ADJUSTING

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

3.7 CLEANING

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

END OF SECTION 26 24 13

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Panelboards for distribution and sub-distribution of electric power and for protection of circuits, including fixing and supporting materials and materials for termination of feeders, sub-circuits and branch circuits for the following types:
 - 1. Lighting and appliance branch-circuit panelboards.
 - 2. Distribution panelboards.
- B. Connection to BMS system, including interface elements such as relays, transducers, etc. as detailed in Division 23 Specification Sections BMS schedules and /or shown on the Drawings.
- C. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Grounding and Bonding".
 - 3. Division 26 Section "Low Voltage Power Conductors and Cables".

1.3 DEFINITIONS

- A. MCB: Miniature circuit breaker.
- B. MCCB: Molded case circuit breaker.
- C. MCS: Molded case switch
- D. LP, PP, FP, SDP: Final branch circuit panelboards, power panelboards feeder pillars and sub-distribution panelboards respectively, for secondary lighting and power distribution with MCS on main incoming and either miniature circuit breaker (MCB) or molded case circuit breaker (MCCB) protection on sub-feeder or branch circuits, as shown on the Drawings.
- E. DP: Distribution panelboards for power distribution with MCS on main incoming and (MCCB) or (MCB) protection outgoing feeder circuit breakers Type 1 or Type 2.
- F. Distribution panelboards or final branch circuit panelboards supplied from emergency source are prefixed with the letter E.
- G. Distribution panelboards or final branch circuit panelboards supplied from Uninterruptable power source are prefixed with the letter U.

- H. Lighting final branch circuit panelboards supplied from central battery system are prefixed with the letters CB.
- I. ELCB: Earth leakage circuit breaker.
- J. RCD: Residual current device.
- K. RCBO: Residual current with over current protection device
- L. RMS: Root mean square.

1.4 SUBMITTALS

- A. Equipment Data: Submit data for approval including, but not limited to, the following:
 - 1. Manufacturers' catalogues indicating specific equipment selected
 - 2. Types of panelboards and circuit breaker characteristics including duties and ratings compensation at and above 40 deg°C ambient conditions and corresponding temperatures within the enclosures.
 - 3. Dimensions of panels and specific contents of each panelboard.
 - 4. Integrated equipment tabulations for coordinated short- circuit series combinations of circuit breakers.
- B. Coordination:
 - 1. Submit to the Engineer a relay and C.B. coordination (selectivity) study.
 - 2. The Current-time characteristics must be plotted on a log-log papers manually or by software program showing that the choice of the C.B. and relay settings are correct for coordination.
 - 3. If selectivity coordination study is failed for any reason, contractor is responsible to change or add any number of breakers, relays, related cables...etc. Such that the selectivity coordination shall be fully achieved with no extra cost to the owner.
 - 4. Short circuit and Voltage Drop Calculation Submit a comprehensive short circuit study as well as voltage drop calculation based on the actual impedance values of the electrical components.
- C. Verification: Submit complete design verification documentations by the original manufacturer in accordance with the standard including test reports, test certificate, calculations, logs, records, etc. Manufacturer of the switchgear and control gear assemblies shall not be permitted to provide any changes to the original manufacturer design but only to provide routine verification documentations. .
- D. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Exact composition of each panelboard, indicating busbar rating, frame and trip ratings of circuit breakers.
 - 2. Typical installation details of panelboards, indicating main feeder and branch circuit conduit connections, terminal provisions, tags, labels, mounting methods and materials used.

- E. Details of Electrical Closets: Submit details to verify clearances, spaces and ventilation of the installation of proposed equipment, prior to starting construction.
- F. Field Test Reports: Submit written test reports and include the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. Panelboard Schedules: For installation in panelboards submit final versions after load balancing.
- H. Feeder Pillars Single Line Diagrams: For installation in feeder pillars submit final versions after load balancing.
- I. Maintenance Data: For panelboards and components to include in maintenance manuals. In addition to requirements specified in Division 1 include the following:
 - 1. Routine maintenance requirements for panel boards 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. List of recommended spare parts with price for 3 years and contacts number and addresses of nominated supplier.
- J. As-Built (record) Drawings: Submit hard and soft copies with labeling.
- K. Coordination Study: Contractor is to submit a complete coordination and protection study for all the electrical system. The coordination shall be fully detailed to show the short circuit currents at each panel location. The study shall show that the protective devices provided do ensure the proper protection and coordination. Any breakers not satisfying the study shall be replaced by proper ones to ensure proper system operation and any related electrical items shall be updated accordingly. The coordination study has to be associated with a coordination study for earth fault currents throughout the system to ensure proper selection of earth fault setting for all breakers to ensure discrimination and proper protection of all system components.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer with minimum five years of successful installation experience on projects utilizing panel boards units similar to those required for this project.
- B. Manufacturer Qualification: A firm regularly engaged in the manufacture of panel boards, of types, sizes, and capacities required, and whose products have been in satisfactory use in similar service for not less than five years.
- C. Codes and Standards: Comply with the latest issue of:
 - 1. IEC 61439-1 "Low Voltage Switchgear and Control Gear Assemblies".

2. IEC 60947-2 "Molded case circuit breakers"
3. IEC 60947-3 "Molded case switch"
4. sIEC 60898 "Miniature circuit breakers"
5. IEC 60529 Specification for degrees of protection provided by enclosures (IP code).
6. IEC 62262 Protection against mechanical impact (IK code).
7. IEC 60898 Specification for circuit-breakers for overcurrent protection for household and similar installations.
8. Other components where not specified are to comply with the relevant IEC standards

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

1.6 COORDINATION

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

1.7 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify Engineer not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
 2. Indicate method of providing temporary utilities.
- B. Environmental Limitations: Rate equipment for continuous operation under the following, unless otherwise indicated:
1. Ambient Temperature: Not exceeding [40] Deg. C.
 2. Altitude: Not exceeding [1000] m.

1.8 SCHEDULES

- A. Schedules shown on drawings indicate the designation and required type of panelboard using the following criteria:
1. Type of construction (MCB or MCCB), referring to type of branch circuit breakers.
 2. Voltage, number of phases and wires.
 3. Branch circuit breaker trip rating and wire size.
 4. Main circuit breaker trip rating and frame size (maximum continuous rating) for MCCB and MCB.
 5. Short-circuit interrupting capacity (IC) in kA.
 6. Special arrangement or provisions.

7. Busbar type and busbar rating in Amps.

1.9 EXTRA MATERIALS

- A. Spare Parts: Provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the following:
 1. 1 set of fixed and moving contacts for every type of replaceable (consumable) contact set.
 2. 2 sets of each type of indicating lights, fuses, LEDs, control switches, and similar devices subject to failure or breakage at any time.
- B. Tools and Instruments: Provide tools and instruments required for normal routine inspection and maintenance and testing of circuit breakers and protective devices as appropriate for type of switchgear supplied.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Schneider Electric (Egypt)
 2. ABB (Egypt)
 3. Siemens (Egypt)
 4. Legrand (Egypt)
 5. GE (Egypt)
 6. Hager (Egypt)

2.2 GENERAL REQUIREMENTS

- A. Rated insulation voltage is to be in accordance with the respective standards.
- B. Panelboards are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 60947, and are to be factory designed and assembled.
- C. Earthing bar is to be half size the phase busbars.
- D. Neutral bar is to be sized as the phase bus bars.
- E. Protection is to be fully rated throughout the systems.
- F. Circuit breakers are to be non-fused type.
- G. Circuit Breaker Arrangement: Panelboards are to have one main incoming circuit breaker and the required number of branch circuit breakers, arranged as shown on the schedules, including spare circuit breakers and spaces for future expansion.

Three-phase panelboards are to be designed for sequence phase connection of branch circuit devices.

- H. Branch Circuit Numbering: On 3-phase panelboard schedules, circuits 1 and 2 are to be connected to red (R) phase, 3 and 4 to yellow (Y) phase, 5 and 6 to blue (B) phase etc., to conform with branch circuit numbering shown on the drawings.
- I. Generally: Coordinate with Building Management System (BMS) supplier (if BMS system is specified) and provide all necessary interfaces, relays, transducers, etc, necessary for the functions specified in the BMS schedules and/or shown on the Drawings.
- J. Surge Protection Device (SPD): All final branch circuits feeding sensitive electronic equipment such as: electronic equipment and telecom racks, Computer, Communication and control equipment shall be equipped with class III surge protective devices as specified under Division 26 Section "Surge Protection for Low-Voltage Electrical Power Circuits". SPDs along with their fused-disconnect switch shall be integrated within the panelboard's enclosure.

2.3 PANELBOARD AND FEEDER PILLARS ENCLOSURES

- A. Type: General purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown on the drawings, comprising box, trim, or trim and door to approved manufacturer's standards and sizes.
- B. Construction: Box, trim and doors where required, are to be Electro-galvanized sheet steel of gauges not less than specified and in accordance with the standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the standards, adequate for the utilized cables/wires subject to the engineers' approval and in no case less than 100 mm on all sides. Enclosure is to have pre-designed angles or threaded end studs to support and adjust mounting of interior panelboard assembly.
- C. Trims are to cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims are to be fixed to cabinet/box by quarter-turn clamps engaging flange of box (use of screws engaging holes in flange of box is not acceptable). Screws where used are to be oval-head, countersunk and flush. Trims for flush mounted panelboards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panelboards are to be exactly sized to form flush fit to box.
- D. Doors are to have concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high are to have vault-type handle and multiple point latch mechanism. Locks are to be keyed alike.
- E. Finish: Inner and outer surfaces of cabinet/boxes, trims, doors etc. Are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, aging and corrosion and of standard gray color to the approval of Engineer.

- F. Directories under glassine, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors are specified. Directories are to be typed to identify panelboards and clearly indicate circuit number and description of load.
- G. Outdoor enclosures are to be heavy duty sheet steel cabinets, minimum 1.5 mm thick, fully weatherproofed (IP 55), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

2.4 BUSBARS

- A. Type: One piece, 98% pure electrolytic copper, based on total maximum operating temperature of 90 deg. C at any point of the bus, at full continuous rating. Bolted or clamped contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminum is not to be used for busbars or panelboard parts.
- B. Design: Busbars are to be shrouded/insulated and rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Busing is to be full size without reduction. Busing and blank plates are to allow installation of future circuit devices, where indicated on the drawings.
- C. Rating: Busbar rating is to be at least equal to 1.25 main-circuit breaker frame size. Where no main circuit breaker is required, busbars are to have main lugs or disconnect switch, with nominal rating equal to standard circuit breaker frame sizes, and as shown on the drawings.
- D. Short-circuit Duty: Busbars are to carry at least 125% of the maximum short-circuit level at point of application for one second, without showing any signs of degradation.
- E. Terminals and connections are to be anti-turn, solder-less screw-pressure type. Screws and bolts used for making copper/copper connections are to be hard copper alloy with lock washers (riveted bus connections are not acceptable).
- F. Neutral bar is to be solid and fully insulated from cabinet or box. One solder-less box type set-screw connector is to be provided for neutral wire of each branch circuit and one bolted clamp-type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral is to be fully sized and rated as for phase busbars.
- G. Earthing bar is to be copper, brazed to panelboard cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

2.5 MOLDED CASE CIRCUIT BREAKERS (MCCBs)

- A. Type: Tested to approved standards, totally enclosed, molded case, constructed from high quality, high temperature resistant, tropicalized, molded insulating materials, for normal operation at maximum temperature within enclosures at point of application, and provided with front operated single toggle type handle mechanism for manual operation of main contacts in addition to automatic

operation under over-current conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws, suitable for copper or aluminum conductors.

- B. Circuit Breaker Trip Units: Unless otherwise specified or shown on the drawings, circuit breakers up to and including 400 a frame size, are to be thermal-magnetic type, having bi-metallic inverse time delay over-current element for small overloads and instantaneous magnetic over-current trip element for operation under short-circuit conditions on each pole. Circuit breakers 250 and larger are to have adjustable instantaneous trips.
- C. Switching Mechanism: Quick-make, quick-break type, with positive trip-free operation so that contacts cannot be held closed against excess currents under manual or automatic operation. Contacts are to be non-welding silver alloy with approved arc-quenching devices of metallic grid construction.
- D. Trip current rating (amps) indicates nominal maximum rating at which overload element is set to operate.
- E. MCCBs for LPs, PPs, SDPs and DPs Type 2: Comply with IEC60947-2 test sequences I, II, utilization category A, and are to have rated ultimate short circuit breaking capacities (sequence III) to meet the electrical requirements at the panelboard location, with preferred ratings in accordance with following tables.
- F. MCCBs for DP Type 1: Rated for maximum voltage of 600v A.C., 250 v D.C. and utilization category B (with an intended short time withstand capability), and are to have rated service short circuit breaking capacities (sequence II) with suitably selected frame sizes and trip ranges to meet the electrical requirements at the distribution panelboard location and schedules shown on the drawings, with declared ratings as percentage (100%, 75% or 50%) of the ultimate ratings as quoted by the circuit breaker manufacturer marked on the circuit breaker rating plate.
- G. Frame size is defined as maximum continuous current rating of circuit breaker which corresponds with its maximum trip range listed below and which is to be related to minimum acceptable short-circuit interrupting ratings, based on fully rated interrupting duties: normal duty (N), high break (H), or current limiting (L), as specified.

- H. Frame sizes are generally to be selected with minimum interrupting capacities at specified voltages and rated frequency, in accordance with the following table:

Trip range frame size(amperes)	Minimum Symm. rms rated			Rating volts(A.C.)
	breaking capacity (ultimate in			
	N	H	L	
kA)				
<u>Thermal-magnetic</u>				
16-100 (1p)	18	-	-	220/240
16-100 (2,3p)	18	-	-	380/415
16-160 (2,3,4p)	35	60	100	380/415
80-250 (2,3,4p)	35	60	100	380/415
160-400 (2,3,4p)	35	60	100	380/415
<u>Electronic</u>				
400-800 (2,3p)	40	60	100	380/415
800-1250 (2,3p)	50	65	100	380/415

- I. Tripped Position: When tripped automatically by over-current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.
- J. Interchangeable Trips: Thermal-magnetic trip circuit breakers 250 A frame size to 400 A frame size are to have interchangeable trip units.
- K. Sealing: Circuit breakers with non-interchangeable trip units are to be sealed. Circuit breakers with interchangeable trip units are to have trip unit covers sealed to prevent tampering.
- L. Compensation: Thermal over-current trips are to be ambient temperature compensated between 25 and 50 deg C.
- M. Electronic trips units, applicable to circuit breakers larger than 400 A frame size and larger, are to be solid state with long time delay settings between 0.5 and 1.0 times maximum trip rating, short time delay range of 3 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg C. Earth fault protection is to be built into trip unit where specified, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.

- N. Accessories: Circuit breakers are to be designed to accommodate standard attachments including shunt-trip, under-voltage release, combined auxiliary and alarm switches, and electrical operator to any circuit breaker of rating (frame size) 100 A and over. Padlocking devices are to be provided, where shown on the Drawings.
- O. Residual current operated earth leakage trip devices (RCDs) are provided as add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth fault current, in addition to over-current and short-circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be as shown on the drawings, and also for main breakers ratings are to be as shown on the Drawings. Circuit breakers are to include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be held closed against earth faults.
- P. Current Limiting Circuit Breakers: Molded case type without fusible elements. When operating within current limiting range, the I_{2t} of let-through current is to be less than 1/2 cycle wave of symmetrical protective short-circuit current as compatible with breaker construction.
- Q. Current limiting circuit breakers are to have, on each pole, adjustable inverse time-delay over-current characteristics for overload protection and instantaneous trip for short-circuit protection. Operation of main contacts is to be based on Electro-magnetic repulsion forces between contacts created by fault current. Ratings are specified at rated voltage for an rms value of prospective short-circuit current.

2.6 MOLDED CASE SWITCHES (MCSs)

A. Molded Case Switch: Similar to circuit breakers but without overload/short circuit protection. Short time rating of switches shall not be less than twelve times the maximum rated operational current for 1 second. Switches shall comply with IEC 60947-3. Switches shall have utilization category AC-22B to IEC 60947-3.

2.7 MINIATURE CIRCUIT BREAKERS (MCBs)

- A. Type: Thermal magnetic non-adjustable type, tested in accordance with IEC 60898.
- B. Minimum short-circuit breaking capacities (to IEC 60947-2) are to be as follows:
 - 1. 6 - 100 A MCB: 6, 10 or 16 kA at 240/415 v A.C.
- C. Construction: MCBs are to be tropicalized for operation at ambient temperatures up to 70 degree C within panelboard enclosure and humidity up to 95%, and are to be constructed from high quality, high temperature, molded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg C.
- D. MCBs and combination devices are to be modular, of unified profile and suitable for mounting either to a standard din rail, or a plug-in system.

- E. Operation: Under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at 5 - 10 times normal rated current (type C characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milliseconds.
- F. Ratings: Preferred rated currents are to be 6, 10, 16, 20, 25, 32, 40, 50, 63, 80 and 100 A, calibrated at 40 deg^c, available as 1, 2, 3 and 4-pole circuit breakers. Derating above 40 deg C is not to exceed 1% per deg C and loading is not to exceed 80% of circuit breaker rating.
- G. Residual current devices for earth leakage protective circuit breakers are to be add-on devices, or built-in and integral with the standard circuit breaker. Non-adjustable sensitivities of 30 ma, 100 ma and 300 ma are to be available for all ratings of 2-pole and 4-pole circuit breakers.
- H. Auxiliaries where shown on the drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.
- I. All MCBs shall be rated at service short circuit equals to bus bar short circuit level.

2.8 MOLDED CASE SWITCH (MCS)

- A. Molded Case Switch: Non-automatic on/off switching device of equal construction to equivalent circuit breaker, having no over-current or fault protective elements, but marked with maximum current withstand and voltage rating.

2.9 DISTRIBUTION PANELBOARDS (DP)

- A. DP Type 1: Form 1 to IEC61439, and have a rated insulation voltage of 1000V and a rated operational voltage of 600V A.C., 240 V D.C., surface mounted to wall or free standing, with doors (unless otherwise shown on the Drawings), suitable for ratings of main breaker and busbars ranging from 225 A to 1200 A, 3-phase, 4-wire (or 3-wire where specifically indicated), suitably and orderly arranged for any selected combination of branch MCCBs ranging from 150 A to 1200 A frame size and short-circuit interrupting ratings as shown on the Drawings. Circuit breakers smaller than 225 A frame size, where indicated, may be grouped on an integral sub-assembly mounted to main chassis.
- B. DP Type 2: Form 1 to IEC61439, and have a rated insulation voltage of 750V and a rated operational voltage of 440V A.C., 240 V D.C. Panelboard is to be recessed or surface mounted type, as shown on the Drawings, complete with trim and door, adjustable trim fixation for flush panels, and with ratings of main circuit breaker and busbars of 100 A, 225/250 A, 400 A or 600 A, 3-phase, 4-wire, with 2 or 3-pole branch circuit breakers, 100 A or 150/160 A frame size for voltages up to 600 V A.C., and 100 A to 250 A frame size at 240 V A.C.
- C. Construction: Sheet steel, minimum 1.5 mm thick for cabinet/box and minimum 2 mm thick for trim or trim and door. Fronts are to be single or twin covers to shield circuit breakers, terminals and live ends.

- D. Interior of panelboard is to be pan assembly consisting of galvanized sheet steel chassis minimum 2 mm thick, folded, flanged and reinforced, with busbars vertically arranged and mounted on molded insulators.
 - E. Molded insulators are to have minimum temperature rating of 130 deg C and insulation grade of 3.5 kV for one minute.
 - F. Circuit breakers are to be mounted in twin arrangement (except for larger circuit breakers) and bolted rigidly to copper cross and center bus connectors.
- 2.10 FINAL BRANCH CIRCUIT, POWER AND SUB-DISTRIBUTION PANELBOARDS - GENERALLY
- A. Arrangement: Comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker. Single and multi-pole circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.
 - B. Indoor Enclosure: Sheet steel, minimum 1.0 mm thick for box/cabinet and minimum 1.5 mm thick for front shield, trim and door. Fixings for flush trim are to be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) are to be at least 100 mm wide. Larger gutters are to be provided where tap-off insulated split connectors are required. Knockouts are to be provided in top or bottom of enclosures and are to provide a neat and uniform conduit/cable terminal arrangement.
- 2.11 FINAL BRANCH CIRCUIT, POWER AND SUBDISTRIBUTION PANELBOARDS AND FEEDER PILLARS - TYPE MCCB
- A. Type: Rated insulation voltage rating 750V and a rated operational voltage of 600V A.C. .250 V D.C. single-phase and neutral (SPN) or 3-phase and neutral (TPN), with bolted 1, 2, or 3-pole MCCBs on branch circuits and 2, 3 or 4-pole MCCB on main incoming,
 - B. Branch circuit breakers are to be MCCB or MCB, 1, 2 or 3-pole, rated 100 A frame size, with trip ratings between 16 A and 100 A, and compatible ICs, selected from normal (N), high-break (H) or current-limiting (L) range.
 - C. Main circuit breaker is to be MCS or MCCB, 2 or 3-pole 100 A, or 2, 3 or 4-pole 160 A, 225/250 A or 400 A continuous rating (frame size), with trip ratings and fully rated non-current limiting ICs of normal (N) or high-break (H) ranges, with or without residual current device (RCD) as indicated on the Drawings.
 - D. Short-circuit Rating: Panelboards may only have integrated equipment (series) short-circuit ratings in accordance with paragraph F of Article 2.2 "GENERAL REQUIREMENTS" hereof.
 - E. Assembly: Busbars are to be rigidly fixed on molded insulators to back pan in vertical arrangement. Branch circuit breakers are to be bolted in twin arrangement to rigid copper cross and center bus connectors. Back pan assembly is to be removable and fixed to four threaded studs integral with cabinet.

2.12 FINAL BRANCH PANELBOARDS AND FEEDER PILLARS - TYPE MCB

- A. Type: Rated insulation voltage rating of 600V and a rated operational voltage of 600V.
- B. Internal Assembly: Comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly is to be complete with neutral terminal block, earthing bar and one piece insulated bolt-on/comb-type phase busbar. Busbars are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards. Panelboards are to comply with IEC 61439.
- C. Internal Assembly: Comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with busbars in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly is to be complete with neutral terminal block, earthing bar and one-piece insulated phase busbar. Busbars are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards.
- D. SPN type panelboards are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.
- E. SPN type main circuit breaker is to be double-pole MCB, with or without earth leakage device (RCD), as shown on the Schedules.
- F. Single-pole and double-pole MCBs for 240 V service, are to have trip ratings between 6 A and 50 A, with ICs as required in the Schedules.
- G. TPN type panelboards are to be suitable for up to 415 V A.C. maximum service voltage, 3-phase and neutral, with MCBs on branch circuits and 3 or 4-pole MCS or MCB or MCCB main incoming, as shown in the Schedules or on the Drawings.
- H. Triple-pole branch circuit breakers are to have trip ratings between 16 A and 100 A, with IC as required in the Schedules.
- I. TPN type panelboard main circuit breakers are to be MCS or MCB or MCCB, 100A continuous current rating, with trip range from 25 A to 100 A, or 225 A MCCB with trip range 70 A to 225 A, normal (N) or high-break (H) duty with/without RCD as shown on the Drawings.
- J. Short-circuit Rating: TPN panelboards may only have integrated equipment (series) short-circuit ratings in accordance with clause paragraph F of Article 2.2 "GENERAL REQUIREMENTS" hereof.

2.13 FINAL BRANCH CIRCUIT PANELBOARDS AND FEEDER PILLARS ; SPLIT-BUS MCCB/MCB TYPES

- A. Assembly is to be as specified for MCB or MCCB type of branch circuit panelboard, but with split-bus arrangement, part of which is controlled by in-built submain contactor or circuit-protective device for group control of a number of branch circuits. Panelboard is to have main circuit breaker for protection and isolation.
- B. Contactors: 2 or 3-pole, Electro-magnetic type, class AC 5a or AC 5b to IEC 60947-4, designed to withstand large initial currents of discharge lamps or tungsten lamp loads respectively, and rated not less than overload setting of protective device upstream. Contacts are to be double break, silver cadmium plated, having self-cleaning wiping action. Control is to be provided by phase-neutral (maximum 220 V) split-coil, for on/off activation by local and/or by remote direct-wired, on/off push buttons. Contactor is to be mechanically latched. Control circuit is to be fused. Auxiliaries are to include local pilot light, parallel remote indicating circuit, 2 N.O. and 2 N.C. auxiliary contacts.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fixing Generally:
 - 1. Align, level and securely fasten panelboards to structure
 - 2. Fix surface mounted outdoor panelboards at least 25mm from wall ensuring supporting members do not prevent flow of air
 - 3. Do not use connecting conduits to support panelboards
 - 4. Close unused openings in panelboard cabinets.
- B. Panelboard Interiors: Do not install in cabinets until all conduit connections to cabinet have been completed.
- C. Wiring Inside Panelboards: Neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections are to be split and bolted type, fully insulated.
- D. Trim: Fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.
- E. Protection: Treat concealed surfaces of recessed cabinets with heavy field application of waterproof compound prior to installation.
- F. Mounting Heights: Top of trim 1880 mm above finished floor, unless otherwise indicated.
- G. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- H. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

- I. Install filler plates in unused spaces.
- J. Provision for Future Circuits at Flush Panelboards: Stub four empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four empty conduits into raised floor space or below slab not on grade.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Basic Electrical Materials and Methods".
- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

- A. Install equipment-grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.4 FIELD QUALITY CONTROL

- A. Generally: Carry out all tests, required by the governing codes and by the Engineer, on panelboards after installation, to verify compliance with the specifications and standards. Inspect conditions within panelboards and verify insulation conditions by use of a megger.
- B. Circuit Breakers: Tests are to include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by Engineer, by applying necessary short-circuit, overload and earth leakage current for tripping circuit breaker as applicable and compare with manufacturer's data/characteristic curves. Measure and report ambient temperature inside enclosure.
- C. Insulation Check Tests: Carry out insulation tests on all busbars, between phases and between phases and earth/cabinet, and between neutral and earth. Record all readings, using 500 V megger for equipment on 240 V systems, and 1000 V megger for equipment on systems up to 600 V, for 1-minute, with circuit breakers in open position.
- D. Routine tests on site are to be carried out, in accordance with the Standards, on all panelboards assembled from standardized components of the manufacturer outside the works of the manufacturer.
- E. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.

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

3.5 ADJUSTING

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

3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. 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 26 24 16

SECTION 26 24 19 - MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes motor control centers and panels for use on ac circuits rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 23 Section "Motors" for electric motors.
 - 2. Division 26 Section "Basic Electrical Materials and Methods".
 - 3. Division 26 Section "Switchboards" for circuit breakers.
 - 4. Division 26 Section "Raceways and Boxes" for conduits.
 - 5. Division 26 Section "Low Voltage Conductors and Cables" for wires and cables.
 - 6. Division 26 Section "Enclosed Switches and Circuit Breakers" for switch disconnectors.

1.3 DEFINITIONS

- A. MCC: Motor Control Center.
- B. MCP: Motor Control Panel.
- C. CT: Current Transformer.
- D. VT: Voltage Transformer.

1.4 SUBMITTALS

- A. Technical Data: Include dimensions, ratings and data on features and components.
- B. For Variable Frequency Drives: Submit manufacturer's performance data including dimensional drawings, customer connection drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFDs FLA rating, certification agency file numbers and catalogue information.
- C. Shop and Installation Drawings: Submit for each motor control center, and prior to ordering materials and equipment, specified in this Section. Include dimensioned plans, elevations, and component lists. Show ratings, including short time and short-circuit ratings, and horizontal and vertical bus ampacities.
 - 1. Complete technical schedule of features, characteristics, ratings, and factory settings on all motor starters, motor protection relays, sensing units, control accessories, etc.
 - 2. Instructional details of equipment, particularly motor control centers and panels.

3. Installation details of motor control centers and panels and of control and sensing accessories.
 4. Exact routing of power and control cables, wiring and conduits.
 5. Feeder termination details at motor control centers, starters, motors, isolating switches, control and sensing accessories etc.
 6. Wiring Diagrams: Interconnecting wiring diagrams (of all power and control circuits) pertinent to class and type specified for motor control center. Schematic diagram of each type of controller unit indicated.
 7. Wiring Diagrams: Submit for approval detailed control wiring diagrams and a list of control equipment with descriptive literature.
 8. Free hand field wiring diagrams or sketches will not be accepted.
- D. Verification: Submit complete design verification documentations by the original manufacturer in accordance with the standard including test reports, test certificate, calculations, logs, records, etc. Manufacturer of the switchgear and controlgear assemblies shall not be permitted to provide any changes to the original manufacturer design but only to provide routine verification documentations. .
- E. Field Test Reports: Submit written test reports and include the following:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Manufacturer's field service report.
- G. Maintenance Data: For motor control center or panel and components to include in maintenance manuals. In addition to requirements specified in Division I include the following:
1. Routine maintenance requirements for motor control center or panel and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current curves, including selectable ranges for each type of overcurrent protective device.
 4. List of recommended spare parts with price for 3 years and contacts number and addresses of nominated supplier.
- H. Qualification Data: For firms and persons specified in "Quality Assurance" Article. Provide evidence of applicable registration or certification.
- I. Coordination Study: Contractor is to submit a complete coordination and protection study for all the electrical system. The coordination shall be fully detailed to show the short circuit currents at each panel location. The study shall show that the protective devices provided do ensure the proper protection and coordination. Any breakers not satisfying the study shall be replaced by proper ones to ensure proper system operation and any related electrical items shall be updated accordingly. The coordination study has to be associated with a coordination study for earth fault currents throughout the system to ensure proper selection of earth fault setting for all breakers to ensure discrimination and proper protection of all system components.
- 1.5 QUALITY ASSURANCE
- A. Installer Qualifications: Engage an experienced installer with minimum five years of successful installation experience on projects utilizing motor control centers and panels units similar to those required for this project.

- B. Manufacturer Qualification: A firm regularly engaged in the manufacture of motor control centers and panels, of types, sizes, and capacities required, and whose products have been in satisfactory use in similar service for not less than five years.
 - C. Codes and Standards: Comply with the latest issue of:
 - 1. IEC 61439: Low Voltage Switchgear and Control Gear Assemblies
 - 2. IEC 60947-2 "Molded case circuit breakers"
 - 3. IEC 60947-3 "Molded case switches"
 - 4. IEC 60831-1 & 2 for power factor correction capacitors.
 - 5. IEC 61641 for internal arc faults.
 - 6. IEC 60529 Specification for degrees of protection provided by enclosures (IP code).
 - 7. IEC 62262 Protection against mechanical impact (IK code).
 - 8. Comply with IEC 61921 for PF correction capacitors.
 - 9. Other components where not specified are to comply with the relevant IEC standards
 - D. Compliance with Local Requirements: Comply with applicable local regulations/code requirements of authorities having jurisdiction. These will have precedence over other codes/standards nominated for the project, unless otherwise approved in writing.
 - E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for main distribution boards, including clearances between main distribution boards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
 - F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for main distribution boards, including clearances between main distribution boards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
 - G. Test certification for this range of motor control centers from internationally recognized testing agency such as ASTA, KEMA etc.
- 1.6 DELIVERY, STORAGE, AND HANDLING
- A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
 - B. Store so condensation will not occur on or in motor control centers. Provide temporary heaters as required to prevent condensation.
 - C. Handle motor control centers according to Standards recommendations. Use factory-installed lifting provisions.
- 1.7 PROJECT CONDITIONS
- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving motor control centers into place.
 - B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Employer or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Engineer not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
 - 2. Indicate method of providing temporary utilities.

- C. Environmental Limitations: Rate equipment for continuous operation under the following, unless otherwise indicated:

1. Ambient Temperature: Not exceeding [40] Deg. C.
2. Altitude: Not exceeding [1000] m.

1.8 COORDINATION

- A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.
- B. Coordinate features, accessories, and functions of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
1. 1 set of fixed and moving contacts for every type of replaceable (consumable) contact set.
 2. 1 operating motor and/or coil for each type of electrically operated circuit breaker.
 3. 2 sets of each type of indicating lights, fuses, LEDs, control switches, and similar devices subject to failure or breakage at any time.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Schneider Electric (Egypt)
 2. ABB (Egypt)
 3. Siemens (Egypt)

2.2 VARIABLE SPEED DRIVES (VSDs)

- A. General:
1. This part of the Specification describes the general requirements for the variable speed drives, the VSDs. The nominal values, the standard documents and the drive's minimum performance are defined in this part. The VSD does not include motors in this specification. The Specification uses the term motor unit which means a combination of the VSD and the motor.
 2. If the Project specific part of the Specification (Appendix A) is in contradiction with the other parts of the document, the Project specific document shall apply.

B. Requirements for the Manufacturer:

1. Country of Origin/Make: The VSD should be manufactured in a European country.
2. Certifications: The frequency converter manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system. The manufacturer shall have the environment certification ISO 14001.
3. Experience: The manufacturer shall have adequate experience in frequency converter manufacturing and have adequate business volume in order to provide credibility in his commitments and a capability of long term support. The manufacturer shall prove his experience by quoting references of units in the specified power and voltage range.
4. Local support:
 - a. The supplier shall have a permanent representative office with a trained and skilled support staff, in the country where the goods are delivered, in order to prove his commitment for local support and to provide a channel for communication. The local representatives shall be easily accessible and shall be able to arrive at the site within 24 to 48 hours' notice.
 - b. The engineers employed by the supplier's regional office shall be certified by the manufacturer and provide start-up service including physical inspection of the drive, connected wiring and final adjustments, to ensure that the VSD meets the required performance.
 - c. The supplier shall be able to give basic drives training to the Customer's engineers, preferably on the site but anyway, in the country where the customer's site is. The training shall, as a minimum, include system concepts and basic troubleshooting. The supplier shall also be capable of solving most VSD problems quickly. He shall also have a 24 hour support from the drives' factory, to avoid any delays during service or repair work on the site.
 - d. The manufacturer shall be able to offer commissioning of the drive to be done by the local office.
 - e. The most common spare parts like fuses, IGBTs as well as main control and IO boards shall be available in 48 hours from the notification through a regional service center of the supplier. The more rarely used spare parts should be available in maximum 5 days on site.

C. Basic requirements for the VSDs

1. General requirements:
 - a. The VSD shall be of the most modern design, yet user friendly and be simple to install, commission and maintain. The VSD shall be able to start and control the speed of a standard squirrel cage induction AC motor. The VSDs shall be CE marked. The VSDs have to be built to comply with the IEC standards. In the Australian market the VSDs shall have a C-tick.
 - b. The materials used in the VSD shall be recyclable, non-toxic and flame retardant.
 - c. The VSD shall be a digitally controlled drive, using, at least, the pulse width modulation (PWM) with flux vector control, a direct torque control (DTC), or equivalent. It shall have IGBT's in the inverter section of the throughout the power range, and it shall have the following minimum specifications.
 - d. Operating conditions:
 - 1) Rated Input Voltage: 400V - 415V, three-phase + 10 percent or 400V-500V, 3 phase + 10 percent or 525V - 690V, 3 phase, - 10 percent, + 5 percent.
 - 2) Rated Input Frequency: 48-63Hz.
 - 3) Fundamental Power Factor: 0.97 or better at nominal load.
 - 4) Efficiency: >98 percent at nominal load.
 - 5) Output Voltage: 0- U_N , 3 phase.

- 6) Output Frequency Range: 0 to 300 Hz, adjustable.
 - 7) Output Frequency Resolution: 0.01 Hz.
 - 8) Accel/Decel Time: 0 - 1800 s, adjustable.
 - 9) Overloadability (by load type):
 - a) Constant Torque: 150 percent of nominal current for 1 min in every 5 mins.
 - b) Variable Torque (pump & fan).
 - 10) Ambient Temperature: 40 deg. C (104 deg. F), for higher temperatures see below.
 - 11) Installation Altitude: 1000 m, for higher altitudes see below.
 - 12) Max. Relative Humidity: 95 percent, non-condensing. In presence of corrosive gases, the max. relative humidity is 60 percent.
 - 13) Max. Corrosion Level of the Cooling Air:
 - a) Chemical Gases: IEC 60721-3-3, class 3C2.
 - b) Solid Particles: IEC 60721-3-3, class 3S2.
 - 14) Max. Vibration Level (IEC 6068-2-6)
 - a) 2 to 9 Hz: 0.3 mm.
 - b) 9 to 200 Hz: 1 m/s².
 - 15) Main Protections: Overcurrent, short circuit, input/output phase loss, motor overload and underload over/under-voltage, overspeed, overtemperature, motor stall, other internal fault.
 - 16) The VSD shall be provided with integrated communication card to interface with BMS.
- e. The VSD shall be able to give a 100 percent output current continuously in the above specified conditions. In order to ensure that the drive can provide the required output current in the specified ambient conditions, the manufacturer shall inform of the required derating, if the ambient temperature given in the Project specific Specification is higher than 40 deg. C (104 deg. F) or if the installation altitude is more than 1000 m above the sea level. The derating factor shall be specified so that neither the lifetime of the VSD nor the unit's performance, overloadability included, nor the reliability of the VSD shall suffer.
- f. Storage conditions (in the protective package):
- 1) Ambient Temperature: - 40 to + 70 deg. C (40 to 158 deg. F)
 - 2) Corrosion Level of the Cooling Air Chemical Gases : IEC 60721-3-3, class 1C2. Solid Particles: IEC 60721-3-3, class 1S3.
 - 3) Max. Vibration Level (IEC 60068-2-6) 2 to 9 Hz: 1.5 mm. 9 to 200 Hz: 5 m/s².
 - 4) Shock (IEC 60068-2-29): Max. 100 m/s², 11 ms.
 - 5) Free fall: 250mm for weight under 100kg. 100 mm for weight over 100 kg.
2. VSD Accuracy: The VSD shall have a minimum speed control accuracy of ± 10 percent of the nominal slip of the motor, without a pulse encoder feedback. In practice, this means e.g. for a 4 pole, 50 Hz motor with a 45 rpm slip speed, an accuracy of ± 0.3 percent of the motor nominal speed. The VSD shall be capable of a dynamic accuracy of at least 0.4 percent sec. without additional options. If this accuracy is not achieved without a speed feedback, the manufacturer shall specify the accuracy that can be reached and if required, a pulse encoder with adequate control devices shall be included in the motor unit at the VSD supplier's expense. The dynamic accuracy means the drive's capability to response fast in a dynamic situation, for example, if the load changes. It is measured by the change of speed and time, i.e. how long it takes to recover to the reference speed.

3. Starting torque and torque step rise time:
 - a. Constant torque applications: The starting torque of the motor unit without a pulse encoder feedback shall be at least 150 percent of the rated motor unit torque.
 - b. Variable torque applications: The starting torque of the motor unit without a pulse encoder feedback shall be at least 100 percent of the rated motor unit torque.
 - c. In case of need of fast torque rise time, the torque step rise time from 10 percent to 90 percent of the full nominal torque should be less than 5 ms, when the motor is fully magnetized. If the motor mechanical time constants are longer than that, the torque step rise time should be according to mechanical time constant.
4. Quality assurance and warranty:
 - a. Every VSD has to be tested functionally. The inverter part of the VSD or each inverter module at least has to be tested by running it with a motor at full nominal load. A test report of the tests made has to be included with the VSD.
 - b. The warranty period of the VSD has to be a minimum of 24 months from the date of delivery or 12 months from the date of commissioning, whichever comes first.

D. Enclosure and mounting:

1. The VSDs up to 75 kW in 400 V and 690 V or 90 kW in 500 V, shall be installed separately in drive modules. There should be a possibility for flange mounting, to provide for cases, when the drive is installed in a cabinet and to enable installation of the heatsink outside the cabinet.
2. Above 75 kW (90 kW in 500 V), the VSD shall be equipped with fuses and a main circuit switch must be available either as standard or, at least, as an option. The switch shall be equipped with a door-interlocked handle, padlockable in the open position. Input fuses shall be of semiconductor type, and their characteristics coordinated with the drive's electronic protection circuits so that they do not blow from normal output faults such as an overcurrent fault. The control panel of the VSD shall be accessible for programming and controls with the main door closed. The whole assembly shall be implemented with a strict consideration of the EMC compatibility and regulations as described further in the Specification.
3. Panel Design Specs:
 - a. Standards: IEC 61439-1, EN 60439 & VDE 660 Part 500.
 - b. Protection Class: IP 21 or better.
 - c. Cabinet access: From front.
 - d. Cable entry and exit: Bottom entry as standard. Both bottom and top entry have to be possible.
 - e. Color, front: Light beige, RAL 7035 or NCS 1502-Y.

E. User interface:

1. General: The user interface shall be similar throughout the power range to avoid confusion amongst the users and need for training in several different units.
2. Inputs and outputs: The following standard inputs and outputs at least shall be provided, to be used in interface with the control system:
 - a. Analog Inputs: 1 x Programmable differential voltage input 0(2) - 10V.
2 x Programmable differential current input 0(4) - 20mA.
 - b. Analog Outputs: 2 x Programmable current outputs 0(4) - 20mA.
 - c. Digital Inputs: 6 x Programmable Digital Inputs, optoisolated, common or
separate ground.

- d. Relay Outputs: 3 x Programmable Digital outputs with a changeover dry Contact.
 - e. All the control terminals shall be clearly marked.
3. The following functions at least shall be available via the IOs:

Input	Output
Analog:	Analog.
Speed reference:	Motor speed.
Torque reference:	Motor torque.
PID-control feedback (actual value):	Motor current.
Correction signal to reference:	Output frequency.
	Output voltage.
	Output of the process PID.
	Controller.
	Control deviation of the PID.
	Controller.
	Actual value of the PID.
	Controller.
	Process speed.
Digital:	Relay.
Start:	Fault.
Stop:	Running.
Forward/reverse:	Ready
Pre-programmed constant speeds:	Rotation direction.
Speed up I down (motor potentiometer):	Fault/warning.
Start and stop from 2nd source:	Warning.
Selection of acceleration I deceleration ramp:	Stall fault or warning.
Selection of user macro:	VSD temperature fault or warning.
Run enable:	VSD temperature fault or warning.
	Selection of control place
Motor magnetized:	Fault reset controlled via serial communications.

4. Serial communications: The VSD shall be equipped with communication port and media for communication with PC software tools. In addition, the following serial communication protocols at least shall be available as option: Modbus, Modbus+, Interbus-S, Profibus DP, LON Bus and DeviceNet. It shall be possible to add the serial communication later.
5. VSD keypad:
- a. The VSD shall have a detachable keypad with a backlit 4 line, 20 character alphanumeric operating display for programming and controlling purposes. The displayed messages shall be in user friendly, descriptive text. Coded messages are not acceptable. Parameter setting shall be possible by using the keypad.
 - b. Parameter setting shall be easily accessible and user friendly with actual text messages. Password protection shall be provided to avoid unauthorized tampering with the set parameters. It shall be possible to read and write the set parameters with the help of the control pad, enabling thus copying of parameters between the VSDs of a similar application, to save time during the commissioning and to avoid mistakes. The VSD shall have a local lockout to prevent accidental transfer from remote to local.

- c. Direct keypad entry shall be provided to observe the following actual parameters. Any 3 of the following parameters or actual values shall be selected to be always displayed:
 - 1) Input Voltage.
 - 2) Input Frequency.
 - 3) Output Voltage.
 - 4) Output Frequency.
 - 5) DC Bus Voltage.
 - 6) Output Power.
 - 7) Output Torque.
 - 8) Output Current.
 - 9) Motor Speed.
 - 10) Process Speed.
 - d. The following parameters shall always be displayed during normal operation:
 - 1) Speed Reference.
 - 2) Run/Stop/Fault.
 - 3) Remote/Local.
 - e. The VSD shall have self-diagnostic properties to display faults and warnings as they occur and be able to store at least 15 previous faults into the fault memory. The fault memory shall be accessible by PC maintenance tools.
 - f. The following drive control functions at least shall be available from the keypad:
 - 1) Run.
 - 2) Stop.
 - 3) Local / Remote selection.
 - 4) Forward/Reverse (if function enabled).
 - 5) Accelerate (manual/mode).
 - 6) Decelerate (manual/mode).
 - 7) Parameter setting.
 - 8) Scrolling and Viewing through actual values.
6. Application programming: The VSD shall be designed for both simple and the most complicated applications, yet it shall be user friendly. The VSD shall have built-in application macros, to allow selection of the range of preprogrammed control configurations and further, the VSD shall enable storing of two customer modified macros at least, to suit the specific application. It shall be possible to reset the parameter settings back to the original macro settings through the keypad. The parameter readouts shall be in text format and not coded.
7. PC Tools: The VSD Supplier shall have a Windows based PC software available for monitoring and controlling the VSDs, and the software shall be offered as an option. The software shall be supplied with the necessary hardware and a provision for connecting a PC with the VSD. It shall be possible to set and modify parameters, control the drive, read actual values and make trend analysis using the software.

F. Software features:

- 1. Power loss ride-through: The drive shall have a power loss ride-through capability. This means that the drive controls should stay alive during a power loss by means of the energy stored in the load. The ride through time shall be the longer the higher the kinetic energy of the load is. The motor shall be magnetized as long as there is kinetic energy in the system.

2. Flying start: The drive shall have a built-in Flying Start feature. This feature will allow a motor unit which is still rotating, to be restarted without first stopping it. The VSD shall restart the motor from the rotating speed and then reaccelerate to the speed indicated by the speed reference signal. The Flying Start feature shall be available in both directions, to be able to start the drive in the required direction regardless of the rotation direction of the motor.
3. Flux Optimization: The VSD shall have a built-in automatic flux optimization function. The flux optimization function minimizes the sum of the magnetizing current and the load current so that the drive can still follow the given reference. This feature reduces energy consumption and motor noise when driving at less than the nominal load.
4. Flux braking: There shall be a possibility for Flux Braking, where VSD increases the motor magnetization to dissipate the extra energy in case of need for small braking power. It shall be possible to use the braking to decelerate the motor from one speed to another not only for stopping the motor.
5. Critical speed jump-over: The VSD shall have programmable skip speeds to jump over critical resonance speeds. If the speed reference is in the critical speed area, it is ignored and the latest speed reference is maintained. 3 programmable critical speeds at least shall be available.
6. Current/speed limiting: In case the acceleration or deceleration ramps are too fast for the drive capacity, the drive shall be able to automatically reduce the ramp to prevent tripping. Also, in case of transient overloads the drive shall automatically reduce speed to prevent an overcurrent trip, if the drive capacity is not sufficient to handle the load.
7. PID-controller The drive shall have a built-in PID-controller for control of the customer process.
8. Restart in the event of a fault trip due to overvoltage, overcurrent or loss of analog signal, the VSD shall be programmable to attempt an automatic restart. For safety reasons, the maximum number of attempts shall be five (selectable) within a short time. If the fault does not clear after the attempts, the drive shall lock out.

G. Environmental effects:

1. Harmonic Distortion: The VSD shall minimize the total harmonic distortion (THD). The THD of the unit for current has to be less than 50 percent in a supply network with a short circuit ratio (Rsc) of 300 (i.e. the ratio of the supply network's short circuit current to the unit's nominal current). If the supply voltage is 440 V or higher, the THD value has to be less than 55 percent. However, the VSD manufacturer shall submit to the Contractor the VSD harmonic spectrum for the Project specific supply network. The spectrum shall be used in the design of appropriate harmonic filters, if required by the Customer. The single harmonics shall be presented up to 25th harmonic and the THD has to be calculated taking into consideration harmonics up to 40th harmonic.
2. EMC Regulations and Compatibility/C-Tick:
 - a. The supplied VSDs shall carry the CE mark (or C-Tick in Australia) indicating that they comply with the essential requirements of the relevant EU directives (or C-Tick requirements in Australia). The VSDs shall meet the requirements set in EN 61800-3 for Industrial Low-Voltage Networks. If the project-specific specification states that the requirements for Public Low-Voltage Networks stated in EN 61800-3 must be met, the supplier shall be able to provide such units at least up to 75kW in earthed networks. If separate EMC filters are required, they shall be of built-in type.
 - b. A detailed description and other directions to maintain the EMC Compatibility during the installation of the VSD and associated field cables and connections, shall be given by the Supplier in conformance with the EMC Directives or C-Tick. The Contractor shall follow the directions during installation, in order to achieve attenuation of the RFI.

3. Audible Noise: The full load audible noise of the frequency converter shall not exceed 70 dB(A) in 200 kW applications and below. Above 200 kW, the full load audible noise shall not exceed 78 dB(A). If the frequency converter is installed in a cabinet and requires a separate cooling fan, these limits also include the noise of the additional cooling fan. This requirement is made to keep the electrical room quiet so that it is not necessary to use hearing protection. The audible noise of the motor should also be minimized. For that purpose the switching frequency of the frequency converter shall be at least 2 kHz throughout the power range.
4. Efficiency: The full load efficiency of the VSD shall be at least 98 percent including all the additional equipment which is needed to meet the Specification.

H. Documents:

1. Documents to be delivered with the quotation: The following documents have to be delivered with the quotation:
 - a. Drawings: Dimension drawings, control connection diagram for a standard unit. If order specific engineering is required, the engineered drawings have to be sent for approval before the delivery.
 - b. Quality Assurance : Quality Plan
2. Documents to be delivered with the delivery: The following documents have to be delivered with the delivery:
 - a. Manuals: These must contain instructions on how to install and start-up the VSD, how to program the VSD, instructions for maintenance and for trouble shooting. The VSD manufacturer must also present proper recycling instructions for the VSDs.
 - b. Drawings: Dimension drawings, control connection diagram.
 - c. Quality Assurance: Test reports.
3. The VSD manufacturer must also present proper recycling instructions for the VSDs.

2.3 STARTERS

- A. Starters for 3 phase motors to be magnetic type to automatically disconnect motor from power supply in case of supply failure, excessive voltage drop, overcurrent and lack of balance in phases. Overload trips to be provided for three phases.
- B. Motor Data: Obtain from equipment supplier before ordering any motor starter, or check motor nameplate for full load current rating and allowable temperature rise in order to select proper overload thermal element for motor starter.
- C. Short circuit protection device fitted to starter to be independent of controller and overload protection to be selected to provide type-2 coordination.
- D. Control voltage for starters and control circuits is not to exceed 110 V.
- E. Step down Control Circuit Transformers: Two winding isolating type.
- F. Control Circuit Protection: Use high rupturing capacity fuses or circuit breakers.
- G. Auxiliary supply for controls other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

- H. Control devices on starters to be as follows unless otherwise indicated or required by driven equipment: start stop push buttons, one red pilot light for "running", one green pilot light for "stopped" and one reset push button.
 - I. Starter type A for single phase motors not exceeding 1/2 HP to be surface or flush mounted, manual two pole toggle type, for non reversing across the line starting, fitted with one overload element.
 - J. Starter type B for three phase motors not exceeding 10 HP to be direct on line, non reversing, magnetic type, with manual reset, 3 pole overload relay and low voltage protection, unless otherwise required by local regulations.
 - K. Starter type C for three phase motors over 10 HP to be one of the following as shown on drawings:
 - 1. Digitally controlled drive (VSD)
 - 2. Solid state reduced voltage controller (Soft starter).
 - 3. Automatic magnetic star delta non reversing type
 - 4. Multistep magnetic auto transformer non reversing type
 - L. Starter type C shall be fitted with 3-pole overload protection relay unless otherwise required by local regulations.
 - M. Individually mounted starters to be totally enclosed in sheet steel enclosure with baked enamel finish. Design is to suit location and application. It is to be impossible to open enclosure door unless isolator is in open position.
 - N. Nameplates: Starters and controls to have engraved nameplates identifying system or defining its function.
 - O. Contactors: Comply with IEC 60947-4, utilization category AC3 or AC4 as applicable, 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, an 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. 3 N.O. (normally open) and 3 N.C. (normally closed) spare contacts are to be provided on each contactor.
 - P. Contactors shall be of robust design and shall comply with BS EN 60947: Part 4-1. They shall operate without undue noise or vibration. Where 2 or more contactors are contained in the same cubicle, they shall be separated by barriers. All secondary wiring shall be so arranged and protected as to prevent its being damaged by arcing.
 - Q. Starter Co-Ordination: Motor starter devices shall be of type 2 co-ordination to IEC 947-4-1.
- 2.4 SOLID-STATE, REDUCED-VOLTAGE CONTROLLER (SOFT STARTER):
NEMA ICS 2 or equivalent IEC, suitable for use with NEMA MG 1, Design B, 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.
- 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.

2.5 COMBINATION STARTERS SWITCH DISCONNECTORS

- A. Components to comprise magnetic starter switch disconnecter and short circuit protection devices required by the Standards, in approved sheet metal enclosure to suit application.
- B. Switch Disconnecter Operating Mechanism: Quick make, quick break, with external operating handle mechanically interlocked with enclosure cover necessitating disconnecting switch to be in OFF position for access to inside of enclosure. Means are to be provided for by passing interlocks. Position of isolating switch to be clearly indicated on cover.
- C. Short circuit protection gear to be HRC fused cartridges or molded case circuit breakers of appropriate current rupturing capacity. Switch disconnectors are not required if circuit breakers are used for the short circuit protection. In this case the circuit breaker will perform the disconnection function.
- D. Operation of circuit breaker to be possible from outside of enclosure. Position of breaker ON/OFF/TRIPPED to be clearly indicated by position of handle.

2.6 PUSH BUTTONS

- A. Push buttons to be one unit momentary contact START/STOP with normally open or normally closed contacts as required by wiring diagrams and with lockout attachments. Heads to be color-coded and STOP button to be protected. Push buttons controlling one piece of equipment to be housed in separate enclosure.
- B. All push buttons shall be of the non-retaining type made of non-hygroscopic materials, non-swelling and fitted to avoid any possibility of sticking.

2.7 RELAYS

- A. Relays to be multi-pole with normally open or normally closed contacts, electrically operated at 110 V maximum, and magnetically held. Contacts to be double break silvered type, interchangeable from normally open to normally closed without additional parts. Relays are to be rated at 10 A, 600 V.
- B. Relays installed on relay bases shall have retaining clips.

2.8 CIRCUIT PROTECTORS AND SWITCHES

- A. Motor Circuit Protector: Molded case, magnetic break type with adjustable instantaneous setting suitable for motor protection.
- B. Motor circuit protectors are to be in compliance with IEC 60947-2, utilization category B, sequence II (service capacity) for motor control centers and sequence III (ultimate capacity) for motor control panels and combination starters unless otherwise indicated on the drawings.

- C. Molded Case Switch: Similar to circuit breakers but without overload/short circuit protection. Short time rating of switches is to be not less than the short circuit current at switch location for 3 cycles. Switches are to have a suitable self-override instantaneous protection and to be in compliance with IEC 60947-3.
- D. Main incoming switches to be equipped to provide earth fault under voltage and phase sequence protection through shunt trip coil. Earth fault detection and interruption to be time coordinated with those of main incoming breaker on main distribution board.

2.9 MOTOR CONTROL CENTER

- A. Type: Totally enclosed, IP 42 for indoor installation, and IP 55 for outdoor installation and in wet areas (e.g. pump rooms), free-standing type.
- B. Construction: 2 mm thick sheet steel, adequately reinforced and braced for maximum rigidity, sand blasted, rust inhibited after fabrication and sprayed with one coat primer and two coats enamel internally and externally.
- C. Components: Motor control center to include the following:
 - 1. Main incoming circuit breaker or isolating switch as shown on the Drawings for terminating incoming supply cables and isolating the busbar system.
 - 2. Main copper horizontal full-length busbars rated as main incoming circuit breaker or as shown on the Drawings.
 - 3. Branch copper vertical full height busbars of adequate capacity to distribute power to each circuit breaker and starter served.
 - 4. Neutral copper busbar rated at half capacity of main busbar and distributed throughout whole motor control center.
 - 5. Earth copper busbars minimum 25 x 6 mm extending full length of motor control center.
 - 6. One voltmeter with commutator, range 0-415 V.
 - 7. Ammeters on main supply with necessary current transformers.
 - 8. Starters, circuit breakers, push buttons, indicating lights, switches, relays, contactors and accessories as shown on the Drawings.
 - 9. Interconnecting and interlock wiring.
- D. Wiring: Motor control center wiring to be as per IEC 61439 standard.
- E. Busbars to be adequately isolated and braced to sustain maximum possible short circuit current.
- F. Compartment doors to be interlocked so that isolators or breakers must be in OFF position before door can be opened.
- G. Spare Positions: Fully equipped cells, ready for connection to motors, are to be provided in adequate number.
- H. Space Positions: Fully equipped cells ready to receive control unit are to be provided in adequate number. Space positions to have blank cover plates.
- I. Starters, switches, other components and electrical devices to be clearly labeled in English as to number and function, with incised letters on black Bakelite with white laminated core. Labels to be permanently fixed under each component.
- J. Incoming line connections to be made with solderless, terminal four bolt type clamps.
- K. Labels: Starters, switches, electrical devices and accessories to be clearly labeled in English as to function and number. Labels to be permanently fixed under each component.

- L. Schematic and wiring diagrams to be firmly fixed within motor control centre, showing each component and cross- referenced with component labels.
- M. Submit for approval electrical schematic diagram of whole installation suggested layout of motor control centre, interior wiring details and complete technical literature on all proposed components, prior to fabrication or purchase.
- N. Selectivity between upstream and downstream shall be achieved, and selectivity study shall be submitted to engineers for approval.
- O. Motor control centers fed directly from MDB shall be equipped with Class II surge protective devices. SPDs along with their fused-disconnect switch shall be integrated within or adjacent to the MCC's enclosure.

2.10 MOTOR CONTROL PANELS

- A. Type: Wall mounted or unit mounted, lockable type, IP 42 for indoor installation.
- B. Construction: Minimum 1.5 mm thick hot-dip galvanized steel sheet, finished with one coat etch primer and one coat stove enamel internally and externally.
- C. Panels installed outdoors and in wet areas to have weatherproof totally sealed water and dustproof IP 54 enclosures.
- D. Components: Panels are to contain necessary breakers, starters, push button switches, selector switches, relays, indicating lights, interconnecting and interlock wiring and all devices and accessories required for automatic or manual operation of equipment as specified under equipment concerned.
- E. Labels: Starters, switches, electrical devices and accessories to be clearly labeled in English as to function and number. Labels to be permanently fixed under each component.
- F. Schematic and wiring diagrams to be mounted in permanent approved manner on inside of panel door. Diagrams are to show each component cross referenced with component labels.
- G. Motor control panels shall be equipped with Class II surge protective devices SPDs along with their fused-disconnect switch shall be integrated within or adjacent to the MCP's enclosure.

2.11 CONTROL SWITCHES

- A. Float Switch: Level operated, heavy duty, bracket mounted type, suitable for application in open tanks, complete with 178 mm spun copper float, brass rod, two stops, floor mounting stand, lever and counterweight. Switch to have oil tight and dust tight enclosure and 2 pole double throw silver contacts that open on liquid rise:
- B. Pressure Switch: Industrial, heavy-duty bellows actuated type, suitable for water service, with contacts to close on falling pressure. Range to be 0.1 to 8 kg/cm². Switch to be good for 1720 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts and setting adjustment:
- C. Low Suction Pressure Switch: Industrial, sensitive, low range, diaphragm actuated type, suitable for water service, with range of 2 to 20 kPa of falling pressure, preset at factory to 3 kPa. Switch to be good for 690 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts, range adjustment knob, sealing cap and range locking nut:

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.
- C. Push-Button Stations: In covers of magnetic controllers for manually started motors where indicated, start contact connected in parallel with sealing auxiliary contact for low-voltage protection.
- D. Hand-off-automatic Selector Switches: In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.

3.2 INSTALLATION

- A. Install motor control centers according to manufacturer's written instructions.
- B. Anchor each motor control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by tack welding or bolting. Level and grout sills flush with motor control center mounting surface.
- C. Install motor control centers on concrete housekeeping bases conforming to Division 3 Section "Cast-in-Place Concrete."
- D. Fuses: Install fuses in each fusible switch as indicated.
- E. Power and Control Wiring: Run in separate conduits unless otherwise specified.
- F. Rigid conduits are not to terminate in nor be fastened to a motor frame or base.
- G. Flexible conduits to be used at motor connections. Allow sufficient slack to permit motor to slide over adjustable length of motor base.
- H. Flexible Conduits: Length and radius to be sufficient to permit bending of feeder cables without damage to conductor or its insulation.
- I. Flexible Conduits: Do not use in place of rigid conduits except at motor connections, unless otherwise specified.
- J. Support conduit with conduit supports in an adequate approved manner.
- K. Conduits are not to cross pipe or vent shafts, ducts or openings. They are to be run a minimum 100 mm away from pipes of non-electrical services.
- L. Conduits: Install so that moisture can drain to lowest point. Provide screw plug at all low points for draining.

3.3 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs according to Division 26 Section "Basic Electrical Materials and Methods."

- B. Operating Instructions: Frame printed operating instructions for motor control centers, including control sequences, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of motor control centers.
- C. Starters: Fix detailed wiring diagram inside enclosure cover to clearly indicate circuits.
- D. Starters: Identify control and power wires either by distinctive colored insulation, engraved tags or other approved method.

3.4 CONTROL WIRING INSTALLATION

- A. Bundle, train, and support wiring in enclosures.
- B. Protect circuits with high rupturing capacity fuses or circuit breakers. Auxiliary supply for controls other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.
- C. Connect hand-off-automatic switch and other automatic control devices according to an indicated wiring diagram or one that is manufacturer approved, where available.
 - 1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the 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.

3.5 EARTHING

- A. Earth motors by connecting green insulated conductor from earthing bushing in starter to motor frame. Run earth conductor together with circuit wiring and terminate in motor terminal box, provided earth terminal in box is connected to motor frame. If this is not feasible, extend earth conductor through insulated bushed opening in terminal box and connect to motor base.
- B. Earth equipment by connecting non-current carrying metal parts of system to earth source. Non-currents carrying metal parts include conduits, cable trays, outlet boxes, cabinets, enclosures, doors, grilles, and barriers protecting or shielding electrical equipment from direct access.

3.6 CONNECTIONS

- A. Tighten motor control center bus joint, electrical connector, and terminal bolts according to manufacturer's published torque-tightening values.

3.7 FIELD QUALITY CONTROL

- A. Testing: After installing motor control center and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform recommended visual and mechanical inspection and electrical test. Certify compliance with test parameters.
 - 2. Remove and replace malfunctioning units with new units, and retest.

- B. Circuit Breakers: Co-ordinate earth fault detection and interruption with those of main incoming breaker on main distribution panel.
- C. Pressure Switches: Test after installation to ensure dependable operation and correct setting.
- D. Low Suction Pressure Switches: Test after installation to ensure dependable operation and correct setting.

3.8 CLEANING

- A. Inspect interior and exterior of motor control centers. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

3.9 DEMONSTRATION

- A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation. Refer to Division 1 Section.”

END OF SECTION 26 24 19

SECTION 262500 - LOW VOLTAGE ENCLOSED BUS ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes bus assemblies and fittings.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".

1.3 SUBMITTALS

- A. Technical Data: Include electrical ratings, dimensions, mounting position, mounting method, vertical supports, materials, firestops, and weather stops for each component.
- B. Shop Drawings: Detail fabrication and installation of enclosed bus assemblies including plans, elevations, sections, component details, and attachments to other construction elements. Detail connections to switchgear, switchboards, transformers, and panel boards. Detail supports and connections to building.
- C. Coordination and Construction Drawings: Include floor plans and sections to show enclosed bus-assembly layouts and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed bus-assembly components through one source from a single manufacturer.
- B. Type tested as per IEC 61439 or UL857

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle bus assemblies according to Standards recommendations.

1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify existing dimensions by field measurements. Verify clearances and locate obstructions within manufacturing and installation tolerances of enclosed bus assemblies.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match product installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Plug-in Units: 10 percent of installed units.
 - 2. Hookstick operator for plug-in units.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB (Germany)
 - 2. Schneider Electric (France)
 - 3. Cutler-Hammer. (U.S.A.)
 - 4. GE (U.S.A.)
 - 5. Klockner Moeller (Germany)
 - 6. Siemens. (Germany)

2.2 BUSBAR TRUNKING (BUSDUCT)

- A. Type: Indoor, 600/1000 V grade, 3-phase, 4-wire with fully sized neutral and half size earth bar, insulated, totally enclosed and of compact design, with ratings as shown on the Drawings at site maximum ambient temperature conditions. Busbar is to comply with approved standards. Short-circuit capacity is to be at least equal to value at main protective device, for 1 second.
- B. Construction: Prefabricated, insulated flat Aluminum conductors, with 2 mm (No. 14 gauge) galvanized sheet steel flanged casing, totally enclosed, non-ventilated, indoor type. Housing is to be bonderized inside and outside and finished with gray baked enamel. Busbars are to be provided with extra insulation between busbars and housing. Joints between sections are to have special insulation, flanged and pressure bolted, easily dismantled and giving equally strong mechanical connection to busbar sections. Any one section of the busduct is to be removable without disturbing adjacent sections.
- C. Reactance: Busbar is to be specially built and assembled to provide low reactance.
- D. Connections: Conductors are to be silvered at all connection surfaces. Connections are to be bolted. At plug-in tap-off unit openings, busbars are to be flared and strengthened against fault stresses.
- E. Plug-in units are to be of rating shown on the Drawings, and comprise circuit breaker housed in sheet steel enclosure complete with stabs, stab shields and earthing stab,

which makes before power connection stabs. Protective interlocks (releasable) are to be provided to prevent opening of cover whilst circuit breaker is plugged in and in the closed position, to prevent insertion or removal of unit when circuit breaker is in the closed position, and to prevent closing circuit breaker with cover open. Circuit breaker is to be as described in Division 26 Section "Switchboards".

- F. Accessories: Busbar is to be complete with necessary factory made adaptor boxes, junction boxes, bends, expansion connections, fittings, fire barriers etc. as may be required to provide complete system between terminal points indicated on the Drawings. Fixing and mounting materials are to be galvanized steel. For vertically mounted busbars, spring suspension type hangers are to be used for equalizing weight of trunking between all supports.
- G. Terminal adaptors or chambers are to be factory made. Coordinated components at both ends are to match equipment connected thereto. Connections are to be made with insulated copper bars of equivalent sections and of exact shapes to fit and be fixed with bolts and spring washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install bus assemblies, level and plumb and according to manufacturer's written instructions, Shop Drawings, and referenced standards.
- B. Support bus assemblies independent of supports for other elements such as equipment enclosure at connections to panel boards and switchboards, pipe, conduit, ceilings, and ducts.
 - 1. Design each fastener and support to carry 90 kg or four times the supported weight of bus assembly, whichever is greater.
 - 2. Support bus assembly to prevent twisting from eccentric loading.
 - 3. Support bus assembly, with not less than 10-mm steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
 - 4. Fasten supports securely to building structure according to Division 26 Section "Basic Electrical Materials and Methods."
- C. Install expansion fittings at locations where bus assembly crosses building expansion joints. Install at other locations so distance between expansion fittings does not exceed 90 percent of manufacturer's recommended distance between fittings.
- D. Install firestop fittings where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetration according to Division 7 Section "Through - Penetration Fire Stop Systems" as directed by Engineer.
- E. Install appropriate weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as wall or roof. Seal around openings to make weathertight.
- F. Install a concrete curb at least 75 mm high around bus-assembly floor penetrations.
- G. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
- H. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

- I. Install bus-assembly plug-in units. Support connecting conduit independent of plug-in unit.
- J. Connect bus assemblies and components to wiring system and to ground as indicated and instructed by the manufacturer.

3.2 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:
 - 1. After installing enclosed bus assemblies and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each recommended visual and mechanical inspection and electrical test. Investigate any insulation-resistance reading less than 30 megohms divided by bus-assembly length in meters. Certify compliance with test parameters.
- B. Repair or replace malfunctioning units. Retests as specified above after repairs or replacements are made.

3.3 ADJUSTING

- A. Set field-adjustable overload trips to match motor loads.
- B. Align bus-assembly runs vertically and horizontally to eliminate sags and twists. Provide additional stiffeners if required to restrict excessive movement.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris. Repair damaged finish to match original finish.

3.5 PROTECTION

- A. Provide final protection to ensure that moisture does not enter bus assembly.

3.6 COMMISSIONING

- A. Infrared Scanning: Two months after Substantial Completion perform an infrared scan of bus assembly including joints and plug-in units.
 - 1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - 2. Perform two follow-up infrared scans of bus assembly, one at four months and the other at 11 months after Substantial Completion.
 - 3. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken and scanning observations after remedial action.

3.7 DEMONSTRATION

- A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.

END OF SECTION 262500

SECTION 262726- WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes wiring devices, lighting switches, socket outlets, cord outlets, automatic and manual lighting control equipment, dimmers, outlet boxes and plates, etc.
- B. Components are to be standard manufactured items, uniform and modular, complying with one set of approved Standards.
- C. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Raceways and Boxes" for boxes.

1.3 SUBMITTALS

- A. Technical Data: Submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each item.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Exact indication of position of each item and outlet box and fitting on layout drawings, with box and equipment types and sizes.
 - 2. Installation details of special devices including fans etc.
 - 3. Wiring diagrams of special items.
- C. Samples: Submit samples of each type of device for approval, unless otherwise agreed in writing by the Engineer.
- D. Maintenance Data: For materials and products to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Comply with related Standards.

1.5 EXTRA MATERIALS

- A. Furnish [2] % (with minimum of one each) extra materials for all products that match those installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Employer.

PART 2 - PRODUCTS

- A. Approved Manufactures: subject to compliance with requirements, provide products by one of the following or approved equal as per Project's Vendor List:

- | | | |
|----|--------------------|-----------|
| 1. | Legrand | (France) |
| 2. | Schneider Electric | (France) |
| 3. | MK/Honeywell | (UK) |
| 4. | ABB | (Germany) |

2.2 PLATES, GENERALLY

- A. Blank Plates: Blank plates are to be installed on outlet boxes, specified under Division 26 Section "Raceways and Boxes", on which no apparatus is installed or where apparatus installed does not have suitable cover for box. Blank plates for wall outlets are to be attached by a bridge with slots for horizontal and vertical adjustment.
- B. Floor outlets and plates are to be watertight and impact resistant.

2.3 PLATES AND CORD-OUTLETS

- A. Design: Square, rectangular or round designed to cover outlet box and to closely fit electrical device, and with polished chromium plated recessed head fixing screws. Combination plates are to be used for grouped outlets and devices.
- B. Cord extension plates are to have threaded cord grip bushings of same material and finish as plates.
- C. Plastic Plates: Heavy gauge, break resistant, pressure molded plastic, polycarbonate or thermoplastic white color, for general use in front of house areas such as: lobbies, reception, service, storage rooms, offices, administration rooms, electrical and low current rooms and the like.
- D. Metal Plates: Heavy gauge, minimum 1 mm thick, for use in back of house area such as: Mechanical rooms/Plants, MV switchgear room, Transformer rooms, Generator rooms, low voltage rooms and elevator machine rooms.
- E. Cable/cord outlet (electric outlet) is to be used for up to 45 A, 250 V rating for connection of power/control cable of fixed appliances. Plate is to have threaded cord grip to anchor cable securely to cover. Box is to include fixed terminal block and cable clamp for termination of cable/cord within.
- F. Lighting outlet is to consist of outlet box, cover plate, and necessary accessories ready for connection to lighting fixture.

2.4 SWITCHES

- A. Generally: Quick-make, quick-break type with silver alloy contacts in arc resisting molded base, with toggle, rocker or push-button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side and/or back connection.
- B. Types: Single, two-way or intermediate, single pole or double pole, as shown on the Drawings.
- C. General Lighting Switch (S1): 10A, 240 V a.c., rocker operated, painted polycarbonate or thermoplastic front cover, for all indoor installations in general (lobbies, typical corridors, offices, BMS, etc...) unless otherwise indicated.
- D. Push Button Switch: As type (S1) but with push button control (push to make, push to break) at Reception Area, Stairs. To manually override the occupancy sensors as described in drawings
- E. Remote Lighting Control Panel for Contactor Control: Multiple two way momentary on/off push switch assembly, with an 'on' pilot light for each circuit controlled (remote contactor). Panel and box are to be sheet steel construction, with see-through steel-framed acrylic door and trim, handle and lock. Enclosure protection IP 42 to IEC 144 for indoor installation and IP 55 for outdoor installation.
- F. Weatherproof Switch (S15): 10 A, 250 V, for installation outdoors, with weatherproof plate, synthetic gasket, weatherproof outlet box, on/off indication, IP 55 enclosure.
- G. Double Pole Switch (S20): Rated 20 A (as shown on the Drawings), 250 V a.c., tumbler operated, to IEC 60669-1 or BS 3676, with stainless steel or molded plastic plate (as required in application area), marked (etched) with equipment controlled (i.e. cooker, air conditioner, water heater) and with red neon pilot light for "on" position. Switch is to be mounted to flush or surface box, as required or as shown on the Drawings, and provided with cord outlet and cord extension to equipment controlled.
- H. Manual Switch: 2 pole, for fractional single phase motors and appliances, to interrupt motor and induction loads, rated 30 A at 240 V a.c., and 20 A at 600 V a.c., toggle operated, with positive indication of on/off position of contacts.
- I. Water heater outlet and 20 A double pole switch

2.5 SOCKET OUTLETS

- A. Generally: To have injection molded plastic base with self-adjusting, non-expanding contacts to prevent permanent distortion, arranged for side and/or back connection and with screw terminals accepting at least three parallel branch-circuit wires.
- B. Types: General-purpose socket outlets are to conform to standard: IEC 60309. And German type standard practice.
- C. Duplex sockets are to be mounted in parallel under one common plate with break-off feature for two-circuit connection.

- D. Weatherproof socket outlets are to be any of the types indicated, enclosed in surface mounted cast metal box and with cover comprising spring-retained gasket hinged flap. Enclosure is to be pre-designed box and cover for type of socket outlet specified.
- E. Standard German Socket Outlet - Type R01: Single phase 3 wire, with 3mm round 2 pins at 19 mm centers, German type, earth at top/bottom, rated 16 A, 250 V, unswitched, with robust shutter mechanism operated by earth pin, used in back of house area such as: service, storage rooms, offices, lobbies, Reception, administration rooms, electrical and low current rooms and the like.
- F. Weatherproof Socket Outlet - Type R05: 16 A, 250 V, 2 pole plus earth, to IEC 60309, German type standard, enclosed in surface mounted, polycarbonate enclosure with cover comprising spring- retained gasket hinged flap.to be used in wet indoor areas and outdoor areas (IP 55).

Man: LEGRAND CAT: Plexo Series 069831 or other approved equal from project's vendors/manufacturer List

- G. Power Socket - Type R41: Single outlet, single phase, three wire, 2P+E, 20A, 200-250 V (otherwise indicated on the drawing), polarized with L-shaped earth contact, splash proof with plastic enclosure and matching plug, IP44 to IEC60309-1&2, Surface Mounted.

Man: LEGRAND CAT: Tempra Series 555 53 or other approved equal from project's vendors/manufacturer List.

- H. Power Socket Outlet - Type R45: Single outlet, 3P+N+E, 3 phase, polarized, earthing type, rated 32 A (as indicated on the drawing), 380/415 V, to BS 4343 and IEC 309, with splash proof plastic enclosure, and hinged spring-return plate, and with matching plug 3P+N+E.

Man: LEGRAND CAT: Tempra Series 555 73 or other approved equal from project's vendors/manufacturer List.

- I. UPS sockets are dedicated green.

2.6 PLUGS

- A. Type: Compatible with type of socket outlet specified, break resistant, of impact resistant molded insulating material (separable construction), with solid brass pins and cord grip and of shape Providing Easy Hand-Grip for Removal.
- B. Quantity: Supply number equal to 20% of total number of each type of socket outlet supplied.
- C. Fuses for standard British type sockets are to be standard 13 A cartridge fuses fitted in plug.

2.7 SPECIAL DEVICES

A. Lighting Contactors

1. Type: Double pole for single phase and neutral circuits, and triple pole for three phase circuits, mechanically held, electrically operated, rated 500 V, of current ratings shown on the Drawings, and complying with IEC-158-1 category AC 2 and AC 3.
2. Contacts: Copper alloy, with silver cadmium alloy double break contacts designed for switching inductive ballast loads and switching of tungsten lamp loads.
3. Auxiliary Contacts: As required to provide specified interlocks and signals as shown on the Drawings, or required by the Specification, with one N.O. and one N.C. spare contacts.
4. Enclosure: Unless forming part of system housed in sheet steel panel, contactor is to be provided with IP 42 enclosure for indoor use or IP 65 enclosure for outdoor use.
5. 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.

B. Photoelectric Cells

1. Photoelectric Cells: Omnidirectional cadmium sulfide, hermetically sealed, with 2:1 on/off adjustment possible by moving light level selector, set to operate at illuminance levels shown on the Drawings. Unit is to include timer giving 3-minute delay to prevent false switching. Temperature range is to be -10 deg. C to +80 deg. C.
2. Safety: Control is to be designed such that in case of failure, unit fails in the on position.
3. Contacts are to close or open as illumination level increases to set level with respect to requirements shown on the Drawings.
4. Enclosure: Heavy duty cast metal, with translucent dome of 'Lexan' (by G.E.) or other equal and approved, to protect against high ultra violet rays, and 180 deg. swivel base and 16 mm threaded conduit mounting. Enclosure is to be weatherproof and protected against high winds and storms.

C. Dimmers for Incandescent or Fluorescent Lamps

1. Generally: Dimming control is to be suitable and rated for type and number of lamps indicated on the Drawings, and is to be electronic with thyristor control of the start of each alternating current flow.
2. Variation of Luminous Intensity: Smooth over continuous dimming range from 1% for incandescent lamps, and from 5% for fluorescent lamps, up to 100% intensity or full normal brightness.

3. Components are to be designed, rated and installed so that dimmer operates continuously at any setting. Components are to be installed in separate enclosure or as part of dimmer control panel as indicated on the Drawings.
4. Fluorescent Dimming: Control systems are to be coordinated design, electronic, used with electronic ballasts specified for dimming, whether for standard type preheat 38 mm conventional fluorescent tubes or 26 mm tri-phosphor tubes.
5. Remote control is to be arranged so that control can be made either local at dimmer or local and remote at positions indicated on the Drawings.

D. Time-Switch

1. Type And Rating: Clock is to be escapement mechanical type, electrically rewound, with 24 hours dial and time adjustment and rated 10 A, 250 V.
2. Spring reserve mechanism is to allow up to 12 hours operation in the event of power failure.
3. Switching is to be capable of performing two on and two off operations, adjustable, over 24 hours.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Locations: Drawings generally show approximate locations of outlets and equipment. Exact locations are to be determined from interior finishing and detail drawings. Any condition that would place an outlet in an unsuitable location is to be referred to the Engineer. Locate switches at strike sides of doors, whether shown on the Drawings or not. In locating outlets allow for overhead pipes, ducts, variations in arrangement, thickness of finishing, window trim, paneling and other engineering features.
- B. Mounting heights for outlet boxes and similar equipment are to be uniform within the same or similar areas. Mounting is to be as shown on the Drawings or as approved by Engineer. Unless otherwise shown or instructed, mount lighting switches and socket outlets generally at 1200 mm and 300 mm from finished floor level respectively. Mount switches with long dimension vertical and operating handle, if of the toggle type, up when in the on position.
- C. Additional outlets to those shown on the Drawings are to be provided as required by equipment manufacturers for control or other wiring.
- D. Recessed Outlet Boxes: Make neat openings, to the satisfaction of the Engineer, allowing for thickness of finishing, and use extension rings if required. Repair damaged finishing to original condition before installation of fittings or plates.
- E. Appearance: Install exposed boxes and plates plumb, square and parallel to finished wall surface. Exposed plates covering recessed boxes are to rest neatly on wall surface without gaps, and fully covering the box.

- F. Grouped Outlets: Arrange neatly so that use of fittings is convenient and clear.
- G. Waterproof and Explosion-Proof Fittings: Follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.
- H. Damaged Fittings: Reject damaged fittings or plates with damaged finish. Protect fittings and plates against damage after installation and until handed over.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Basic Electrical Materials and Methods."
 - 1. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.
 - 2. Receptacles: Identify panel board and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

3.3 CONNECTIONS

- A. Single pole switches are to switch the phase wire. Do not run neutral wire through switches having neutral shunt or bridge.
- B. Exposed Outlet Boxes: Securely fasten to wall with machine screws to permanent inserts or lead anchors.
- C. Connection Of Appliances:
 - 1. Where appliance is designed to adapt directly to outlet box, extend electrical wiring to incoming terminals inside appliance.
 - 2. Where appliance is not designed to adapt to outlet box, install the connecting wiring in flexible conduit firmly fixed to outlet box cover plate and to terminal box on appliance.
- D. Tighten electrical connectors and terminals according to manufacturers' published torque-tightening values.

3.4 FIELD QUALITY CONTROL

- A. Visual Inspection: Fittings and equipment are to be inspected for fixing and workmanship.
- B. Megger tests are to include switch and socket outlet tests together with insulation resistance of wiring installations.
- C. Operation: Devices are to be tested for operation and are to perform as intended at full load without any signs of heating.
- D. Equipment is to be insulation tested and observed, under full-load for not less than 3 days operation, with respect to undue heating and performance in general.

3.5 CLEANING

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

END OF SECTION 262726

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
 - 1. Service disconnecting means.
 - 2. Motor and equipment disconnecting means.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Wiring Devices" for attachment plugs, receptacles, and toggle switches used for disconnecting means.
 - 3. Division 26 Section "Switchboards" for circuit breakers.
- C. Components are to be standard manufactured items, uniform and modular, complying with one set of approved Standards.

1.3 SUBMITTALS

- A. Technical Data: Submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each type of switch, circuit breaker, accessory, and component indicated.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details.
 - b. Current and voltage ratings.
 - c. Short-circuit current rating.
 - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

- C. Field Test Reports: Submit written test reports and include the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Samples: Submit samples of each type of equipment for approval, unless otherwise agreed in writing by the Engineer.
- E. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals. In addition to requirements specified under "Closeout Procedures," include the following:
 - 1. Routine maintenance requirements for components.
 - 2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
 - 3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.4 QUALITY ASSURANCE

- A. Comply with related Standards.

1.5 COORDINATION

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

1.6 EXTRA MATERIALS

- A. Furnish extra materials described below that match product installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Employer.
 - 1. Spare Fuses for Fused Switches: **[10%.]**

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Merlin Gerin (France)
 - 2. ABB (Germany)
 - 3. Cutler-Hammer. (U.S.A.)
 - 4. G.E. (U.S.A.)

- | | | |
|----|--------------|-----------|
| 5. | M.E.M. | (England) |
| 6. | Siemens | (Germany) |
| 7. | Westinghouse | (U.S.A.) |

2.2 SWITCH DISCONNECTOR (DISCONNECTING SWITCH)

- A. Rating: 500 V, 2, 3 or 4 pole, load break, short-circuit make, in accordance with IEC 60408, utilization category 22 for heating and lighting loads, category 23 for motor circuits, and with ampere rating shown on the Drawings.
- B. Design: **non-fused**, air-break switch disconnecter, single throw, safety type, housed in separate metallic enclosure with arc quenching devices on each pole.
- C. Operating Mechanism: quick-make, quick-break, independent of operator, with external operating handle mechanically interlocked to prevent opening the door unless switch is in open position. Switch disconnecter is to have provision for by-passing interlock. Position of handle is to be positive and clearly indicated on cover.
- D. Enclosure: general purpose sheet steel for indoor use IP 42, and weather-proof type cast-metal or sheet steel for outdoor installations IP 65, unless otherwise required or shown on the Drawings. Locking of operating handle is to be possible in open and closed positions.

2.3 ENCLOSED CIRCUIT BREAKERS

- A. Circuit Breaker: Refer to respective type specifications in Division 26 Section "Switchboards".
- B. Enclosures: Meet environmental conditions of installed location in accordance with IEC 60529.

2.4 FACTORY FINISHES

- A. Finish: Manufacturer's standard [Coordinate custom-color requirements with sample submittal requirements] paint applied to factory-assembled and -tested enclosures before shipping.

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.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Locations: Drawings generally show approximate locations of equipment. Exact locations are to be determined from detail drawings. Any condition that would place equipment in an unsuitable location is to be referred to the Engineer.
- B. Waterproof Fittings: Follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.
- C. Damaged Equipment: Reject damaged equipment. Protect equipment against damage after installation and until handed over.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Basic Electrical Materials and Methods."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

- A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.
- B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.5 FIELD QUALITY CONTROL

- A. Visual Inspection: Equipment is to be inspected for fixing and workmanship.
- B. Operation: Devices are to be tested for operation and are to perform as intended at full load without any signs of heating.
- C. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
 - 2. Test continuity of each line- and load-side circuit.

3.6 CLEANING

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

END OF SECTION 26 28 16

SECTION 26 32 13.13 - DIESEL-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes standby/emergency power supply installation comprising the following:

1. Diesel generating set, with associated auxiliaries, exhaust system, start-up system, cooling system, fuel system, batteries and charger etc.
2. Fuel storage and transfer system
3. Instrumentation, protection, control and monitoring equipment
4. Integrated Parallel of generator sets, where applicable
5. Outdoor enclosure, where applicable
6. Manually operated overhead hoist
7. Inter-plant cabling and wiring
8. Earthing.
9. Connection to BMS system, including interface elements such as relays, transducers, etc. as detailed in Division 23 Specification Sections BMS schedules and /or shown on the Drawings.
10. Synchronization switchboard.

- B. Related Sections include the following:

1. Division 23 Section "Mechanical Vibration Controls and Seismic Restraints" for muffler and exhaust piping supports.
2. Division 23 Section "Pipe Insulation" for muffler and exhaust pipe insulation.
3. Division 23 Section "Fuel Oil Piping" for interior fuel piping and fuel storage tank.
4. Division 23 Section "Hydronic Piping" for coolant piping external to engine generator.
5. Division 23 Section "Metal Ducts" for combustion air and radiator fan discharge connections.
6. Division 26 Section "Basic Electrical Materials and Methods"
7. Division 26 Section "Manual and Automatic Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generator sets.
8. Division 26 Section "Low Voltage Power Conductors and Cables"
9. Division 26 section "Grounding and Bonding"

1.3 SUBMITTALS

- A. Product Data: Submit full technical data of equipment for approval including, but not limited to, the following:

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

2. Description and operating criteria of engine; type, model, manufacturer, fuel and lubricating oil types and specific consumption, starting conditions and starting periods from cold to full-load pick-up, governor and response characteristics due to sudden load changes, super-charger, fuel injection system, cooling system and radiator, air filters, fuel filters, oil filters and pumps.
 3. Description and operating criteria of generator, exciter and voltage regulator, with loading response and short-circuit characteristics, insulation, cooling and accessories.
 4. Dimensioned outline plan and elevation drawings of engine generator set and other components specified, weights and forces, mounting methods, vibration protection etc.
 5. Battery type, make, charge/discharge characteristics, capacity and constructional features.
 6. Battery charger, method of charging, equalizing and trickle charging.
 7. Daily fuel tanks, pipes and accessories; materials and construction.
 8. Exhaust system and silencers; materials and construction.
 9. Control instruments, protection, alarms, cut-outs, indicating lamps, indicating instruments and all other devices or components.
 10. Time-current characteristic curves for generator protective device.
 11. Synchronization system where specified for two or more sets are in parallel, including technical data, instruments, governor and voltage regulation, with characteristic curves etc.
 12. Calculated noise levels in dBA at typical points within engine room and at various locations inside and outside.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
1. Certified manufacturers' dimensional drawings, templates and installation instructions for equipment and accessories, showing weights and distribution of forces, location and size of cabling (power and control), piping connections to equipment, and other pertinent data.
 2. Plans and elevations of all equipment.
 3. Separate unit wiring diagrams, schematics and interconnecting wiring diagrams.
 4. Constructional details of daily service fuel tank, including outline drawings showing piping arrangements, connections and dimensions.
 5. Complete execution drawings of associated auxiliaries.
- C. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- D. Routine Tests and Factory Test Reports: Fully assembled plant or equipment is to be tested at the factory, 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, showing evidence of compliance with specified requirements.
- E. Field Test and Observation Reports: Indicate and interpret test results and inspection records relative to compliance with performance requirements.
- F. Certified Summary of Performance Tests: Demonstrate compliance with specified requirement to meet performance criteria for sensitive loads.
- G. Sound measurement test report.
- H. Field test report of tests specified in Part 3.
- I. Maintenance Data: For each packaged engine generator and accessories to include in maintenance manuals specified in Division 1. Include the following:
1. Delete subparagraph below except for remote locations.

2. List of tools and replacement items recommended to be stored at the Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
3. Detail operating instructions for both normal and abnormal conditions.

1.4 QUALITY ASSURANCE

- A. Local Representative: Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy Engineer may disqualify a manufacturer.
- B. Standards: Equipment and component parts are to comply with ISO 3046, ISO 8528, IEC 60034, IEC 60085 and CISPR, or equivalent NEMA, ANSI, IEEE and DIN Standards and recommendations of ABGSM (Association of British Set Manufacturers) where such standards meet with or supersede the ISO and IEC Standards.
- C. NFPA Compliance
 1. Comply with NFPA 37 "Installation and Use of Stationary Combustion Engines and Gas Turbines";
 2. Comply with NFPA 101 "Code for safety to life from Fire in Buildings and Structures"
 3. Comply with NFPA 110 "Standard for emergency and stand by power supply systems".

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 WARRANTY

- A. Manufacturers Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period
 1. Warranty Period: 1 year from date of Substantial Completion.

1.7 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance service by skilled, competent employees of the generator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper generator operation at rated speed and capacity. Use parts and supplies as used in the manufacture and installation of original equipment.
 1. Include 24-hour-per-day, 7-day-per-week emergency callback service.
 - a. Response Time: 4 hours or less.

1.8 EXTRA MATERIALS

- A. Spare Parts: Provide manufacturer's recommended spare parts for 1000 hours operation of the plant. Provide list of manufacturer's spare parts for 2000 hours operation together with current prices. Pack with protective covering for storage and identify with labels describing contents.
- B. Tools and Instruments: Provide tools and instruments required for normal routine inspection, testing, operation and general maintenance, as recommended by the manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Caterpillar (U.S.A.)
 - 2. Cummins (U.S.A.)
 - 3. Mitsubishi (Japan)
 - 4. Deutz (Germany)
 - 5. Kohler (U.S.A.)
 - 6. MAN-B&W (Germany)
 - 7. Volvo (Sweden)
- B. Approved Manufacturers for Short-Break or No-Break Sets: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Auto-Diesels (U.K.)
 - 2. AEG (Germany)
 - 3. Secure Power Systems and Diesel Electric (Belgium)

2.2 PLANT DESCRIPTION

- A. Performance Class: Diesel generator set is to be class [G2 20 % voltage drop / free drop at 100% loading) to IS08528-1.
- B. Generator Set Assembly: Compact package type, with all equipment mounted on one rigid steel bed frame suitable for skidding. Radiator is to be mounted on the set or remotely as shown on the Drawings. Design is to permit easy operation, maintenance and repair.
- C. Vibration reduction is to be achieved by appropriate design and careful balancing at factory. Compact set is to have approved anti-vibration isolators of steel spring or resilient neoprene between rotating equipment and bed-frame, limiting transmission of vibration to building to a maximum of 0.04 mm amplitude throughout the operating vibration frequency range.
- D. Noise reduction is to be achieved by approved methods at source of noise, with sound level measured at 10 m limited to 65 dBA at 20 Hz down to 41 dBA at 10,000 Hz.
- E. Cold Starting: Engine is to be fully equipped to start and pick up initial load specified at specified minimum ambient temperature. Provide coolant heater.

- F. Equipment ratings are to be as shown on the Drawings or the next higher standard ratings provided by the manufacturer. Ratings are to be net **Standby** to consumer, excluding fan and any auxiliaries, auxiliary drives and losses, delivered at specified frequency, voltage and power factor and under worst climatic conditions on site.

2.3 DIESEL GENERATOR SET

- A. Components: Set is to basically consist of diesel engine, brushless synchronous generator with direct flexible coupling to engine and single or parallel control cubicle as required and shown on the Drawings.
- B. Governing is to be to ISO 3046, electronic type governor with limits of speed control as specified.
- C. Starting and Stopping: When in the automatic mode the set is to start and stop automatically by a signal sensed through an auxiliary contact in the load transfer switchgear. The set is to stop, after an adjustable cool- down period (2 - 30 minutes).
- D. Duty: Plant is to reach full speed within **10** seconds from start impulse and accept immediately **100%** of net rated output (load being mixed, steady and inductive, with motor starting loads as shown on the Drawings). Transient voltage variation is not to exceed **10%** under any step-load application for which the system is intended, up to full rated load, recovering to within $\pm 2\%$ within a few cycles.
- E. Failure to Start: Should engine fail to start following a start impulse, the system is to come to rest for a few seconds. Two further starting attempts are to be automatically made with intermediate 20-second maximum periods of rest. Should the set fail to start after three attempts, an alarm is to sound and a 'start failure' signal illuminate.
- F. Hand operation is to be possible for testing or normal operation through a test/manual/off/auto selector switch.
- G. Regular Exercising: While on 'auto', the set is to start regularly and automatically every week and is to operate for 30 minutes before stopping.

2.4 DIESEL ENGINE AND AUXILIARIES

- A. Design: Diesel engine is to be designed for type of load and application required. Engine and governor are to be selected to meet operating requirements and response specified.
- B. Engine Type: Compression-ignition type, with direct solid-injection, turbo-charged after-cooled, for ratings over 100 kW, water cooled, with air-cooled radiator inline or V-type cylinder arrangement suitable for direct coupling to driven machine.
- C. Engine Cycle: **2 or 4**stroke cycle.
- D. Engine Speed: **1500** rpm.
- E. Type of Fuel: diesel oil.
- F. Engine rating is to be such that alternator can deliver net specified rated output as specified earlier, with temperature rise not exceeding rise allowed by the Standards.

- G. Accessibility: It is to be possible to:
1. Remove rocker-box covers without disturbing fuel injection pipes or other components.
 2. Remove and replace pistons and piston rods, liners, big and small end shells and caps without dismantling engine.
 3. Bar engine over by hand for spill timing check and adjustment.
- H. Measuring Instruments: Engine mounted instruments are to include, at least, water temperature gauge, lubricating oil temperature gauge and pressure gauge, speedometer and running time meter. It is to be possible to measure, with extra instrumentation, coolant temperature at lower end of radiator, air depression after air filter, air boost and temperature using methods recommended by manufacturer. Instrument accesses are to be normally sealed by threaded blanking caps. Speed is to be sensed via a magnetic pickup off the Engine Thy Wheel Ring Gear.
- I. Cooling System: Engine is to be water cooled with gear- driven water pumps. System is to be pressurized, with heavy-duty tropical radiator cooled by reverse flow fan. Fan cowl and hand protection guards are to be fitted. Coolant temperature is to be controlled by one or more thermostats as determined by design of system. Radiator is to be sized for continuous performance at 110% rated load at worst operating ambient conditions with a 7 to 8 deg. C temperature differential. Radiator is to be non-ferrous metal, incorporating pressure valve, radiator cap and drain cock and with integral expansion tank. Direct acting modulating thermostatic diversion valve is to control engine cooling water temperature. Under normal operation, by-pass is not to be fully closed. Treated or fresh cooling water and anti-corrosion and anti-freeze additives are to be used as recommended by Manufacturer for Specific Conditions of Installation.
- J. Cooling Airflow: Obstructions in path of cooling air flow (openings, louvers, grilles, mesh, ducts, bends etc.) are not to reduce air flow below that needed at full rated output. Fan and radiator characteristics are to be selected accordingly. Advise if additional booster fans are required and provide necessary control gear for automatic operation.
- K. Cylinders are to have removable liners. Wet type liners are to have witness hole between liner sealing rings of each cylinder for early detection of coolant or oil leakage. Each cylinder is to have drilled and tapped hole and valve for connections of pressure indicator.
- L. Lubricating Oil System: Pressurized circulating type, using two engine-driven, gear type lubricating oil pumps with full flow filters and replaceable elements and lubricating oil heat exchanger. Filter system is to have spring loaded by-pass valve to permit oil circulation if filters become clogged. Audible and visual alarms are to cut-in when valve starts opening. Lubricating oil cooler is to be shell and tube heat exchanger with water from engine radiator as the cooling medium. Direct acting thermostatic diversion valve is to control oil temperature. Under normal operation by-pass is not to be fully closed.
- M. Fuel system is to have injection pump and injectors that are easily removable and replaceable for servicing. Engine is to have integral, gear type, engine driven transfer pump to lift fuel against a head of 2.5 m and supply it through filters to injection pump at constant pressure. Fuel filter elements are to be easily replaceable.
- N. Exhaust system is to be complete with flanged, bolted, galvanized, seamless steel pipe sections, long sweep elbows, flexible expansion sections, clean-outs, residential silencer, wall thimbles and supporting steelwork. Silencer is to be independently supported. Indoor hot exhaust parts are to be insulated with mineral wool / rock wool material, not less than 50 mm thick, retained by wire ties and clad with sheet metal aluminum (22 - SWG) covers to protect insulation. Exhaust system is to be designed to reduce back-pressure to below maximum specified by the manufacturer, in relation to exhaust pipe length shown on the Drawings.

- O. Electric Starting System: Engine starting is to be manual by push-button or automatic through control system at control panel. System is to consist of heavy-duty 24V D.C. starter motor, heavy-duty battery and battery charger. Cranking motor and battery are to be rated for cranking the engine when cold and at lowest temperature recorded. Starting pinion is to automatically disengage when engine fires.
- P. Storage Battery: Lead-acid, sealed-in-plastic type, complete with battery rack and inter-cell connectors. Battery is to have sufficient capacity to provide minimum four cranking periods.
- Q. Battery Charger: 25% over-rated, solid state, full-wave rectifier type, adequate to fully recharge depleted battery in not more than 8 hours and to automatically control rate of charge (providing a high-charge rate to a depleted battery and reducing to a trickle-charge rate when battery is fully charged). Ammeter is to be provided to indicate charging rate, which is to be adjustable. Battery charger is to be mounted in control cubicle, unless otherwise approved.
- R. Electronic Governor is to provide isochronous governing, paralleling and load sharing of generator sets. Governor is to have zero percent (isochronous) setting and adjustable drop from zero percent to 10% droop. System is to include power supply unit, magnetic speed pick-up, control module and actuator using fast response D.C. motor drive or equally approved alternative. Governor is to be designed for fast-response and high precision of speed (frequency) control, automatic paralleling and load sharing and is to include speed adjustment to $\pm 5\%$ of normal, while running, and with remote control interface. Frequency deviation under 25% sudden load change is not to exceed 0.5 Hz, recovering to stable speed condition of ± 0.1 Hz in 0.5 seconds.
- S. Governor over-speed trip is to automatically close fuel pump racks in event of engine over-speed. Device is to be separate and independent from governing mechanism.
- T. Protective system is to comprise automatic engine shut- down and generator trip with visual and audible alarms in event of over-speed, low lubricating oil pressure, high cooling water temperature and over cranking.

2.5 GENERATOR (ALTERNATOR)

- A. Type: Synchronous, low reactance, high efficiency, revolving field type, with brushless exciter and flexible coupling, sized to pick up effective load without exceeding transient and steady-state voltage deviation limits specified up to its full nominal rating and designed for the performance stipulated in the Specification. It is to be single-bearing construction with bearings of the sleeve or sealed ball type.
- B. Leads and Cables: Phase leads are to be brought out fully insulated to a terminal cable box of heavy gauge sheet steel, protection IP 44. Control and protection cables are to be brought out to a separate terminal box.
- C. Maximum voltage difference between the three phases at 100%-balanced load is not to exceed 1%. With unbalanced load up to 8% on one phase at unity power factor and zero load on other phases, the line-to-neutral voltages are not to differ by more than 2%.
- D. Characteristics:
 - 1. Number of Phases: 3.
 - 2. Rated Voltage, Frequency, and Net Rated Output: As shown on the Drawings.
 - 3. Rated power factor: 0.8.
 - 4. Winding Connection: Re-connectable with ends brought out and fully insulated.
 - 5. Maximum Unbalanced Load Current, (negative sequence component of current) with None of the Phase Currents Exceeding Rated Current: 8% of the rated current.

6. Overload: 10% nameplate rating for 1 hour every 12 hours.
 7. Rotor: Salient pole type, incorporating damping grid.
 8. Excitation: Brushless, with rotating armature rectifiers and discharge resistors.
 9. Voltage Regulator: Automatic, with readily accessible controls for voltage level.
 10. Insulation: Class H for stator and class H for rotor & exciter, with class F temperature rise, unless other indicated on the drawings.
 11. Enclosure: Drip proof and screen protected (IP 21 to IEC 144).
 12. Cooling: Built-in centrifugal fans.
 13. Maintained Short Circuit: 250% for 2 seconds.
 14. Over-speed: 120% (minimum) for 2 minutes.
 15. Telephone Harmonic Factor (THF) at no Load: 3% max.
 16. Waveform Distortion Factor at no Load: 5% max.
- E. Voltage Regulation: Overall voltage deviation within normal speed variations is to be within limits specified from no-load to full-load, from hot to cold and with load power factor from 0.8 lagging to unity. Regulator is to automatically reduce voltage if load exceeds capacity of generator. Voltage build-up is to be positive and rapid even when full load is suddenly applied. Line-to-line voltage waveform deviation factor is not to exceed $\pm 5\%$. Total harmonic content is not to exceed 5% and that of one harmonic not to exceed 2%. Radio interference suppression is to be within the limits set by the Standards, grade (N).
- F. Exciter: Armature is to be 3-phase, directly mounted to generator shaft and connected to generator field windings through six solid state, hermetically sealed, silicon rectifiers, accessible for maintenance or repair. Exciter is to have field suppression system to eliminate any source of diode failure resulting from high inductive loads and surges. Exciter field windings are to be stationary. Exciter-regulator combination is to maintain output voltage within limits specified for any load up to 110% generator rating and under any sudden load changes specified.
- G. Voltage Regulator: Solid state, volts/Hz type, utilizing silicon semi-conductor devices in control and power stages, with built-in Electro-magnetic interference suppression and designed for single or parallel operation. Manual adjustment to $\pm 5\%$ of regulated voltage level is to be possible by a potentiometer at control panel. All components are to be sealed, moisture and heat resistant, with a suitable environmentally protected enclosure. Voltage regulator is to automatically reduce voltage if load exceeds capacity of generator and is to sustain a 3-phase short-circuit current at the generator terminals for the period for which the short-circuit protection operates and at least for 3 seconds. Voltage regulator power is to be supported by generator voltage and current to maintain excitation field power.
- H. Two-position switch is to be provided for selection of manual or automatic mode of regulated voltage control.
- I. Sets Operating In Parallel: Cross-current compensation and necessary paralleling modules are to be provided to effect sharing of active and reactive loads equally between generators.

2.6 INSTRUMENTATION, PROTECTION AND CONTROL EQUIPMENT

- A. Generating Set Instruments, Protection and Controls: Control relays, sensing equipment, switchgear protective relays and devices and start, stop and shutdown controls are to be provided as necessary for operation specified. Generating set, instruments, protection and controls are to be mounted preferably in one control cubicle.
- B. Instruments and controls for a non-paralleled set are to include at least the following:
1. Voltmeter and 7-position selector switch.
 2. Ammeter and 4-position selector switch.
 3. Frequency meter.
 4. Off/test/manual/auto duty switch.

5. Manual-start and stop push buttons.
 6. Kilowatt-hour meter.
 7. Power factor meter.
 8. Service-hour running counter.
 9. Plant exerciser.
 10. Potentiometer for voltage level control.
 11. Speed raise/lower device.
 12. Cool-down time setting controls.
 13. Illuminated indicator panel with LEDs at least for low oil pressure, high water temperature, over-speed, fail-to-start, generator overload, reverse-power, generator on load, battery low charge state
 14. Lamp test push-button.
 15. Indicating gauge and low level fuel alarm.
 16. Battery charger, on/off switch, pilot lights.
 17. D.C. ammeter.
 18. Alarm sounder and reset controls.
 19. Anti-condensation heater.
- C. Protective gear is to ensure orderly engine stop or shutdown with reset relays, as required for safety and operational reliability, and is to include the following:
1. Output **power circuit breaker (PACB)** with solid state trip unit, in accordance with Division 26 Section "Switchboards", (electrically operated and electrically tripped by shunt release) for over-current and external earth fault protection.
 2. Over-voltage protection with voltage and time lag adjustment.
 3. Loss-of-field/ under excitation protection.
 4. Phase unbalance via negative phase sequence protection.
 5. Restricted earth-fault protection, with current adjustable settings between 0 and 20% of rated current, and time adjustable settings 0 to 3 seconds.
 6. Reverse power relay (for sets operating in parallel).
- D. Control and Protective Gear Cubicles: Generator set mounted instrument and/or control cubicles are to be resiliently mounted, preventing transmission of vibration to the components. Separately mounted instrument and control cubicles are to be self-supporting, floor mounted and free- standing. Cubicles are to be sheet steel construction, ventilated indoor type, vermin and dust-proof, (IP 42 to IEC 144), with lockable hinged doors and instrument panels, separate compartments for control devices, protective relays, circuit breaker(s) and neutral earthing device. Inner and outer surfaces of steel enclosures are to be cleaned, phosphatized, primed with heavy-duty rust inhibiting primer and finished with two coats of enamel. Wiring is to be 600 V, modularly arranged, with connections made at front terminal blocks with no live conductors exposed. Wires are to have approved numbered ferrules at each terminal. Printed circuit plug-in boards, where applicable, are to be of industry standards, accessible and withdrawable, mounted in standard racks.
- E. Load Shedding: An automatic microprocessor based load shedding system is to be provided for load connection / disconnection according to load priorities and generator power availability as described on the drawings.
- F. Step Loading : An automatic step loading system is to be provided for sequential application of emergency loads with an adjustable (0- 30 sec) time delay between each two steps as described on the drawings. The system is to comprise all necessary control equipment including under over/ voltage sensing relays, time delay relays, interface devices and wiring with respective circuit breakers.
- G. Relays: Front adjustable, sealed type, with dust-tight enclosures, removable covers, test terminal blocks and plugs for testing relay without removal from case. Removal from casing is to automatically short-circuit respective current transformer secondary windings.

- H. Instruments are to be housed in enameled metal cases for switchboard flush installation, with scales and markings protected and sealed. Indicating meters are to be minimum 76 mm square. Accuracy is to be within 2% unless otherwise specified. Voltmeters and ammeters are to be moving iron type for A.C. measurements and moving coil type for D.C. measurements.
- I. Current Transformers: Class 2 for measuring and protection.
- J. Voltage Transformers: Single phase, dry type, 0.5 accuracy class.
- K. KWH Meter: 3-element type for unbalanced 3-phase, 4- wire loads, fitted with 6-digit cyclometer.

2.7 FUEL STORAGE AND TRANSFER

- A. Day-tank Construction: Closed cylindrical steel, inclined at least 3 degrees from horizontal and fitted with drain plug, inlet and outlet pipe connectors and breather pipe.
- B. Day-tank breather pipe is to have replaceable paper air filter or breather caps with air filters.
- C. Day-tank instruments are to include float switch, solenoid valve and dial-type level indicator to give alarm on over-fill and low-level.
- D. Day-tank Filling Pumps: Electrically operated, automatically started and stopped, duplex pumps and standby manual pump, installed on piping system between storage tank and one or more day-tanks for fuel transfer. Motor is to be totally enclosed, fan-cooled, squirrel-cage induction type, with integrally coupled pump-rotor contained on one base. Pump is to be self-priming type against the specific head shown on the Drawings. Priming plug, sealed and protected bearings and combination starter with thermal overload protection and circuit breaker for short-circuit protection are to be provided. Operation is to be interlocked with float switches in day-tank. All necessary check valves, by- pass valves, float valves and maintenance valves on piping system are to be provided as shown on the Drawings.
- E. FST Connections: Female threaded, black forged steel pipe couplings, fitted through holes in top of tank and welded all around inside and outside. Connections, except vent connection, are to extend inside tank to within 150 mm of bottom and are to be seamless black steel pipes of same size as connection and braced to tank walls. Vent connection is not to extend inside tank more than 20 mm.
- F. Fuel Lines: Heavy gauge, black seamless steel, to ISO/R65 or equal, treated internally with corrosion resistant paint and with joints sealed with PTEE tape. Plumber's twine or gasket sealing compound are not to be used. Changes in direction and branching and jointing are to be with regular pipefitting. Field fabricated and bent fittings are not to be used.
- G. Fuel Lines: Fuel feed line to day-tank is to have by- pass with stopcock. Size of fuel return line from day-tank to main fuel tank is to be to manufacturer's recommendations.
- H. Valves Generally: 827.4 kPa (steam working pressure rating and 1380 kPa cold water non-shock pressure rating and type that can be repacked under pressure.
- I. Pipe Hangers and Supports: Galvanized steel.

2.8 MISCELLANEOUS REQUIREMENTS

- A. Manually Operated Overhead Hoist: Chain operated, self-aligning, low headroom type, comprising trolley with gear mechanism combined into a compact unit, designed to run on

lower flanges of I-beam runway. Hoist is to have shock resistant suspension, positive action Western type local brake; lifetime lubricated sealed bearings and load safety hook. Trolley is to have four alloy cast iron wheels. Safety factor is to be minimum of 5. Capacity of hoist is to be as indicated on the Drawings, and is to be tested to 1.5 times rated capacity.

- B. Power and Control Cables: Comply with Division 26 Section "Conductors and Cables", and Section "Control/Signal Transmission Media" of the Specification and as shown on the Drawings.
- C. Earthing Equipment: Comply with Division 26 Section "Grounding and Bonding" of the Specification.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine roughing-in of cooling-system piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

3.2 CONCRETE BASES

- A. Install concrete bases of dimensions indicated or otherwise required for packaged engine generators. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 26 Section "Basic Electrical Materials and Methods."

3.3 INSTALLATION

- A. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and manufacturers' equipment drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
- B. Install packaged engine generator to provide access for periodic maintenance, including removal of drivers and accessories.
- C. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases or building structure are provided as and when required and that they are properly installed.
- D. Tools: Use only tools recommended by equipment manufacturers for installations, particularly in making connections and adjustments.
- E. Supervision: Carry out equipment installation under the direct supervision of a qualified technician, licensed by and trained at the factory. Final adjustments and putting into satisfactory operation are to be made by a specialist delegated by the factory.
- F. Generating Set: Install to maintain alignment and minimize engine and generator stresses. Protect instrumentation and control equipment including engine mounted instruments from

machine vibration. Mountings and method of mounting are to be as recommended by the manufacturer and approved by Engineer.

- G. 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.
- H. Engine Hot-Air Exhaust Duct: Install approved canvas duct with metal frames between radiator and louvered opening in wall for radiator exhaust air.
- I. Tank Vent Pipe: Extend to nearest outside wall of building and carry up to at least 2 m above ground level with end at least 1 m away from any building opening. Slope vent pipe back to tank without traps and support securely. Provide replaceable dust filter and gooseneck bend or approved weatherproof vent cap at top of pipe.
- J. Pipe Hangers and Supports: Fasten securely to building structure with approved masonry expansion bolts, minimum 20 mm diameter and install in accordance with manufacturers' instructions.
- K. Earthing: Install earthing system in accordance with Division 26 Section "Grounding and Bonding" of the Specification.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
 - 1. Install piping adjacent to packaged engine generator to allow service and maintenance.
 - 2. Connect water supply to cooling system.
 - 3. Connect cooling-system water supply and drain piping to diesel engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.
 - 4. Connect exhaust-system piping to diesel engines.
- B. Electrical wiring and connections are specified in Division 26 Sections.
- C. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.5 IDENTIFICATION

- A. Identify system components according to Division 26 Section "Basic Electrical Materials and Methods."

3.6 FIELD QUALITY CONTROL

- A. Equipment: Inspect equipment upon delivery to Site and report any loss or damage to Engineer.
- B. Earthing resistance tests if any are to be carried out to verify specified requirements.

- C. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
- D. Load tests 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.
- E. 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 shutdown and alarm signaling and indication, under simulated fault conditions.
 - 5. Measurement of vibration transmission to building structure.
 - 6. Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
 - 7. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
- F. Load Banks: If actual loads are not made available at time of acceptance testing, provide load banks to carry out complete test cycle of the system under loading and switching conditions necessary to prove compliance with the Specification.
- G. Piping System: Using carbon dioxide or nitrogen from pressurized cylinder, test each system to 1.5 times normal operating pressure. Do not subject equipment, apparatus or to pressure exceeding prescribed test pressure obtained from nameplate data or from manufacturers' published data. Apply tests before connecting piping to equipment. Remove or disconnect and blank off relief valves, instruments and devices that might be damaged by test pressure. Maintain test pressure on system for 24 hours during which time there is to be no noticeable drop in pressure. Check for leaks using soap solution. Isolate source of pressure during testing.
- H. Coordinate tests with tests for transfer switches and run them concurrently.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- K. Test instruments shall have been calibrated within the last 12 months, traceable to applicable standards, and adequate for making positive observation of test results. Make calibration records available for examination on request.

3.7 COMMISSIONING

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

3.8 CLEANING

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

3.9 DEMONSTRATION

1. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation as specified below. Coordinate this training with that for transfer switches.
2. Train the Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with the Owner, through the Engineer, with at least 7 days' advance notice.

END OF SECTION 26 32 13.13

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including Conditions of Contract, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 26, Section "Basic Electrical Materials and Methods".
 - 2. Division 26, Section "Grounding and Bonding".
 - 3. Division 26, Section "Low Voltage Power Conductors and Cables".

1.2 SUMMARY

- A. This Section includes three-phase, on-line, static-type, uninterruptible power supply (UPS) system installation, comprising the following:
 - 1. Complete rectifier/charger-battery-inverter system with automatic static switch and maintenance by-pass circuit
 - 2. Output panelboard
 - 3. Remote monitoring panel & necessary interface for data on faults/monitoring to the Building Automation and Control Systems (where specified under Mechanical Works).
 - 4. Input isolation transformer for UPS units rated at 80 kVA and above
 - 5. Power conditioner
 - 6. Interplant power and control cabling
 - 7. Connection of normal a.c. power from assigned terminals/switch/circuit breaker, as shown on the Drawings
 - 8. Earthing system.
 - 9. Connection to BMS system, including interface elements such as relays, transducers, etc. as detailed in Division 25 Specification Sections BMS schedules and /or shown on the Drawings.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. LCD: Liquid-crystal display.
- C. LED: Light-emitting diode.
- D. UPS: Uninterruptible power supply.

1.4 SUBMITTALS

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

1. Manufacturers' catalogues, detailed description, compliance with the Standards, dimensions and weights, system operation, operating characteristics, methods of operation, protective and control provisions, heat losses, ambient conditions and limitations on electronic components etc. beyond which such components may suffer partial or permanent damage.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
1. Plans and front and side elevations, with indication of built-on control and indicating devices and instruments, exact dimensions and weights, cabling etc.
 2. One-line diagram with ratings of each piece of equipment, cabling, grounding etc.
 3. Control and elementary diagrams, wiring diagrams and the like.
 4. Installation and mounting details.
 5. Batteries arrangement and mounting details.
 6. Rating/derating selection calculations to be included.
- C. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.
- D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- E. Test Certificates: Submit type test and routine test certificates. System is to undergo a functional and load test program approved by the Engineer, and is to undergo a minimum 72 hours 'burn-in' test, under site simulated conditions, prior to shipment.
- F. Field Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.
- G. Maintenance Data: For UPS units to include in maintenance manuals specified in Division 1. 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.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Experienced installer who is an authorized representative of UPS manufacturer for both installation and maintenance of units required for this Project.
- B. Local Representative: Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy Engineer may disqualify a manufacturer.
1. Service Center: UPS system manufacturer maintains a local service center capable of providing training, parts, and emergency maintenance and repairs at the Project site within 2 hours maximum response time, round-the-clock, 7 days.
- C. Standards: Installation is to comply with relevant IEC, BS, EIA, NEMA and IEEE or equal Standards. Materials and components are to be manufacturer's latest design, and Standards used are to be approved prior to manufacture. Radio frequency interference (RFI) suppression is to be in accordance with CISPR and IEC 50091-2 recommendations.

- D. Products shall be sourced either directly from manufacturer, or from authorized agent/representative.

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 manufacturers' ambient temperature and humidity tolerances for non-operating equipment.

1.7 PROJECT CONDITIONS

- A. Temperature limits within which equipment is to be designed to operate are zero to +40 deg. C at 100% rated output. Equipment is to be capable of operating under up to 55 deg. C ambient conditions with derating factor of 1.25% per deg.C over 40 deg. C.

1.8 WARRANTY

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

- 1. Warranty Period: 1 year from date of substantial completion.

1.9 EXTRA MATERIALS

- A. Spare Parts List: Provide spare parts list of all spares with price validity of 5 years for all spare parts of each UPS model.
- B. Spare Parts: Provide manufacturer's recommended spare parts for 1000 hours operation of UPS system. Provide list of manufacturer's spare parts for 2000 hours operation together with current prices.
- C. Tools and Instruments: Provide tools and instruments required for normal routine inspection, testing, operation and general maintenance, as recommended by the manufacturer.

1.10 MAINTENANCE SERVICE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- | | | |
|----|--------------|-----------------|
| 1. | ABB | (Germany/Italy) |
| 2. | Invertomatic | (Switzerland) |
| 3. | Merlin-Gerin | (France) |
| 4. | Siemens | (Germany) |
| 5. | GE | (USA) |
| 6. | Socomec | (France) |
| 7. | Emerson | (USA) |
| 8. | Legrand | (France) |

2.2 SYSTEM DESCRIPTION

- A. System is to be of the programmable type, microprocessor based with CPU and memory capabilities for storage of alarms, faults, status change, etc. The UPS shall permit setting parameters for the environment and type of usage to be specified by the Engineer. UPS is to be of the self-diagnostic type, equipped with a self-test function to verify correct system operation. The self-test shall identify the parts of the UPS requiring repair in case of a fault. The system shall be provided with multi-password levels to limit access to software and data.
- B. General: System is to be interposed between normal a.c. power supply and critical load, to secure a minimum period of continuity of no-break battery back-up for 15 minutes in case of failure of normal a.c. supply and maintain output voltage, frequency and phase deviation within specified tolerances.
- C. System is to be **Non-redundant** as shown on the drawings. UPS is to be maintained (continuously supplying load through the inverter), with automatic no-break transfer to or retransfer from alternate source (bypass) in case of failure or overload on rectifier- battery-inverter system.
- D. Normal a.c. power supply will be available from one protected source fed from either normal a.c. network or from a.c. Characteristics of output of generator set (when provided) and UPS system are to be coordinated for best results. Study and advise on special requirements of generator characteristic output and stability.
- E. System overall efficiency is not to be less than 93 % at full load and 94 % at half load.
- F. Noise level of complete assembly is not to exceed **70 dB (A)** at 1.0 m distance anywhere within UPS room as per ISO 3746.

2.3 SYSTEM OPERATION

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

- B. Automatic Transfer To Bypass: Static transfer switch is to automatically transfer critical (100%) load from inverter to by-pass source (which is normal a.c. supply) if:
 - 1. Inverter output voltage characteristics fall outside specified limits.
 - 2. Critical load exceeds overload rating of UPS.
 - 3. Over-temperature is sensed.
 - 4. Manual (push button) command is given.
 - 5. Transfer to by-pass mode is to be inhibited, and an alarm initiated if voltage, frequency and/or phase shift of by-pass power is outside acceptable tolerances.
- C. Re-Transfer To Inverter: Re-transfer of critical load from auto by-pass source to inverter (UPS mode) is only to be possible under the following conditions:
 - 1. Inverter output voltage characteristics return to within specified tolerances.
 - 2. Original load current reduces to within rated full load capacity of UPS.
 - 3. Re-transfer selector switch is in automatic position.
- D. Lock-out feature is to inhibit re-transfer if by-pass source conditions are outside preset tolerances or if UPS output and by-pass are not synchronized and phase locked or if UPS output is not restored to normal conditions.
- E. Normal Power Restored: When normal power is restored following an outage, rectifier/charger is to initially draw no power except for transformer in-rush current. After approximately 15 seconds (walk-in time), input power requirements are to rise to power level to drive critical load and recharge battery.
- F. Provide maintenance disconnecting switch fully rated to carry the full load input current of the UPS.

2.4 SYSTEM CHARACTERISTICS

- A. Rectifier/Charger Input:
 - 1. Nominal Input Voltage: 400 V, **three** phase, **4** wire, **50** Hz.
 - 2. Voltage input variation: +10%, -15% from nominal.
 - 3. Frequency: +/-5% from nominal.
 - 4. Transformer Exciting Current In Rush: Less than 600 % nominal current.
 - 5. Power Factor: 0.8 lagging at full load and nominal input voltage.
 - 6. Total Harmonic Feedback: Maximum 2 % at 100% load.
 - 7. Current Limiting: 115% max. of that required to operate inverters and charge battery at full rated load, adjustment possible between 100% and 125%.
 - 8. Walk-in Current in Rush: 25% to 100% FLC in 15 seconds.
- B. Rectifier/Charger Output:
 - 1. Float and Equalize Operation: Adjustable, automatic, compatible with battery.
 - 2. Regulation: +/-1% max. from 0-100% load.
 - 3. Ripple: +/-1% rms. (0 to 100% resistive load).
- C. Static Inverters:
 - 1. Nominal net system power output rating: [refer to drawings] with load power factor 0.7-lag to 0.9- lead.
 - 2. Nominal output voltage: 400 V, **three** phase, **4** wire, **50** Hz, adjustable +/-5% of nominal.

3. Output voltage regulation:
 - a. Balanced load: $\pm 1\%$ at 100% load
 - b. Unbalanced load (3-phase output only): $\pm 3\%$ at 100% load
4. Phase Displacement: 120 deg. (± 5 deg.) at 100% load unbalance.
5. Output Voltage Waveform: 5% max. total harmonic, 3% max. single harmonic.
6. Frequency Stability: Normally synchronized to input line frequency over 4% adjustable range; free running at ± 0 . Full battery voltage variation, load and p.f. range; slew rate not to exceed 0.1 Hz/sec.
7. Dynamic Output Voltage Tolerance Sudden Full Load Removal: **[0-100-0%]** $\pm 3\%$ max. recovering application or to within 1% in less than 20 milliseconds.
8. Over-load Rating: 125% for 10 minutes, 150% for 60 seconds, 1000% for 5 cycles, 105% continuous.

D. Automatic Static Transfer Switch:

1. Transfer Time: 150 microsecond (overlapping) maximum.
2. Total Sensing and Transfer/Retransfer Time: 2 milliseconds, maximum.
3. Retransfer Mode: automatic/inhibit (selectable).
4. Retransfer Delay: 2 - 32 secs. in auto mode (selectable).
5. Transfer Point: $\pm 10\%$ of nominal output voltage (adjustable).
6. Retransfer Point: $\pm 5\%$ of nominal output voltage (adjustable).
7. Transfer Inhibit Point: $\pm 20\%$ of nominal output voltage (adjustable).

2.5 COMPONENTS AND ACCESSORIES

- A. Materials and Parts: Electronic devices are to be solid state, hermetically sealed. Indicator lights are to be twin LED type, those denoting blown fuse conditions are to be seen by operator without removing panels or opening cabinet doors. Power connections and remote alarm and control wiring are to be accessible at terminal boards. Power semi- conductors are to be fused. Metal surfaces including copper and aluminium heat sinks and busbars are to be treated with permanent protective coating. Electro-mechanical power devices and relays are to be vacuum impregnated, insulated for maximum operating voltage conditions, and enclosed in dust-tight enclosures. Cables are to be fire resistant high temperature grade.
- B. UPS is to be provided with a socket connection for a serial RS 485, RS 422, modbus, profibus interface to be linked to a portable PC, to a modem or to the BMS system for communication with the UPS. It shall enable interrogation of the UPS about status, faults, data stored, reprogramming, control, etc. without any additional hardware/software. All above parameters to be made available on existing BMS system. Potential free contact to be provided.
- C. Housing: Equipment is to be housed in a free-standing, well ventilated, totally enclosed modular assembly with front accessible lockable doors, giving easy access for maintenance, inspection and adjustments, and with provisions for handling and lifting during and after installation. Enclosures are to be suitable for industrial, tropical environments, protection IP **20** to IEC 60947-1, of galvanized sheet steel construction treated against corrosion and with light grey RAL7032 baked paint or epoxy finish to approved standard.
- D. Sub-assemblies and components are to be mounted on pull- out and/or swing-out trays, of the plug-in type where possible. Where it is not possible to mount components in pull-out or swing-out trays, they are to be easily accessible inside the enclosure. Assemblies shall be replaceable without requiring any adjustments or settings in the UPS.
- E. Ventilation: For units rated over 5 kVA, an integral, forced-air, cooling system is to be provided in each UPS module to remove dissipated heat efficiently, and ensure components operate within environmental ratings. Air is to enter bottom of cabinet through replaceable

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

- F. Rectifier/charger unit is to have mainline circuit breaker and two-winding dry-type, Class H insulated, class B temperature rise, with metallic electrostatic shielding, high efficiency (98%), regulating transformer and is to be automatic with soft start-up (walk-in) feature, using IGBT technology to suit power output requirements and protect against primary power surges, lightning transients, under-voltage and over-voltage conditions. Output is to be passed through LC filters to d.c. bus.
- G. Rectifier/charger unit is to be capable of supplying full load power to inverter, and to charge the battery from a discharge condition to 95% charge within ten times discharge period, and maintain full charge at floating voltage until next operation. Charger current is to be voltage regulated and current limited.
- H. Inverter is to employ Insulated Gate Bipolar Transistors (IGBT) technology in three leg, space vector modulation (SVM) design with high frequency switching technique, and complete with output transformer and filters. Inverter start-up is to be automatic, to reach full voltage within milliseconds and deliver power to the load within 2 seconds. Inverter is to start at any load including short-circuit. Output transformer is to be two-winding dry-type, Class H insulated, class B temperature rise, with metallic electrostatic shielding, high efficiency (98%),
- I. Inverter oscillator is to operate and maintain output frequency of inverter within specified tolerances, and be capable of synchronization and phase-locking to normal power supply frequency. When inverter is phase-locked to normal power supply, and latter fails, oscillator is to automatically revert to free running state (quartz oscillator) and maintain specified limits.
- J. Automatic static transfer switch is to be continuously rated at full load (100% FL), hybrid type (make-before-break), solid state transfer device with logic thyristor assembly isolatable or completely removable for maintenance. When signal to close switch is initiated, thyristors are to instantaneously conduct power to prevent deviations and breaks in load voltage outside specified tolerances.
- K. Maintenance By-Pass Switching: Manual (make-before- break) by-pass switch is to allow load to be transferred to by-pass source without interruption of output, and provide isolation of UPS and static switch during maintenance. Test position is to permit testing of static switch while load is being fed from bypass power circuit. Transfer inhibited warning circuit is to be provided to give an alarm indication in case by-pass supply is beyond acceptable tolerances.
- L. Protection: UPS modules are to have built-in or inherent electronic current-limiting protection against permanent self damage effective down to short-circuits. Fast acting, current limiting devices are to protect against failure of any solid state component. Internal failure in any UPS module is to cause immediate isolation from input and output by operation of static interrupters or causing shut down of faulty module. Protection is to be provided against, but is not limited to, the following:
 - 1. Input over and under voltage and power line surges
 - 2. Output over voltage and voltage surges
 - 3. Sudden abnormal changes in output load conditions
 - 4. Short-circuits at output terminals
 - 5. Inverter and rectifier overcurrent
 - 6. Auxiliary Control Circuit Overcurrent.

- M. UPS Output Neutral: Designed to continuously carry twice the full load phase current.
- N. Input Filter Disconnection: UPS control system is to disconnect the input filters in case of interruption of utility power supply failure while the UPS is operating at light loads (less than 25%).
- O. Battery: High rate discharge, heavy duty, industrial, high impact resistant, clear plastic encased, sealed lead- acid (gas recombination) type cells with automatically re-closing explosion proof safety vents. Electrolyte specific gravity is not to exceed 1.25 when fully charged at 25 deg. C. Ampere-hour rating is to be sufficient for emergency period specified with all inverters operating at full rated output, to a discharge limit of not less than 1.65 V per cell. Cells are to be normally maintained at 2.25 V per cell. Guaranteed life is not to be less than 10 years, with a capacity drop down to not less than 80% under normal expected service.
- P. Battery Cabinets: The battery enclosure shall match style and appearance of the UPS enclosure, and shall be designed to be installed adjacent to the UPS. It shall be of steel construction, with plastic insulating rails at points of contact with battery cases. Cabinets are to be painted with electrolyte resistant paint, are to be of appropriate design for space in which installed, and directly accessible for maintenance. Cables are to be rubber insulated electrolyte resistant type. The cabinet shall be provided with a temperature sensor and connected to the charger in order to control the battery current according to temperature.
- Q. Mimic Panel: UPS assembly is to include a mimic diagram with digital and LED displays, indicating instruments and control devices, in true relative positions.
- R. Local panel instruments are to include at least the following (digital readings):
1. Inverter input voltmeter, measuring d.c. bus volts.
 2. Battery ammeter, measuring charge/ discharge current.
 3. A.C. voltmeter to measure inverter output voltage, normal supply voltage or system output.
 4. UPS output ammeter and frequency meter.
- S. Local Panel Indicators are to include at least the following:
1. System on battery supply
 2. Inverter phase locked to verify synchronization between inverter output and normal a.c. supply input.
 3. Static switch on normal a.c. supply (bypass mode).
 4. Static switch inhibited.
 5. Over-temperature, indicating excessive temperature in heat sinks for transformers, rectifier/charger and inverter (alarm to automatically transfer load to by-pass circuit).
 6. Inverter output overload, indicating inverter output beyond specified rating failure of any stage, d.c. bus earth fault, inverter output earth fault.
 7. Event history display for the last 200 events.
- T. Local built-in controls are to include at least the following:
1. Inverter on/off.
 2. Battery input circuit breaker.
 3. Auto/manual reset-test switch.
 4. Manual reset switch.
 5. Hybrid switch transfer test push-button.
 6. Re-transfer auto/inhibit selector switch to allow automatic re-transfer of load to inverter after timed interval of normal operation and inhibit re-transfer of load to inverter until hybrid switch is in auto-mode.

7. Battery automatic/equalize recharge timer, 0 - 30 hours adjustable, with automatic/boost/equalize switch (accessible to maintenance personnel only and to be used only with manufacturer's recommendation for type of battery specified).
 8. Voltage and frequency adjustment controls with locking devices (accessible to maintenance personnel only).
 9. Indicator test/reset switch.
 10. Control power supply isolator (accessible to maintenance personnel only).
 11. Alarm test-accept-reset.
- U. Local built-in alarms causing horn to sound, with tripping command if required, are to include at least the following:
1. Fan failure: Alarm only.
 2. Over Temperature: Alarm with automatic transfer of load to by-pass after a safe preset period.
 3. D.C. Volts out of Limits: Alarm with indication.
 4. Fuse Failure: Alarm.
 5. Battery on Load/Disconnected: Alarm only.
 6. Overloads: Alarm only with a trip command if prolonged, for each rectifier/inverter unit.
 7. Normal a.c. Supply Failure: Alarm only.
 8. Hybrid Switch Operation to by-pass Mode: Alarm only.
 9. Low and High Output Voltage: Alarm only.
- V. Remote panel control and indicators are to include at least the following:
1. Audible alarm to sound for any alarm condition.
 2. LED indicators for mains power available.
 3. By-pass source available.
 4. Inverter a.c. output available.
 5. Inverter synchronized and phase locked.
 6. Critical load connected to inverter.
 7. Critical load connected to by-pass source.
 8. Hybrid transfer switch inhibited.
 9. High/low d.c. voltage.
 10. Over-temperature.
 11. Inverter output overload.
 12. Alarm-indicator switch.
 13. Emergency system shutdown push-button.
 14. Silence/test/reset switch.

2.6 UPS LOAD OUTPUT PANELBOARD

- A. Type: Separately mounted or built-in, sheet steel enclosed, generally in accordance with Division 26 Section "Panelboards" of the Specification, MCB panelboard construction.
- B. Ratings: Main and branch circuit breaker selection and ratings are to be time-current coordinated with inverter protection and overload requirements of critical loads to avoid interruption of power to healthy circuits in case of faults. Provide 20% spare circuits for additional loads.

2.7 POWER CONDITIONER

- A. Construction: Sheet steel encased, vented and fan cooled as necessary and is to include combination of high leakage-reactance magnetic circuit and electronic sensing fast response control circuits. Moving parts will not be allowed. Unit is to have manual automatic main protective and disconnecting circuit breaker with pilot light. Conditioner is to consist of high-grade core material and is to sustain heavy overloads (such as motor starting) without undue heating.
- B. Protection: Power conditioner is to be protected with suppression against all types of transients, spikes and power line noise, generally caused by lighting, switching, machine operation, under-voltages or over-voltages caused by faults or fault-clearing devices and voltage variations of mains input.
- C. Performance: Power conditioner is to regulate power line voltage to perform within the following requirements:
 - 1. Nominal Input Voltage: 380 V, 50 Hz.
 - 2. Output Rating: [refer to drawings] kW (0.7 lag to 0.9 lead PF).
 - 3. Nominal Output Voltage: 400 V, three phase, 4 wire.
 - 4. Input Voltage Variation: +/-20%.
 - 5. Output Voltage Adjustability Range: +/-5 %.
 - 6. Noise Level: Less than 55 dB at 1.0 m.
 - 7. Transient Response Time: 0.16 - 5 cycles.
 - 8. Total Harmonics: Less than 3%.
 - 9. Attenuation of Transients Outside Line Voltage Peak: 45:1 and better.
 - 10. Overload Capability: 1000% for 15 seconds.
 - 11. Efficiency: Over 90%.
 - 12. Regulation: +/-0.1% of nominal output voltage (at any load and load unbalance up to 33% in case of 3 phase units).
 - 13. Ambient Temperature: 25 deg. C.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
- B. 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.
- C. Tools: Use only tools recommended by equipment manufacturers for installations, particularly in making connections and adjustments.
- D. 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.

3.2 GROUNDING

- A. Provide direct interference free grounding circuit in accordance with Division 26 Section "Grounding and Bonding" of the Specification.

3.3 IDENTIFICATION

- A. Identify components and wiring according to Division 26 Section "Basic Electrical Materials and Methods."

3.4 BATTERY EQUALIZATION

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

3.5 FIELD QUALITY CONTROL

- A. Electrical Tests and Inspections: Perform tests and inspections according to manufacturer's written instructions and as listed below to demonstrate condition and performance of each component of the UPS:
 - 1. Inspect interiors of enclosures, including the following:
 - 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.
- B. Power Supply Output Disturbance: Provide microprocessor based instrument, and monitor and record power supply output disturbance of voltage and frequency. Instrument details are to be submitted for approval.
- C. Test Periods are to be prolonged (over 24 hours) and as requested by Engineer, to verify and obtain realistic voltage and frequency profile under any loading and switching conditions within the criteria specified.
- D. Data logging is to include high and low average voltage, sags and surges, spikes and spike bursts, drop-outs, high and low frequencies etc. with print-out and storage on cassette tape for subsequent re-entry into instrument's memory for display or print-out.
- E. Tests are to include loads at various power factors from low-load to overload condition, and measurements of temperature, heat losses, output voltage, wave shape, and harmonic content and frequency stability.
- F. Retest: Correct deficiencies and retest until specified requirements are met.
- G. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

3.6 DEMONSTRATION

- A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation. Refer to Division 1 Section "[**Demonstration and Training**]" and "[**Closeout Procedures**]."

END OF SECTION 263353

SECTION 26 35 33 - POWER FACTOR CORRECTION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes **automatic power** factor correction equipment rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include **[dimensions; shipping, installed, and operating weights of multiple capacitor cells or elements; and]** 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: Detail internal and interconnecting wiring and differentiate between manufacturer-installed and field-installed wiring.
- C. Factory Test Reports: Evidence of product's compliance with specified requirements.
- D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- E. Maintenance Data: For equipment to include in maintenance manuals. 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 or equivalent IEC.

1.5 COORDINATION

- A. Coordinate sensor-communication module package with [BMS] data network **26** for successful transmission and remote readout of remote monitoring data specified in this Section.

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. Deliver extra materials to Employer.
 - 1. Fuses: **10%** for every type and rating, but not less than 3 of each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Power Factor Correction Capacitors:
 - a. ABB Control, Inc.
 - b. Aerovox Inc.
 - c. ARCO Electric Products Corp.
 - d. Commonwealth Sprague Capacitor, Inc.
 - e. General Electric Co.; Business Information Center.
 - f. Powell Electric Manufacturing Co.
 - g. Square D Groupe Schneider.
 - h. Versatex Industries.
 - 2. Automatic Power Factor Correction Units:
 - a. ABB Control, Inc.
 - b. ABB Control, Inc.
 - c. General Electric Co.; Business Information Center.
 - d. Square D Groupe Schneider.
 - e. Versatex Industries.

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, non-interchangeable 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.
 - 3. Neon Indicator Lamp for Each Fuse: Connect to illuminate when fuse has opened, but is still in place, and locate so it is visible from outside the enclosure.

- E. Discharge Resistors: Factory installed and wired. **[Resistors may be omitted if permitted by NFPA 70.]**
- 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: NEMA 250, Type 12 or as indicated.
 - 2. Outdoor Enclosures: NEMA 250, Type 4, equipped with watertight conduit connections.

2.3 FIXED CAPACITORS

- A. Description: Integrally fused, unless otherwise indicated.
- B. Internal Wiring: Factory wired, ready for field connection to external circuits at a single set of pressure terminals.

2.4 AUTOMATIC POWER FACTOR CORRECTION UNITS

- A. Comply with NEMA ICS 2.
- B. Description: Capacitor banks, contactors, controls, and accessories factory installed in **[independent enclosures] [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. Controls: Solid-state, microprocessor-based controls, including the following:
 - 1. Under voltage relay that interrupts capacitor switching and disconnects capacitors for power supply interruptions longer than 15 minutes.
 - 2. "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching.
- 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. Inductors: Air-core-type, connected in capacitor circuits; rated to limit switching surges to within contactor ratings.
- I. Mechanical Bracing for Current-Carrying Parts: Adequate to withstand the maximum fault current to which they may be exposed.

- J. Identification of Energized Capacitor Banks: LED indicating lamps on front panel.
- K. Enclosure Access: Hinged door with hand-operated catch. Door is interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.
- L. Local Display: LED or liquid-crystal digital type, mounted in door of enclosure.
 - 1. Indicated target and actual power factors.
 - 2. Accuracy: Plus or minus 1 percent.
 - 3. Mounting: Flush or semiflush in unit door.
- M. Current Transformer: Type, configuration, and ratio to suit sensing and mounting conditions.
- 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 **[BACS][and][electrical power monitoring and control network]**. Communication module transmits data to remote monitoring devices. Data includes **[actual corrected power factor] [number of capacitor steps connected]**.

2.5 FACTORY FINISH

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

2.6 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install freestanding equipment on concrete bases. Maintain minimum workspace according to manufacturer's written instructions.
- B. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.

3.2 IDENTIFICATION

- A. Identify components according to Division 26 Section "Basic Electrical Materials and Methods."

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect **[automatic power factor correction]** equipment installation and connections. Report results in writing. Include the following:
 - 1. Operational Test: After electrical circuits have been energized, connect and observe units to confirm proper operation.
 - 2. Replace damaged and malfunctioning controls and equipment.
- C. Inspection: Perform external and internal inspections of capacitor equipment for damage and for compliance with the Contract Documents and manufacturer's documentation. Check electrical and mechanical bolted connections for required torquing.
- D. Testing: Perform the following and certify compliance with test parameters:
 - 1. Test insulation resistance between capacitor terminals and case. Follow manufacturer's written instructions or those below:
 - a. Use test voltages 500 V minimum, for equipment rated 250 V and less, and 1000 V minimum, for equipment rated more than 250 V.
 - b. Apply test voltage for 60 seconds.
 - c. Investigate, report, and resolve insulation resistance less than that stated by manufacturer's literature or less than allowable 25 megohms for equipment rated 250 V and less and 100 megohms for equipment rated more than 250 V.
 - 2. Measure capacitance of pole-to-pole capacitor combinations and compare with manufacturer's published values. Report readings, and investigate and resolve discrepancies more than 10 percent of manufacturer's nominal values.
 - 3. Energize circuits and demonstrate electrical operating features of automatic power factor correction units according to manufacturer's written instructions.
 - 4. Verify accuracy of remotely monitored parameters transmitted from automatic power factor correction units by communication module.
- E. Correct deficiencies shown by inspections and tests on site where possible, and retest; otherwise, remove and replace with new units and retest.
- F. Report of Tests and Inspections: Written record **[including adjustment settings]**.

3.4 ADJUSTING

- A. Adjust for optimum automatic power factor correction.

3.5 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.

3.6 DEMONSTRATION

Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.

END OF SECTION 26 35 33

SECTION 26 36 23 – ENCLOSED TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switch.
- B. Related Sections include the following:
 - 1. Division 23 Section "Electric-Drive, Centrifugal Fire Pumps" for automatic transfer switches for fire pumps.
 - 2. Division 23 Section "Electric-Drive, Vertical-Turbine Fire Pumps" for automatic transfer switches for fire pumps.
 - 3. Division 26 Section "Basic Electrical Materials and Methods".
 - 4. Division 26 Section "Switchboards" for circuit breakers.

1.3 SUBMITTALS

- A. Technical Data: Include ratings and dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
- B. Wiring Diagrams: Detail wiring for transfer switches and differentiate between manufacturer-installed and field-installed wiring. Show both power and control wiring.
- C. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- D. Product Certificates: Signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for load ratings and short-circuit closing and withstand ratings applicable to units for Project.
- E. Field Test Reports: Indicate and interpret test and inspection results for compliance with performance requirements.
- F. Maintenance Data: For each type of product to include in maintenance manuals specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions, including software, where applicable.
- G. As-Built (Record) Drawings: At Project close-out, submit Record Drawings of installed electrical systems, in accordance with requirements of the Specification, Division 1.

1.4 QUALITY ASSURANCE

- A. Local Representative: Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy the Engineer may disqualify a manufacturer.
- B. Source Limitations: Obtain automatic transfer switch, and related control panels through one source from a single manufacturer.
- C. Comply with IEC 60947-6.
- D. Comply with UL 1008, NFPA 70 and 110.
- E. Comply with NFPA 99.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Conventional Transfer Switches:
 - a. GE (U.S.A.)
 - b. ASCO by Emerson Network Power (U.S.A.)
 - c. Zenith by General electric (U.S.A.)
 - d. Cummins Corp. (U.S.A.)
 - e. Kohler Co. (U.S.A.)
 - 2. Transfer Switches Using Molded-Case Switches or Circuit Breakers:
 - a. ABB (Switzerland)
 - b. Schneider Electric (France)
- B. Locally assembled transfer switches meeting the Specification are **not** acceptable.

2.2 MAINS FAILURE AUTOMATIC TRANSFER SWITCH (ATS)

- A. Type: Conforming to IEC 60947-6 or UL 1008 and to applicable standards. Wall or floor mounted, galvanized sheet steel cubicle of equal construction to control cubicle, comprising two main contractors, circuit breakers or double throw switches and controls necessary for automatic transfer of power supply from normal source to stand-by source, voltage sensing control relay and time delay relays to signal generator start and stop, auxiliary switches and indicating lights etc. as necessary for the required operation of the system.
- 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 is to open. After an adjustable period of 0 - 10 seconds from sensing stabilized rated voltage and frequency of generator at the ATS, (Voltage pick-up adjustable from 85% to 100% nominal); frequency

pick-up adjustable from 90% to 100% nominal, the emergency contactor is to close. Upon restoration of normal mains supply to above the preset limits, adjustable between 90% and 100% of rated voltage and/or frequency, for an adjustable preset period of 2 - 30 minutes, emergency contactor is to open and after a presettable 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: Initiate after retransfer of the load to normal source. (Refer to generator set controls upon shut-down).
- D. ATS for Large Motor Loads: Include factory-installed and factory-wired internal motor control under-voltage and timing relays. Relays control designated starters to de-energize motors prior to transfer and re-energize them selectively at adjustable time intervals after transfer. Control connection to motor starters is to be through wiring external to the ATS. Time delay for motor starting is to be individually adjustable between 1 and 60 seconds. Relay contacts are to be rated for actual motor-control circuit inrush and seal currents, or for pilot duty as indicated.
- E. ATS for Large Motor Loads: Where indicated, include factory-installed and factory-wired internal in-phase monitor relay. The relay controls transfer so it occurs when the 2 sources or source and load are synchronized in phase. The relay compares phase relationship and frequency difference between the normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if the transfer can be completed within 60 electrical degrees. In-phase transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage. Where an in-phase monitor is to be provided, this is to defeat the 'pause' in the transfer contactors and assume control of the switching operation.
- F. Mechanical and Electrical Interlocks: Required 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.
- G. Selector Switches are to be provided as follows:
 - 1. Operating selector switch is to include the following:
 - a. Auto: Generator set is set for automatic operation and the generator set starts if a power outage occurs, as described above.
 - b. Test: Simulates a power outage, starts and runs the generating set as Normal position.
 - c. Manual position with all interlocks required to operate generator in case failure of the automatic operation at the transfer switch.
 - d. Emergency stop (separate): Shuts down the generating set and prevents it from starting. This is used when servicing the generator.
 - 2. Another selector switch is to be provided for two positions, "With load" and "Without load" for testing or exercising:
 - a. "With Load": the generating set is to carry the load during testing or exercising periods.
 - b. "Without Load": generating set is to start but not assume the load.
- H. Pilot Lights are to indicate which contactor is on.
- I. Instruments are to include voltmeter and ammeter with selector switches.

- J. Contactors are to comply with IEC 60947, 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, an 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 on each contactor.
- K. Circuit Breakers used instead of contactors 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 conductors, 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.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Floor-Mounted Switch: Level and anchor unit to floor.
- B. Identify components according to Division 16 Section "Basic Electrical Materials and Methods."

3.2 WIRING TO REMOTE COMPONENTS

- A. Match type and number of cables and conductors to control and communications requirements of transfer switches as recommended by the manufacturer. Increase raceway sizes at no additional cost to Employer if necessary to accommodate required wiring.

3.3 CONNECTIONS

- A. Ground equipment as indicated and as required by the Standards.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing in addition to tests recommended by the manufacturer:
1. Before energizing equipment, after transfer-switch products have been installed:
 - a. Measure insulation resistance phase-to phase and phase-to-ground with insulation-resistance tester. Include control circuits. Use test voltages and procedure recommended by manufacturer. Meet manufacturer's specified minimum resistance.
 - b. Check for electrical continuity of circuits and for short circuits.
 - c. Inspect For:
 - 1) Physical damage.
 - 2) Proper installation and connection
 - 3) Integrity of barriers, covers, and safety features.
 - d. Verify that manual transfer warnings are properly placed.
 - e. Perform manual transfer operation.
 2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Verify time-delay settings.
 - c. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - d. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - e. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown sequence.
- B. Coordinate tests with tests of generator plant and run them concurrently.
- C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.5 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 equipment internally, on completion of installation, according to manufacturer's written instructions.

3.6 DEMONSTRATION

1. Train Employer's maintenance personnel to adjust, operate, and maintain the transfer switches and related equipment as specified below: Coordinate this training with that for generator equipment.
2. Train the Employer's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.

3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with the Employer, through the Engineer, with at least 7 days' advance notice.
5. Provide a minimum of 4 hours of instruction.

END OF SECTION 26 36 23

SECTION 13100 - LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes lightning protection for buildings and associated structures and includes requirements for lightning protection systems components including, but not limited to, the following:
 - 1. Air Termination Network.
 - 2. Down Conductors
 - 3. Connections to reinforcing bars of structures
 - 4. Bonding.
 - 5. Accessories.
- B. Related Sections include the following:
 - 1. Division 16 Section "Basic Electrical Materials and Methods".
 - 2. Division 16 Section "Grounding and Bonding".

1.3 SUBMITTALS

- A. Product Data: Submit data for air terminals, fasteners, test links ground point and rods, connectors, wall inserts and bolts and any accessories forming part of the lightning protective system.
- B. Shop Drawings: Detail the lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding locations and provisions. Include indications for use of raceway and sleeves, and data on how concealment requirements will be met.
- C. Record (As-Built) Drawings: Indicate nature of soil, special grounding arrangements, date and particulars of additives to soil or in bore-holes if used, test conditions and results obtained.
- D. Records: Submit the following:
 - 1. Actual layout and components of the system.
 - 2. Nature of soil and characteristics and any special grounding arrangement.
 - 3. Test conditions and results.
- E. 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.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has specialized in installing lightning protection systems similar in material, design and extent to those indicated for this Project and whose work has resulted in installations with a record of successful in-service performance.

B. Standards: Comply with IEC 62305 "Protection against lightning".

1.5 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

1.6 TERMS USED

A. The following terms used on Drawings and in the Specification are synonymous and may be used interchangeably:

1. "Earth" and "Ground".
2. "Earthing" and "Grounding".

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. A-C Lightning Protection, Inc. (USA).
2. Automatic Lightning Protection. (USA).
3. Furse, W.J. and Co. (UK).
4. Harger Lightning Protection, Inc. (USA).
5. Heary Bros. Lightning Protection Co. Inc. (USA).
6. Independent Protection Company, Inc. (USA).
7. Robbins Lightning, Incorporated. (USA).
8. Thompson Lightning Protection, Inc. (USA).
9. Wallis (UK).

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Provide lightning protection system materials and components that comply with approved manufacturer's standard design, in accordance with published product information and the Standards specified in this Section.

B. Provide air terminals, bonding plates, conductors, connectors, conductor straps, fasteners, splicers and other components required for a complete system that meets the Standards specified in this Section.

C. Roof Conductors: Bare, high conductivity, annealed Aluminum strip, 25 x 3 mm.

D. Bonding Conductors: High conductivity, bare annealed aluminum tape, 20 x 2.5 mm minimum dimensions, or 70 mm² soft drawn stranded aluminum cable.

- E. Accessories: Supports, joints, fasteners, clamps, bonds, test links, etc., are to be copper or copper alloy and specially manufactured for the purpose. Clamps and connectors are to be specifically designed and sized for clamping and connecting to the various shapes and surfaces of bonded metalwork. Provide bimetallic connectors between different materials. Galvanized or plated steel nails, screws and bolts will not be accepted on copper/aluminum installations.
- F. Flexible Bonding Straps: Flexible annealed aluminum braid, 25 x 3.5 mm, suitable for bonding flat surfaces, cut to length required and with drilled flat terminals for bolted connections. Provide special bimetallic alloy terminals for joining to aluminum conductive parts.
- G. Down Conductors: Round solid aluminum, 8 mm diameter, covered with PVC of approved color.
- H. Test Links: Two-bolt split-coupling, copper alloy, made to join two ends of down conductor specified. Plate indicating position and number of electrodes is to be fitted above each test link.

2.3 TECHNICAL REQUIREMENTS - USING DOWN CONDUCTORS

- A. Flat Concrete Roofed Buildings Air Termination Network: Provide horizontal conductors around periphery (or parapet), and along inner edges of roofs that are higher than adjacent parts, unless they fall in zone of protection of a higher conductor. Install horizontal conductors in a mesh of **5mx5m** maximum spacing. Join all elements of lightning protective system together.
- B. A combination of vertical rods and mesh conductors can compose the air termination systems.
- C.
- D. Down Conductors: Space at **10m** Every down conductor is to:
 - 1. Be protected against corrosion for 0.3 m above and below ground level.
 - 2. Be insulated with PVC or polyethylene (5 mm thick) from test link to electrode connection point (to reduce potential gradient at ground level which otherwise would be lethal to humans or animals).
- E. Joints and interconnections in ground termination network are to be exothermic welds except that down conductor is to be connected by a single or multi-conductor bolted U-connector clamp at ground pits.
- F. Bonding: Bond all metalwork in or on outside of structure to the lightning protective system at points above the test joint (test link) to avoid side flashing. Metalwork includes but is not necessarily limited to: water pipes, tanks, sign structures, communication supports, metal sheaths and exposed parts of electrical installations, vents, exterior metal staircases, metal window frames, vent pipes, steel doors or door frames, main grounding terminal or bar of electrical installation and reinforcing bars of concrete structures if these are in continuous electrical contact.
- G. Bond metal leaving or entering a structure (having system continuity such as water piping, etc.), as follows:
 - 1. As directly as possible to the ground termination.
 - 2. Near point at which service enters or leaves the structure.
 - 3. At nearest ground point or at nearest main grounding terminal or bar of protective grounding system.

2.4 TECHNICAL REQUIREMENTS- USING THE NATURAL COMPONENTS OF THE STRUCTURE AS DOWN CONDUCTORS

- A. Flat Concrete Roofed Buildings Air Termination Network: Provide horizontal conductors around periphery (or parapet), and along inner edges of roofs that are higher than adjacent parts, unless they fall in zone of protection of a higher conductor. Install horizontal conductors in a mesh of **5mx5m** maximum spacing. Join all elements of lightning protective system together.
- B. A combination of vertical rods and mesh conductors can compose the air termination systems.
- C. Down Conductors: Connect air termination network to ground via down conductors and steel reinforcement of concrete structure, at the positions shown on Drawings and in conformity with specified Standards for down conductors. Ensure good contact between reinforcing bars during construction, by fixing the bars with tying wire, for both vertical to vertical bars, and horizontal to vertical bars.
- D. Bonding: Bond all metalwork in or on outside of structure to the lightning protective system roof conductors or to exposed grounding points bonded to reinforcing bars in the structure. Metalwork includes but is not necessarily limited to: water pipes, tanks, sign structure, communication supports, metal sheaths and exposed parts of electrical installations, vents, exterior metal staircases, metal window frames, vent pipes, doors or door frames and main grounding terminal or bar of electrical installations.
- E. Bond metal leaving or entering a structure (having system continuity such as water piping, etc.), as follows:
 - 1. As directly as possible to the ground termination.
 - 2. Near point at which service enters or leaves the structure.
 - 3. At nearest ground point or at nearest main grounding terminal or bar of protective grounding system.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to IEC 62305.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.
- C. Conceal the following conductors:
 - 1. System conductors.
 - 2. Down conductors.
 - 3. Interior conductors.
 - 4. Conductors within normal view from exterior locations at grade within 60 m of building.
 - 5. Notify Engineer at least 48 hours in advance of inspection before concealing lightning protection components.
- D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components.
- E. Bends in conductors are not to be less than 200 mm radius and are not to exceed 90 degree turn.

F. Down conductors are to follow most direct path between air terminals and grounding network, avoiding sharp bends and narrow loops. Re-entrant loops are not permissible. Tight angle bends may be allowed where absolutely necessary at edge of roof, whereby length of loop in relation to distance between its start and end is kept below eight times. Where required, direct path is to be through an air space in a non-combustible, non-metallic duct with net cross-section 15 times area of conductor.

- G. Mechanical Protection of Down Conductors: Provide asbestos cement or pipes underground, starting 0.3 m below ground and to a height of 1.2 m above ground. Test link is to be positioned 1.3 m above ground.
- H. Prevent corrosion on down conductors due to atmospheric, chemical, electrolytic or other causes. Where acid condition of soil is likely to corrode conductor, provide lead pipe sleeve or equivalent encasement from at least 900 mm below ground to at least 900 mm above ground with top sealed against moisture. Provide lead coating for copper subject to severe corrosion from sulfur compounds.
- I. Joints and Bonds: Clean and treat contact surfaces with non-corrosive compound. Protect joints between dissimilar metals from moisture by inert, tenacious material, and with overlapping joints not less than 20 mm long. Provide as few joints and bonds as possible and make mechanically and electrically effective by clamping, bolting or exothermic welding. Cross-sectional areas of joints and bonds are not to be less than that of main conductor.
- J. Bond exposed metal parts of structure to lightning protective system if clearance between any element of lightning system and metal part is less than 1800 mm or the distance allowed by the specified Standard, whichever is smaller.

3.2 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

- A. Periodic Inspections: Perform periodic inspections during installation of lightning protection systems and at Substantial Completion.

END OF SECTION 13100

SECTION 26 51 00 – INTERIOR LIGHTING

PART 1 - GENERAL

1.1. RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions and Division-1 (General requirements), apply to work of this section.
- B. General Provisions for Electrical Work, Section 16050, apply to work of this section.

1.2. DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation all lighting fixtures, drivers, and lamps in accordance with Drawings and Specifications.
- B. The design was made based on LED lighting fixtures, the supplier shall provide LED lighting fixtures equivalent to the designed lighting fixtures indicated on the drawings to provide the same lux level required for each space and to submit software run from the lighting program (Dialux) for consultant review and approval.

1.3. QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of lighting fixtures, drivers, and lamps, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, NEC, UL, NEMA, IEEE, IESNA, ANSI, IEC and DIN/VDE Standards pertaining to lighting fixtures, ballasts, and lamps. Provide lighting fixtures, drivers, and lamps products and components which have been labelled by approved authorities.
- C. In case of conflict among the referenced standards and codes, the more stringent provision will govern.

1.4. SUBMITTALS

- A. Product Data: Submit manufacturer's data for lighting fixtures, drivers, and lamps; include the following:
 - 1. Details of construction and finishes.
 - 2. Electrical ratings.
 - 3. Mounting.
 - 4. Photometric data.
 - 5. Submit samples as directed by the Engineer.
 - 6. Drawings to scale.
- B. Samples: Submit sample for each type of lighting fixture specified in the lighting fixtures schedule for review and approval.

C. Contractor must submit certificates according to one of the followings:

C.1 Test certificates for the proposed LED lighting luminaires according to IEC standard as follows:

1. IEC 62717: Requirements for the performance of LED modules,
2. IEC 62722-1: General requirements for the performance of luminaires,
3. IEC 62722-2-1: Particular requirements for the performance of LED luminaires.
4. ENEC PLUS.

C.2 Test certificates for the proposed LED lighting luminaires according to IES standard as follows:

1. LM-79 Test Report or any approved equal test according to its relevant code, showing electrical and photometric performance for the whole luminaires including but not limited to the following:
 - 1.a. Manufacturer's name and designation of solid state lighting (SSL) product under test.
 - 1.b. Measurement quantities measured (total luminous flux, luminous efficacy, etc.).
 - 1.c. Rated electrical values (clarify AC (frequency) or DC) and nominal correlated color temperature (CCT) of the SSL product tested.
 - 1.d. Number of hours operated prior to measurement (0 h for rating new products).
 - 1.e. Total operating time of the product for measurements including stabilization.
 - 1.f. Ambient temperature.
 - 1.g. Designation and type of reference standard used (wattage, lamp type, intensity distribution type - omni-directional/directional) and its traceability.
 - 1.h. Photometric measurement conditions (for sphere measurement, diameter of the sphere, coating reflectance, 4π or 2π geometry. For goniophotometer, photometric distance.).
 - 1.i. Measured total luminous flux (lm) and input voltage (V), current (A), and power (W) of each SSL Product.
 - 1.j. Luminous intensity distribution (if applicable).
 - 1.k. Color quantities (chromaticity coordinates, CCT and/or Color Rendering Index (CRI) for white light products).
2. LM-80 Test Report or any approved equal test according to its relevant code, showing measuring Lumen Maintenance of LED light sources including but not limited to the following:
 - 2.a. Number of LED light sources tested.
 - 2.b. Description of LED light sources.
 - 2.c. Description of auxiliary equipment.
 - 2.d. Ambient conditions including airflow, temperature and relative humidity.
 - 2.e. Drive current of the LED light source during lifetime test.
 - 2.f. Lumen maintenance data for each individual LED light source along with median value, standard deviation, minimum and maximum lumen maintenance value for all of the LED light sources.
 - 2.g. Observation of LED light source failures including the failure conditions and time of failure
3. TM-21 Test Report, showing projecting long term lumen maintenance of LED light sources.

4. LM-82 Test Report showing the characters of LED light engines and LED lamps for electrical and photometric properties as a function of temperature in form of Lumens/Watt efficacy at $25^{\circ}\text{C}\pm 1^{\circ}\text{C}$.
5. Thermal Management Test report, In Situ Temperature Management Test Report (ISTMT) under UL 1958 is preferred or equivalent.
6. Photo-biological Test Report from accredited NVLAP.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All LED's and controllers should be supplied with the luminaires as per the manufacturer recommendations.
- B. The supplier shall submit test reports that indicate clearly the life time and luminaire performance (electrical & photometrical) at the designated ambient temperature and selected driver current.
- C. LED chip type shall be chip on board (COB).
- D. Heat sink material shall be Aluminum Alloy with less copper content for heat dissipation.
- E. A minimum life time of L85 (10K) greater than 60,000 hrs can be accepted at designated ambient temperature of 40°C in accordance to IES TM-21-11.
- F. All luminaires shall be manufactured to IEC 60598-1 and 60598-2 or equivalent.
- G. All luminaires shall be provided with LED chip compatible with the control gear used.
- H. Luminaires shall not be suspended by their flexible cord. A separate means of suspension shall be provided.
- I. All flexible cords shall be anchored at both ends such that the cord is free from strain.
- J. Any plastics used in the luminaire shall be light and UV stable and shall be suitable for their application.
- K. All sheet steel components shall be suitably pre-treated and electrostatically spray-painted using acrylic polyester or epoxy powders.
- L. Non-compatible materials shall not be used in contact with each other.
- M. Diffusers shall be restrained to prevent them from falling out of the body of the luminaires under normal conditions and when re-lamping.
- N. All luminaires designed for external use shall be constructed to minimum classification of IP 66 and be class 1 unless otherwise stated.
- O. All LED luminaires shall work at 40°C ambient temperature and 90°C relative humidity.
- P. The manufacturer/Supplier shall verify number of switching cycles before failure at least 15,000 times for the luminaires.

2.2 LED LUMINAIRES

- A. The manufacturer/supplier shall provide photo-biological test reports from accredited laboratories to prove that the fixture is classed as “Exempt” or “Low Risk” in accordance to ANSI/IESNA RP-27 or IEC 62471.
- B. The LEDs shall only be from Standard Deviation Color Matching (SDCM) or MacAdam Ellipse to be lower than 4 (< 4 SDCM) or (< 4-Steps MacAdam Ellipse).
- C. IESNA LM-79 Test report shall be submitted for each type of luminaire used with the selected driver current, it will not be permitted to use any driver current except the current rated with the test reports.
- D. The Whole luminaire minimum efficacy shall be ≥ 80 lm/cctW at designated ambient temperature of 40 °C in accordance to LM-82 Test Report.
- E. Thermal Management Test report must be provided, preferred In Situ Temperature Management Test Report (ISTMT) under UL 1958 or equivalent.
- F. TM-21 reported life time should be run for 10,000 hrs confirming Tsp used in (coming from Thermal Management Test report at elevated ambient temperature 40°C).
- G. All LED luminaires shall be supplied complete with LED controller as per the manufacturer recommendations.
- H. All cables shall be secured within the luminary body to prevent loose lengths from touching hot surfaces or becoming trapped beneath cover plates. Cable clips or cleats shall be captive and if secured by adhesive, shall not loosen with age.
- I. Wiring within the fixture shall be 125°C, 500V and to be as per manufacturer recommendation.
- J. LED modules shall be of 4000° k color temperatures and the CRI shall be greater than 80.
- K. The manufacturer/supplier shall submit stamped warranty: 5 years for the whole luminaire (LED Chip, Driver...etc.).
- L. The LED luminaires which are used at spaces classified as a clean room space must be sealed , easy to clean ,at IP 65 and classified as a ” Clean room luminaire”.
- M. The LED luminaires which are used at operating rooms must be classified as an operating room luminaire.
- N. The LED luminaires which are used at Magnetic Resonance Imaging “MRI” scan rooms must be classified as a DC nonferrous LED luminaire and to be supplied by a maximum 24v dc source outside the MRI scan room and to be classified as an MRI scan room luminaire.

2.3 LED Drivers Technical Requirements

General:

- A. Drivers shall be **RoHS** Compliant.
- B. Drivers shall have a total individual Luminaire Harmonic Distortion (THD) of $\leq 20\%$ in accordance with **ANSI C82.77 (2002)**. However the Contractor shall measure the harmonic at the supply point (L.V side of the distribution substation) after the installation of all the LED luminaires and adopt harmonic compensation methods to limit the total harmonics distortion in the supply voltage to maximum 5% as per **IEEE 519 regulations**.
- C. The Driver and driver output current shall be fully tested and compatible with the exact LED chips/engine of the luminaire.
- D. The Driver and driver output current shall be fully tested and compatible with the KNX lighting actuators.
- E. Drivers shall have a Power Factor (PF) of $L \geq 0.90$.
- F. Input Voltage; capable of 120-277 volt, single phase.
- G. Power can be UL Class 1 or II output or similar European CE or International equivalent.
- H. Drivers shall be IP 21.

2.4 PARTICULAR REQUIREMENTS

A. GENERAL

The Contractor shall be responsible for ensuring that the design and installation of all lighting complies with illuminating engineering society (IES) and with this specification.

All layouts shall be developed in conjunction with the Owner's Authorized Representative.

In general all lighting shall be wired in a minimum of 3 mm² single core cables and protected by a 16 A Type C or D MCB. Larger cable sizes shall be used where necessary to comply with the IEE wiring regulations 17th. Edition.

B. PLANT AREAS

The contractor shall ensure luminaires are positioned such that lighting levels are not significantly affected by adjacent services such as pipe work or ductwork. Where necessary luminaires shall be installed on chains.

The contractor shall consider the use of plant rooms (electrical room, AHU room, etc.) before determining the lighting design criteria.

2.5 ACCEPTABLE MANUFACTURERS

A. LIGHTING FIXTURE

1. Philips
2. Kenall
3. Zumtobel
4. Trilux
5. Targetti
6. Thorn
7. General Electric (GE)
8. Cooper
9. Troll
10. Emergi-lite

B. FOR DRIVERS

1. PHILIPS
2. Osram
3. Samsung
4. General Electric (GE)

C. FOR LED CHIPS

1. BRIDGELUX
2. CITIZEN
3. CREE
4. NICHIA
5. OSRAM
6. PHILIPS
7. SAMSUNG

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which lighting fixtures are to be installed. Notify in writing of conditions detrimental to proper completion of work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- a. Install lighting fixtures as indicated, in accordance with lighting fixture manufacturer's written instructions, requirements of applicable Standards and in accordance with recognized industry practices to insure that installation complies with requirements and fulfills intended function.
- b. Coordinate as necessary to properly interface installation of lighting fixtures with other works.
- c. Install each fixture properly and safely. Furnish and erect hangers, rods, mounting brackets, supports, bases, cables, canopies, channels, frames, and other equipment required.
- d. Furnish lighting fixtures complete with appurtenances required for the proper, safe and distortion-free installation in the various surfaces in which they appear.

- e. Obtain each lighting fixture packaged with complete instructions and illustrations showing how to install. Install lighting fixtures in strict conformance with manufacturer's recommendations and instructions.
- f. Install lighting fixtures plumb and at a height from the floor as specified. In cases where conditions make this impractical, refer to the consultant for a decision. Use ball aligners, hang straights and canopies on pendant fixtures.
- g. Do not install fixtures and/or parts such as finishing plates and trims for recessed fixtures until all plastering and painting that may mark fixtures finish has been completed.
- h. Lighting fixture locations in mechanical and technical rooms is approximate. Coordinate mounting height and location of lighting fixtures to clear equipment and to illuminate equipment adequately.
- i. Support all lighting fixtures independently.
- j. Whenever a fixture or its hanger canopy is applied to a surface mounted outlet box, utilize a finishing ring to conceal the outlet box.
- k. Make splices in internal wiring with approved insulated "wire nut" type mechanical connectors, suitable for the temperature and voltage conditions to which they are subjected.
- l. Use wire suitable for temperature, current, and voltage conditions to which it is subjected where utilized for connections to or between individual lamp sockets and lamp auxiliaries (i.e., wires which do not constitute "through circuit" wiring).
- m. Replace blemished, damaged or unsatisfactory fixtures as directed.
- n. Install all lighting units set true and free of light leaks, warps, dents, and other irregularities.
- o. Install all lighting units free of dust and dirt.
- p. Do not scale electrical drawings for exact location of the lighting fixtures. In general, the approved coordinated reflected ceiling workshop plans shall indicate the proper locations of lighting fixtures.
- q. Rigidly align continuous rows of lighting fixtures for true in-line appearance.
- r. Do not install recessed fluorescent fixtures weighing more than 18 kilograms directly on a concealed or exposed ceiling spline of a lightweight acoustical ceiling system. Support such fixtures from the building structure.
- s. Do not mount surface or pendant type fixtures regardless of their weight directly on the concealed or exposed ceiling spline of a lightweight, acoustical ceiling system. Support such fixtures from the building structure.
- t. Install reflector cones, baffles, aperture plates, light controlling element for air handling fixtures, visible trim, and decorative elements after completion of ceiling tiles, painting and general cleanup.
- u. Carefully handle to avoid scratching or fingerprinting and provide completely clean to the Owner at the time of acceptance.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of lighting fixtures and after building circuitry has been energized; apply electrical energy to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.
- B. Certify that the equipment has been properly installed, adjusted, and tested.

END OF SECTION 265100

SECTION 265600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes exterior lighting units with luminaires, lamps, ballasts, poles/support structures, and accessories and related power distribution and control, protective earthing and related builder's work including column foundations, cable pits, cable trenches and ductwork.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Interior Lighting" for interior fixtures, lamps, ballasts, emergency lighting units, and accessories; and for exterior luminaires normally mounted on buildings.

1.3 DEFINITIONS

- A. Lighting Unit: A luminaire or an assembly of luminaires complete with a common support, including pole, post, or other structure, and mounting and support accessories.
- B. Luminaire (Light Fixture): A complete lighting device consisting of lamp(s) and ballast(s), when applicable, together with parts designed to distribute light, to position and protect lamps, and to connect lamps to power supply.

1.4 SUBMITTALS

- A. Equipment Data: For each type of lighting unit indicated submit complete data for approval including, but not limited to, the following:
 - 1. Detailed literature, in English, for each type of luminaire or fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles, and any modification to a standard product if applicable
 - 2. Detailed specification and drawings for each column type including shape, base/mounting flanges, bolts, nuts etc, cross-sections, design criteria and calculations, brackets, finishes, provisions for cabling, cut-out or circuit-breaker etc.
 - 3. Photometric data for lighting calculations including polar curves, coefficients of utilization, efficiency and depreciation factors.
 - 4. Materials and dimensions of luminaires and poles.
 - 5. Certified results of laboratory tests for fixtures and lamps for electrical ratings and photometric data.
 - 6. Certified results of laboratory tests for fixtures and lamps for photometric performance.

7. High-intensity-discharge luminaire ballasts.
- B. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 1. Layout of equipment in exact positions with mounting and construction details, concrete foundation dimensions and reinforcement, routing and sections of duct-banks and trenches, backfill and packing material, earthing rods etc.
 2. Cabling and wiring diagrams, single line drawings, loads, phase distribution, protection and control, earthing and the like.
 3. Calculations of illumination and glare levels, based on CIE methods.
- C. Samples: submit fully equipped sample of luminaire or other materials or components if required by Engineer.
- D. Product Certificates: Signed by manufacturers of lighting units certifying that products comply with requirements.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- F. Maintenance Data: For lighting units to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

- A. Standards: Luminaires generally are to comply with IEC 60598 and the applicable CISPR recommendations. Manufacturer is to verify compliance with these standards and the applicable local regulations and design standards.
- B. Technical Requirements: Minor deviations from the Drawings may be considered for improvement in construction details, but no changes are to be made without the written approval of the Engineer.
- C. Ambient Conditions: Unless otherwise specified, equipment is to be designed and derated for continuous and trouble-free service at 50 deg. C ambient temperature and 100% relative humidity, with temperature reaching 70 deg. C in direct sunlight and with high content of ultra-violet rays. Equipment is to withstand full load operation whilst exposed to sun.

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

- A. Store poles on decay-resistant treated skids at least 300 mm above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- B. Retain factory-applied pole wrappings on poles until just before pole installation. Handle poles with web fabric straps.

1.7 EXTRA MATERIALS

- A. Spare Parts: Provide items necessary for maintenance, and up to 5% (or nearest whole unit) of installed quantities of each type of lamp, control gear, fuses, luminaire covers, special bolts or nuts, lamp-holders and the like which are subject to burning, breakage or failure.
- B. Furnish extra materials described below that match product 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: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
4. 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. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule shown on plans.

2.2 LIGHTING COLUMNS

- A. Construction: Columns are to be circular section, tapered, formed sheet steel, electrically welded, and of height specified. Columns up to 12-m height are to be one piece section. Columns above 12 m and up to 20-m height may be supplied in two piece sections, of the slip joint type with sufficient overlap to ensure correct vertical alignment of column after assembly. Columns are to have minimum wall thickness of 3 mm at base. Sheet steel is to have minimum rupturing resistance of 37 kg/mm² and minimum yield strength of 24 kg/mm².
- B. Top of column is to be designed to receive single or double arm brackets or other arrangement required, supporting number of luminaires shown on the Drawings. Bracket arrangement is to be designed to ensure that failure, due to wind induced oscillations, does not occur and that rotation from desired alignment is not possible.
- C. Column Design: Column cross-section, thickness of steel, joints, welds, bolts etc. are to be designed to withstand gust wind velocity of 160 km/hr blowing in the most unfavorable direction at a height 10 m above ground level, with column fully equipped. Fatigue of steel is in no case to exceed half elasticity limit, taking into account dynamic stresses due to vibrations. Steel flange plate, of adequate thickness, is to be solidly welded onto lower edge of column as shown on the Drawings, and is to have specified number of holes for holding down bolts together with central cable access hole not less than 150 mm diameter.
- D. Access door of weatherproof construction is to be positioned at column base and is to be suitably sized to insert and service the supply cable terminations and protective device. Door is to be flush fitting with retaining mechanism and positive locking arrangement with removable hexagonal key. Column is to be reinforced at door opening. Opposite each door, a non-hygroscopic baseboard of suitable size to accept appropriate equipment is to be fixed to inside of column by purpose-made brackets. Stainless steel earthing stud with washers and nuts is to be welded inside the column near the access door.
- E. Finish: Welds are to be smooth with spatter removed, inside and outside surfaces of column are to be cleaned by pickling or blasting and are to be free of grease. Steel components of columns to be hot-dip galvanized after fabrication. Minimum thickness of zinc coating is to be 500 g/m² on both inside and outside surfaces of column. Galvanizing is to be to NFA 91 / 121 or BS EN ISO 1461. Any damage to galvanizing is to be rectified during erection by wire brushing affected area and treating with approved rust converter to the satisfaction of Engineer. Flange plate and inside and outside of column base are to be coated with heavy bitumen paint prior to erection.

- F. Protection and Wiring: Columns with one or two luminaires are to be connected over one phase and neutral. Columns with three or more luminaires are to be connected over 3 phases and neutral, unless otherwise shown on the Drawings. Bolted terminals and cable lugs are to be provided with 3 phases and neutral terminals, for incoming and outgoing 3 phase 4-wire cable, and of the sizes shown on Drawings. One circuit breaker, single pole 6 A is to be provided for each phase leading to a luminaire. Circuit breakers are to be compensated and rated for 50 deg. C ambient with interrupting capacity of at least 9 kA, and are to be mounted in weatherproof enclosure at baseboard. Wiring is to be PVC insulated 3 core or 4 core 85-deg. C conductor temperature. Cable is to be at least 4 mm² copper conductor.

2.3 ROAD LIGHTING LUMINAIRES

- A. Construction: Totally enclosed, dust protected and splash proof, conforming to at least IP 54 of IEC 60529, shock resistant and specially designed to house required lamps, electrical gear and accessories. Body is to be corrosion resistant, extruded, pressure die-cast or fabricated aluminum alloy.
- B. Finish: Exposed metal parts of luminaires are to be factory finished, stove enameled, with suitable corrosion resisting paint capable of resisting heat emitted by lamp during continuous operation, and under full sunlight conditions. Color is to be agreed with Engineer.
- C. Mirror Reflectors: 99.5% purity, glazed and anodized aluminum or die-cast, super-purity aluminum vapor-deposited, and coated with transparent layer of silicon protection against wiping.
- D. Luminaire Protectors: Heat and shock resistant glass, mounted into suitable frame assembly fixed to body by captive screws, and secured by extra safety clamps to allow replacement of protector and reflector. Ozone resistant ethylene propylene or approved equivalent rubber is to ensure sealing of the front glass.
- E. Lamp Sockets: High-grade porcelain, mounted in support brackets with provision to adjust lamps vertically and axially. Lamp support and locking system are to grip and prevent lamp movement in operation.
- F. Ballast and control-gear are to be mounted in luminaire in separate compartment isolated from lamp, and with end-terminal blocks fitted with quick-disconnect electrical leads. Where required, control gear is to be contained in the pre-wired box, having an enclosure of IP 65, and mounted on luminaire ring separately from luminaires. Control gear is to be plug in type for operation at [220] V, a.c. single phase, [50] Hz. Ballast is to be specially selected for particular type of lamps used, and lamps are to be able to start with at least +/-10% variation of nominal voltage and continue in normal operation with dips attaining 20% for four seconds. Control gear losses are not to exceed 10% of normal lamp wattage. RFI suppression device is to be provided. Power factor is to be compensated to at least 0.9 lagging.
- G. HRC fuse cartridges, suitably rated and conforming to IEC 60269 or BS 88, are to be provided, complete with base, for protection of the luminaire. Fuse is to be rated to withstand starting current and is to be preferably located in control gear enclosure.
- H. Terminal Blocks: Suitable screw-tunnel type, clearly marked with arrangement to facilitate maintenance, quick replacement and easy disconnection of individual components.
- I. Lamps: Number and types shown on the Drawings and as described in Division 26 Section "Interior Lighting".

2.4 FLOODLIGHTS

- A. Type: Totally enclosed type, weather, dust and shock resistant, IP 64 of IEC 60529.
- B. Housing: High pressure die-cast aluminum alloy, closed on front by hinged framed protector highly resistant to thermal and mechanical shocks, and set in position by at least eight heavy duty stainless steel spring clamps with silicon sealing gasket. Enclosure is to be in accordance with IEC 60598-2-5, and is to be suitable for operation in an ambient temperature of 70 deg. C.
- C. Reflectors: High purity (over 99% reflectance) anodized aluminum, secured in precision aligned internal tracks to provide beam distribution required.
- D. Connection box is to be located at rear of floodlight body with gland connections to accept 4 mm² PVC/PVC three core cable. Lamp and control gear to be mounted in two separate and isolated compartments.
- E. Control Gear: Plug-in type, [220] V, [50] Hz, power factor compensated to at least 0.9 lagging. Ballasts and ignitors are to be type specially adapted for make of lamps selected. Ignitors are to be electronic thyristor type. Lamp is to be able to start with at least +/-10% line voltage, and with normal operation dips up to 20% for four seconds. Compensation is to ensure that there is no large increase in operating current during starting. Control gear losses are not to exceed 10%. Cables for internal wiring in control gear compartments are to be single core 2.5 mm² copper conductors with high temperature insulation and sheath.
- F. Finish: Exposed metal parts of floodlights are to be painted with corrosion and heat resistant paint, resisting operating temperatures attained in direct sunlight while lamp is burning.
- G. Mounting: Floodlights are to be located as shown on the Drawings and mounted on specially designed brackets to allow swiveling in any desired direction and locking firmly in final position. Protractor scale is to be provided for accurate setting.
- H. Earthing Terminals: Bolted earthing terminal is to be provided in each fitting.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment: Install equipment to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made to accomplish this but no changes are to be made without the approval of Engineer.
- B. Column Bases: Install columns on concrete bases as detailed on the Drawings. Before commencement of construction, ensure that bases are suitable for column installation.
- C. Holding Down and Plumb Adjusting Nuts, Washers, Locknuts or Nyloc Nuts: Stainless steel or cadmium plated.
- D. Columns: Erect columns so that luminaires are located on a line parallel to theoretical profile of road. Alignment of columns, both horizontally and vertically, is to be secured to the satisfaction of Engineer. Brackets are to be set at 90 degrees to longitudinal axis of road.

- E. Install poles as follows:
1. Use web fabric slings (not chain or cable) to raise and set poles.
 2. Mount pole to foundation with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 3. Secure poles level, plumb, and square.
 4. Grout void between pole base and foundation. Use non-shrinking or expanding concrete grout firmly packed in entire void space.
 5. Use a short piece of 13-mm diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- F. Luminaire Attachment with Adjustable Features or Aiming: Attach luminaires and supports to allow aiming for indicated light distribution.
- G. Mounting Adjustments: After demonstrating to Engineer that specified lighting requirements have been met, carry out final setting and locking in position of the floodlights.
- H. Luminaire Attachment: Fasten to indicated structural supports.
- I. Lamp luminaires with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.
- J. Cabling Conduits and Ductwork: Carry out in accordance with Division 26 Section "Conductors and Cabling". Cable ducts are to be directly buried except at crossings with other service work or roads.

3.2 INSPECTION AND TESTS ON SITE

- A. Visual inspection is to include inspection of condition of each piece of equipment, quality of workmanship, alignment, perpendicularity, labeling and the like, all in conformance with the Specification.
- B. Insulation resistance and continuity tests are to be carried out on each circuit and piece of equipment before energization, with circuit breakers in the open position and lamps not installed.
- C. Operational tests are to be carried out on all circuit breakers and control gear, with lamps installed, including recording voltage at terminals of ballasts on final columns of each circuit and at distribution panel or the like.
- D. Performance tests are to be carried out after 100 hours normal operation, and are to include measurement of lighting and uniformity levels on required illuminated surfaces.
- E. Other tests are to be carried out as required by the Engineer to verify conformity with the Specification.
- F. Earthing resistance tests are to include measurement of earth electrode resistance at final points of circuits and continuity of protective conductors.
- G. Results of tests are to be recorded on site and signed by witnessing parties.
- H. Provide instruments to make and record test results.
- I. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:

1. Measure light intensities at night if specific illumination performance is indicated. Use calibrated photometers.
 2. Check intensity and uniformity of illumination.
 3. Check excessively noisy ballasts.
- J. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.
- K. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.3 CONNECTIONS

- A. Ground Equipment:
1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.
- B. Ground metal poles/support structures according to Division 26 Section "Grounding and Bonding."
1. Nonmetallic Poles: Ground metallic components of lighting units and foundations. Connect luminaires to grounding system with conductor as shown on plans or in accordance with Regulations.

3.4 CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.
- B. Adjust amiable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

END OF SECTION 265600

SECTION 271000– STRUCTURED CABLING SYSTEM

GENERAL

1.1 RELATED DOCUMENTS

A. Contract

1. General provisions of the Contract, including Conditions of Contract, apply to this Section.
2. In particular, refer to these documents for all elements related to costs and responsibility related to delivery, storage, and roll-out phase.

B. Related Sections

1. Requirements of the following applies to this Section:
 - a. Division 26 Section “Basic Materials and Methods”.
 - b. Division 26 Section “Grounding & Bonding”.
 - c. Division 26 Section “Raceways & Boxes”.
 - d. Division 26 Section “Cable trays & Ladders”.
 - e. Division 27 Section “Voice Communications System”.
 - f. Division 28 Section “IP Surveillance CCTV”.
 - h. Division 28 Section “Access Control Systems”.

1.2 DEFINITIONS

- A. EMI: Electromagnetic Interference.
- B. EN: European Standard.
- C. FCC: Federal Communications Commission.
- D. IEC: International Electro-technical Commission.
- E. IP: Internet Protocol.
- F. ISO: International Standard Organization.
- G. LAN: Local Area Network.
- H. MDF: Main Distribution Frame.
- I. NFPA: National Fire Protection Association.
- J. QoS: Quality of Service.
- K. SCN: Structured Cabling Network.
- L. SLA: Service Level Agreement.
- M. SNMP: Simple Network Management Protocol.

- N. STP: Shielded Twisted Pair (some refer to this item as FTP: Foil-shielded Twisted Pair).
- O. UL: Underwriters Laboratories.
- P. UTP: Unshielded Twisted Pair.
- Q. WAN: Wide Area Network.
- R. WWW: World Wide Web.
- S. SM : Single mode fiber optical cable
- T. MM: Multimode fiber optical cable

1.3 SUMMARY

- A. This Section describes the Structured Cabling Network required to be implemented in the project premises.
- B. Scope of work consists of the installation of a generic structured wiring system based upon a star topology to connect all manner of applications covering voice and data transmission.
- C. 25% spare capacity is required at all levels of the system.

1.4 SYSTEM DESCRIPTION

- A. Overview of Current Environment
- C. Scope of Works
 - 1. The Scope of Works shall include, but not limited to, detailed engineering, coordination, manufacture, supply, transportation, delivery, installation, testing, commissioning, setting to work, training and maintenance services during the 24-month Warranty Period, Operation and Maintenance services for the Structured Cabling Network of The project. This shall include at least the following tasks:
 - a. Coordination with The project, existing contractors, and providers of interfaced systems,
 - b. Project management,
 - c. Planning management,
 - d. Detailed functional analysis until approval by The client,
 - e. Finalization of system to the approval of The client,
 - f. Detailed software specification to the approval of The client,
 - g. Delivery of the interface control document to the approval of The client,
 - h. Software development, complying with the detailed software specification,
 - i. Supply of needed Structured Cabling Network equipment and components,
 - j. . Transport, unloading, and storage on the site of the required equipment and components,
 - k. . Equipment installation,
 - l. . Software installation,
 - m. . System installation and configuration,
 - n. . System integration with interfaced and existing systems,
 - o. . Complete testing of the system (unit tests, integration tests, final acceptance tests, users' tests, etc.),
 - p. . Training,
 - q. in The project premises,
 - r. System roll-out,
 - s. System maintenance after successful initial proving period during Warranty,
 - t. Supply of spare parts for 2 years,

- u. System maintenance tools delivery,
 - v. Writing and delivering of documentation (user's manual, maintenance manual, test reports, etc.),
 - w. Operation and Maintenance as an option to The client.
2. This Section specifies the needs for the Structured Cabling Network and associated services to be purchased. The Structured Cabling Network represents passive components required to operate the overall IT network of The project. It provides interfaces with other systems, and with other dedicated or existing networks as applicable.
 3. This Section specifies the furnishing, installing, certification, testing, and guarantee of a complete and operating Structured Cabling Network in The project premises. The Contractor shall submit detailed schematic with appropriate matrix explaining all cable runs associated with various systems, to the approval of the Employer's Representative. Type of cable specified is the minimum requirements envisaged, but it is the responsibility of the Contractor to provide the type (e.g. MM/SM) as required to meet the requirements of the associated systems.
 4. Technical specifications and architecture principles are generic and can be used to future extensions.
 5. This Section includes equipment for Structured Cabling Network (SCN) including, but not limited to, the following:
 - a. Backbone Cabling subsystem:
 1. Multi core Fiber optic cable MM / SM type.
 - b. Horizontal Cabling subsystem:
 1. Cat 6 UTP shall be used for all horizontal cabling.
 - c. Cabinets,
 - d. 19" 42 U Racks,
 - e. Optical fiber patch panels,
 - f. RJ45 copper patch panels:
 1. Horizontal cables shall be terminated in high density Cat 6 patch panels.
 - g. Wire guide,
 - h. Optical fiber cables,
 - i. Unscreened Twisted Pair (UTP) cat6 cables,
 - j. Optical connectors,
 - k. RJ45 connectors,
 - l. Patch cords,
 - m. Cable trunks,
 - n. Outlet box and frame,
 - o. Earthing and grounding.
 6. The terminal equipment's of the following systems will be distributed on the structured cabling network:
 - a. Wired data networks / IP telephony/CCTV /Access control/ parking system ...ETC
 7. Technical (IT) Rooms:
 - a. Cabinets:
 1. Adequately sized cabinets shall be provided for all horizontal cables in each technical (IT) room for copper –Connections, fiber optic uplinks, and Active/Passive communication and data processing equipment.
 - b. Patch Panels and Accessories:
 1. Provide copper patch panels and accessories for data, voice, medical and video

signals for all other systems to be connected in the technical (IT) rooms.

8. Provide fiber patch panels, patch cords, and accessories for termination of cables for data and all other systems.
9. It shall be the responsibility of the Contractor to calculate and size the Structured Cabling Network as required for the specific systems, and to ensure minimum 50% spare on all fiber optic cable links. Special care shall be taken in technical rooms with more than two stacks, to take care of the additional uplink requirements.
10. This document also includes the recommendations and necessary coordination with power distribution in relation with the cabling system.
11. Labeling scheme for outlets, patch panels, cables, junction boxes, cabinets, etc. shall be unique and informative.

D. Coordination

1. Coordinate Works of this Section with the Employer's:
 - a. Departments, contractors, organization, etc.
 - b. Construction and implementation works.
 - c. Active communication and data processing equipment.
 - d. Fiber optic cabling infrastructure.
 - e. Workstations and servers suppliers.
 - f. IT systems providers using the Structured Cabling Network.
 - g. Others (list given above not exhaustive).
2. Meet jointly with representatives of above concerned organizations, contractors, and Employer's Representative to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.
3. Record agreements reached in meetings and distribute record to other participants.
4. Adjust arrangements and locations of equipment in technical rooms and way of wiring closets to accommodate and optimize arrangement and space requirements.

E. Variant and Options

1. The Contractor should propose no variant.
2. Options consisting in additional provisions to the basic system may be submitted to the Employer for approval, with specifications, characteristics, aiming and full particulars of calculations and equipment selections. All options shall be priced separately.

1.5 SUBMITTALS

A. Design Submission

1. Shall include, but not limited to:
 - a. Equipment and material datasheets must include (at least) the following information:
 1. Product performance and existing features,
 2. Environment requirements (Power, temperature, etc.),
 3. Features, hardware releases roadmap on the next two years,
 4. Standardized tests passed and results and available product certificates,
 5. Product compatibility matrix with other manufacturers/vendors (specify level of testing in operation, lab test, declarative or theoretical),
2. System Requirement and Design Specification

- a. System Architecture and justification.
- b. Justification of performance requirements.
3. Technical documentation and troubleshooting guides shall be provided in English, both paper and electronic version, for each type of component in the offer.
4. Product Certificates: signed by Manufacturers certifying that products furnished comply with requirements.
5. Test Plan:
 - a. The Contractor shall provide Test Plan on the testing methodologies used for various tests involved throughout different stages of the Works. This shall also include the plan for integrated tests for interface with other systems. The Contractor shall submit the Test Plan for approval by the Employer's Representative.
 - b. Test program shall be part of the test plan.
 - c. In establishing the test program, the Contractor and the Employer's Representative shall agree which activities shall be attended by the Employer's Representative.
 - d. After approval, the Test Plan shall be amended as required during the life of the Project to reflect changes in system design and the identification of additional testing requirements.

B. Project Schedule

1. Provide a detailed Build Plan that includes, but is not limited to:
 - a. All activities required to deliver a production ready network to the project.
 1. The duration of each activity in days,
 2. The resources required to complete each activity,
 3. Any dependencies amongst activities.

C. Product Data

1. Include detailed Manufacturer's specifications and data sheets for each system component.
2. Include data on features, ratings, and performance for each component specified.
3. For each type of equipment and material, submit data for approval including catalogues and literature, sufficiently detailed for engineering purposes, and with full description of components and operating parameters.

D. Shop Drawings

1. Indicate layout, wiring diagrams including typical details and dimensions.
2. Locate devices and components on drawings.
3. Submit drawings for approval including, but not limited to, the following:
 - a. Detailed system schematic diagram,
 - b. Layout of network components,
 - c. System labeling schedules, including electronic copy of labeling schedules in software and format selected by the Employer's Representative.
4. Complete electrical and physical characteristics of network components.
5. Complete system wiring diagrams, size and type of cables, enclosures, and terminal, splice boxes etc., and routing plans of wiring system.
6. Include dimensioned plan and elevation views of components. Show access and workspace requirements.

E. Manufacturer's Installation Instructions

1. Provide Manufacturer's installation instructions.
 2. Certificates signed by Manufacturers of equipment certifying that the provided products comply with contract specified requirements.
- F. System Operation Description
1. Include method of operation and supervision of each component and each type of circuit, and sequence of operations for manually and automatically initiated system inputs.
 2. Description must cover this specific Project; Manufacturer's standard descriptions for generic systems are not acceptable.
- G. Product Certificates
1. The Contractor shall provide certificates signed by Manufacturers of components certifying that the provided products comply with requirements.
- H. Qualification Data
1. For firms and persons specified in "Quality Assurance" an article shall be written to explain and demonstrate their capabilities and experience which shall not be less than 10 years working in this field for similar projects.
 2. To 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 the Employer's Representative.
 3. An experienced Contractor, which is an authorized representative of the Manufacturer, for both installation and maintenance purpose, is formally required for this Section.
- I. Tests and Certificates
1. Test Specifications as defined in the Test Plan shall be submitted for Approval.
 2. Submit complete certified Manufacturer's type and routine test records, in accordance with the Standards specified in "Quality Assurance" Article.
 3. It shall specify test results for compliance with performance contract requirements.
 4. Include record of signal ground resistance measurement certified by the Contractor.
- J. Field Test Reports
1. As specified in "On-Site Tests and Inspections" Article of this Section, the Contractor shall indicate and interpret test results for compliance with system description and performance requirements.
- K. Record (As-Built) Drawings
1. Complete wiring diagrams, including complete terminal strip layout and identification, and wire termination and tagging for all conductors.
 2. Locations for all components installed and/or connected to under this Specification.
- L. Sample Warranty
1. Copy of Manufacturer's proposed warranty, stating obligations, remedies, limitations, and exclusions.
 2. Provide copy of sub-contractor's warranty certificates.
 3. Provide Contractor's warranty certificates.

M. Maintenance Data

1. For products and systems, the Contractor shall include maintenance manuals
2. The Contractor shall include data for each type of product, including all features and operating sequences, both automatic and manual.
3. The Contractor shall include user's software data and recommendations for spare parts and components to be stocked at Project site.

1.6 REGULATIONS AND STANDARDS

A. Rules

1. The Works shall be conformed to requirements of referenced industry standards, applicable Sections.
2. The Works shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Employer's Representative, in writing.
3. Conflict: Should an instance occur in this Specification and referenced Sections in which equipment, components, material or construction methods called for is less than minimum requirement of the referenced industry standards, rules, local regulation, etc., the Employer's Representative shall be immediately informed in writing. Consequent to the Employer's Representative's approval, supply the equipment, components, material and perform the work as through called for to minimum code standards.

B. Standards

1. Standards to be used is the IEC or other equal and approved codes, taking into account that network cables with fitted accessories and connector and wiring have to be of fire rated type in accordance with all NFPA requirements codes (NFPA72 and extensions).
2. System components, parts, and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).
 - a. ISO/IEC 11801: latest edition regarding Information Technology and generic cabling for customer premise.
 - b. EIA/TIA 568, Commercial Building for Telecommunication Wiring Standard.
 - c. EIA/TIA 569, Commercial Building for Telecommunication Pathways and spaces.
 - d. EIA/TIA 606 for Telecommunications Infrastructure: this document provides the user with guidelines and choices of classes of administration for maintaining telecommunications infrastructure.
 - e. EIA/TIA 607 Commercial Building Grounding (Earthling) and Bonding Requirements for Telecommunications (ANSI/J-STD-607-A-2002).
 - f. IEC 60754-1 & 2 Test on Gases Evolved During Combustion of Materials from Cables and Test on Gases Evolved During Combustion of Electric Cables.
 - g. IEC 61034-1 & 2 Test and Measurement of Smoke Density of Cables Burning under Defined Conditions.
 - h. IEC 60331 part 11 & 12, Tests for Electric Cables under Fire
 - i. IEC 60332 Tests on Electric Cables under Fire Conditions.

- j. IEC 60364-1 Electrical Installations of Buildings, Fundamental Principles, Assessment of General Characteristics, Definitions.
- 3. Comply with the latest issue of several material and test standards, which have been developed and published by Institute of Electrical and Electronics Engineers (IEEE) for data communications industry, but not limited to:
 - a. 802.1 – Network Management Group,
 - b. 802.2 – Logical Link Control Group,
 - c. 802.3 – Carrier Sense Multiple Access/Collision Detection Group,
 - d. 802.6 – Metropolitan Area Networking Group,
 - e. 802.7 – Broadband Technical Advisory Group,
 - f. 802.8 – Optic Fiber Technical Advisory Group,
 - g. 802.9 – Integrated Voice and Data LAN Working Group,
 - h. 802.10 – LAN Security Working Group,
 - i. 802.11 – Wireless Networks
 - j. 802.12 – Fast Ethernet.
- 4. Comply, as often as possible, with both ITU-T (International Telecommunications Union) recommendations and US standards. When standards are not compatible in both Europe and US (e.g. telecom interfaces SDH STMx vs. SONET OCx) detailed compatibility and interface availability shall be provided.
- 5. Comply with the latest issue of several material and test standards, which have been developed and published by Network Equipment Building System (NEBS). Level 1, Level 2, and Level 3 are applicable to this Section:
 - a. SR3580: NEBS: Criteria Levels.
 - b. GR-63-Core: NEBS: Physical Protection.
 - c. GR-1089-Core: NEBS: EMC and Safety.
- 6. European Telecommunications Standards Institute (ETSI).
- 7. Safety:
 - a. UL 1950, 3rd edition.
 - b. EN 60950/IEC60950.
 - c. EN60825 Laser Safety (Class 1).
- 8. EMI:
 - a. FCC part 15 Class A, B.
 - b. EN55022 Class A, B.
- 9. Immunity:
 - a. EN-61000-4-2 ESD.
 - b. EN-61000-4-3 Radiated Immunity.
 - c. EN-61000-4-4 EFT.
 - d. EN-61000-4-5 Surge.
 - e. EN-61000-4-6 Low-Frequency Common Immunity.
 - f. EN-61000-4-11 Voltage Dips and Sags.
 - g. EN-61000-3-2 Power-Line Harmonics.
- 10. NFPA 70: National Electrical Code.

C. Precautions

- 1. The above list is a partial list issued from standard organizations. Additional consideration may be required to provide protection of communication equipment and materials and protection of data from intrusion, induced noise or other events that can disrupt vital operation.

1.7 QUALITY ASSURANCE

A. Requirements

1. All Works shall be executed and controlled by a quality management system in accordance with the requirements of ISO 9001.
2. This system shall comprise all the participants to the Contract within the Contractor's teams and its sub-contractors.
3. The Quality Assurance Plan is based on quality manuals of the Contractor and subcontractors.
4. The Contractor nominates from the beginning of the Project, the person in charge of quality assurance of the whole project, who is directly linked to the Project Director.
5. The Contractor should establish from the beginning of the Project, the Quality Assurance Plan based on Contractor's quality system that should define:
 - a. Scope of Quality Assurance Plan, with conditions of validity and revision,
 - b. Approach and structure of the Contractor's quality management system to fill the requirements of the Contract and ISO 9001,
 - c. Organization retained for the Project with sub-contractors list,
 - d. Details of how the Contractor proposes to manage sub-contractors and to sure that the relevant quality system requirements of ISO 9001/2 are observed and implemented by the sub-contractors in the execution of the works sub contracted,
 - e. The quality plans of the Contractor.

B. Manufacturer Qualifications

1. A firm specializing in providing Structured Cabling Network components and materials similar to that indicated for this Project and with a record of successful in-service performance.
2. Manufacturer's systems shall be, as often as possible, a standard "off-the-shelf" package utilizing the latest hardware and software technology. Any major system development effort necessary to meet specified requirements is unacceptable. Even if this system is a new concept, it should not require huge development and shall be based on existing and proven technologies.
3. Manufacturer or factory-authorized agency shall maintain a service center capable of providing training, parts, and emergency maintenance and repairs for overall system at Project site with eight hours of maximum response time.

C. Installer Qualifications

1. An experienced Installer, as indicated in 1.5 H, who is an authorized representative of the equipment Manufacturer for both installation and maintenance of Manufacturer's equipment, and who has completed system installations similar in design and extent to that indicated for this Project, with a record of successful in-service performance.

D. Materials and Workmanship

1. They shall conform to the latest issue of all industry standards, publications, or regulations referenced in this Section, including the following, as applicable:
 - a. Regulations and Standards: System components, parts, and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).
 - b. Compliance with Local Requirements: Comply with applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Employer's Representative, in writing.
 - c. Conform to requirements of referenced industry standards, applicable Sections.

E. Source Limitations

1. For each category of technology used for the Structured Cabling Network, obtain system components from one Manufacturer who shall assume responsibility for the system components and for their compatibility.

1.8 COORDINATION

A. Coordinate Work of this Section with:

1. LAN passive network suppliers.
2. Infrastructure and cabling contractors.
3. Etc.

B. Coordinate with The project to confirm location of equipment, devices and system components.

C. Meet jointly with representatives of concerned organizations, contractors, and Employer's Representative to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.

D. Record agreements reached in meetings and distribute record to other participants.

1.9 TESTING AND REPORTS

A. The Contractor shall test all components and circuits of the Structured Cabling Network after installation to ensure functionality and performance within industry approved guidelines.

B. A written report shall be submitted describing testing procedure and detailing test results.

C. The Contractor shall provide and supply all necessary technical and skilled manpower, tools, test equipment, materials and transportation required for performing system and components testing.

1.10 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals

1. The Contractor shall submit full system documentation for the installed system and all ancillary equipment.
2. System documentation shall consist of:
 - a. A complete set of product data for all component and parts.
 - b. A complete set of operations manuals for all components of the system.
 - c. Maintenance manuals for all components of the system and for the system as a whole.

B. Test procedure, data and results from acceptance testing.

1.11 WARRANTY

A. Special Warranty

1. Manufacturer's Warranty: Provide written warranty, signed by the Manufacturer and the Installer agreeing to replace system devices and that fail in materials or workmanship within specified warranty period.

B. Initial Experimental Period

1. There shall be an experimental period of 90 days after successful testing and commissioning of the system, but before issuance of substantial completion certificate. During this period, the Contractor shall undertake supervision and responsibility for operation of the system under actual site conditions. If any malfunctioning or anomaly noted on the system during this period, it shall be attended immediately. The experimental period will restart automatically from the date of clearing such troubles and start normal operation.
2. During this period, the Contractor shall fully demonstrate the system performance under actual operation conditions. This demonstration is to confirm, to the satisfaction of the Employer's Representative, that the system is free of remarks and is ready for provisional taking over.
3. After the satisfactory completion of this period, the system is to be taken over by the Employer, as per Contract Conditions, whereby the Warranty Period is to commence.

C. Warranty Period

1. Two years from the satisfactory completion of the Experimental Period.
2. During the Warranty Period, the Contractor shall undertake Maintenance actions as defined in the Maintenance and Warranty Article.
3. During the Warranty Period, the Contractor shall provide, at its own cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.

D. Manufacturer Product Performance

4. The Contractor shall provide a Manufacturer endorsed and backed extended 20-years product, performance, application, and labor warranty which shall:
5. Warrant against defects in materials and workmanship (extended product warranty) for a period of 10 years.
6. Warrant that all cabling components of the installed system will meet or exceed the specifications of TIA/EIA 568B and ISO/IEC IS 11801 (performance warranty) for a period of 20 years.
7. Warrant that all unshielded/shielded twisted pair cabling links/channels will meet or exceed the attenuation and NEXT requirements of TIA/EIA TSB 67 and ISO/IEC 11801 (performance warranty) for a period of 20 years.
8. Warrant that all fiber links/channels shall meet or exceed the loss and band width requirements of TIA/EIA TSB 67 and ISO/IEC 11801 (performance warranty) for a period of 20 years.
9. Warrant that the system shall be application independent and shall support both current and future applications that use the TIA/EIA 568B or ISO/IEC 11801 component and link/channel specifications for cabling (application warranty), for a period of 20 years.
10. Warrant that all labor attributable to and required by the above shall be supplied at no cost to the Owner for a period of 10 years.

1.12 COMMISSIONING

A. Purpose

11. During this phase the equipment are powered and the automation and networking are gradually integrated layer by layer.
12. The tests shall be performed by the Contractor and witnessed by the Employer's Representative.
13. Any defects, which may become apparent during the course of these tests, shall be immediately

rectified by the Contractor at his expense.

14. The Site Acceptance Test Specifications shall be prepared by the Contractor and submitted for Approval.
15. All Site Acceptance Tests shall be carried out in the presence of the Employer's representative who shall sign off the testing documentation on satisfactory completion of the tests.
16. The results of the Site Acceptance Tests, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representative.

B. Tests

1. Those tests are divided into 2 sub-phases.
2. Preliminary Testing:
 - a. Mechanical:
 1. Mechanical tests,
 2. Calibration of the cables.
 - b. Automatism / Electrical:
 1. Powering Tests with electricity,
 2. Control of Input/Output,
 3. Control of the safety measure either personal or material,
 4. Test of local mode operation.
 - c. Network / Software Tests:
 1. Test of the Network,
 2. Test of the Supervision Workstation user interface,
 3. Test of the portable Terminal user interface.
3. Test of the System:
 - a. The tests performed during this phase are performed with and without loading conditions.
 1. Testing the crippled mode (Safe shut down consecutive to loss of energy, etc.).

1.13 MAINTENANCE

A. Maintenance Service

1. During the Warranty Period, Manufacturer or factory-authorized agency shall maintain a service center capable of providing spare parts and emergency maintenance and repairs for the overall system at Project site 7 days a week and 24 hours a day. Competent personnel shall be dispatched to rectify stoppages at any time during the day or night when being called on by the Employer.
2. The Contractor shall submit a Service-Call Report to be sent to the Employer immediately following every call out, indicating the time of call out visit, cause, remedial action taken and the time that the service was restored.
3. A Maintenance Manpower Plan shall demonstrate the Contractor's committed resource level available for all types of activities to be carried out within the Warranty Period. Such plan shall be submitted for Approval six months before commencement of the Warranty Period.

4. The Contractor's response time, during the Warranty Period, shall not exceed 1 hour. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.
5. During the Warranty Period, the MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on site, but shall exclude the response time.
6. During the Warranty Period, the monthly average of the Repair Time shall be lower or equal to six minutes for each device. This performance will be checked.
7. The Contractor shall liaise with the Employer's Representative and carry out safety and performance inspections for the installation on site. Any necessary adjustments to the installation shall be made within 14 days of completion of such checks. A Safety and Quality Report shall be submitted, no later than 14 Days after such safety and performance checks, for the Employer's Representative's approval.
8. The Contractor shall provide at least four inspection visits at six-month interval during the Warranty Period.
9. The Contractor shall be responsible to clear away from the Site all surplus materials, rubbish, temporary works of every kind and leave the whole of the Site and installation clean and in a workmanlike condition to the satisfaction of the Employer's Representative, upon completion of each item of the repair, and maintenance works.

1.14 GLOBAL SYSTEM REQUIREMENTS

A. General

1. Cables shall enter the equipment racks or enclosures in such a manner that all doors or access panels shall open and close without disturbing or damaging the cables. All cables shall be installed in conduit, ducts, conduit, trunk or trays (fiber runner) in accordance with section 16130 & 16139 and NEC art.517 and 800. Coordinate the features of material and equipment so they form an integrated system. Match components and interconnections for optimum future performance.

1.15 SPARE PARTS AND EXTRA MATERIAL

A. Extra Materials

1. The Contractor shall provide extra material that match products installed and that are packaged with protective covering for storage and identified with labels clearly describing contents to ensure the operation of the Structured Cabling Network.
2. The Contractor shall provide, together with an itemized list, all test equipment and tools required for routine maintenance, safety checks and equipment repair. The Contractor shall deliver test equipment and tools at the same time as the system equipment. The Contractor shall provide the following test equipment:
 - a. Optical Time Domain Reflect-Meter (OTDR) for all wavelengths from 633 nm to 1575 nm and fiber/connector combinations.
 - b. Photometer for fiber optic measurements on short distances in complement of the OTDR.
 - c. Digital cable analyzer, level III accuracy, for twisted pairs cables, that display result up to 250 MHz as a minimum.
 - d. Ten complete termination tool kits for RJ45 Cat 6 jacks connectors, similar to the RJ45 installed.
 - e. Ten complete kits for fiber termination, single mode and multimode single or duplex LC or SC, connectors similar to the SC connectors installed.
 - f. Ten sets of wiring tools for RJ45 Cat 6 jacks installation.
 - g. Complete fiber optic programmable fusion or mechanical splicing tool equipment.

B. Spare Parts

1. The Contractor shall provide Manufacturer recommended spare parts for all major components in the system for two years fault free operation.
2. However, a minimum of 2% peripherals of each type installed, but not less than one from each type shall be included in the deliverable irrespective of Manufacturer recommendation.
3. During the Warranty Period, the Contractor shall provide, at his cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.
4. The Contractor shall guarantee the flow and availability of the spare parts without a major design change for at least ten years period.

PART 2 - PRODUCTS

2.1 GENERAL

- A. This Section describes the minimum requirements for the Structured Cabling Network.
- B. All hardware must be a current offering of the Manufacture, and be receiving the highest level of support offered by the Manufacture.
- C. All hardware shall be new equipment.
- D. The purpose of the Structured Cabling Network is to realize a common cabling infrastructure able to connect any type of equipment such as voice, data and video terminals.
- E. In order to achieve this purpose and to perpetuate as much as possible the present investments, the cabling system shall be of:
 1. Routing Type: Each room shall be equipped with one or several connecting access points according to their use and surface area on one end and the terminals to be installed on the other end.
 2. Standardized Type: All sockets of each connecting access points shall have the same technical characteristics and shall be equipped with the same number of pairs.
 3. ISO Code Type: Cabling system shall comply with the international ISO 11801 codes. In addition, cabling system shall comply with the performances of the existing active communication and data processing networks, twisted pairs type or fiber optic type.

2.2 MANUFACTURE

- A. Available Manufacturers: Manufacturers shall provide the products in compliance with the requirements of the specifications and to be incorporated with the Work are listed below:
 1. Systimax- (U.S.A)
 2. Nexsan (FRANCE)
 3. R&M
 4. Corning

2.3 ARCHITECTURE OF THE STRUCTURED CABLING NETWORK

- A. The architecture of the cabling system shall be sufficiently flexible in order to allow any in put reconfiguration at the distribution level.
- 2. B. Network architecture shall be based on the following parts:
 - 1. Building Core/Distribution Node.
 - 3. Floor Distribution Node.
 - 4. Horizontal Cabling Network.
 - 5. Backbone Cabling Network.
- C. Distribution panels shall include one or several cabinets or group of panels to be installed in technical rooms.

2.3 EQUIPMENT CABINETS

- A. 19 inch Cabinets
 - 1. All cabinets shall be free standing standard universal 19 inch wide racks for distribution nodes of small capacity, which may be of wall mounted 19 inch racks.
 - 2. 19-inch cabinets shall be provided with the following equipment:
 - a. Two PDUs Fuseless, including 4x IEC63020 C19 sockets & 12 x IEC 320 EN 60320C13 minimum.
 - b. A pair of 19 inch front uprights set back 100 mm from front face.
 - c. 42 U 800x1000 mm or 800 x800 mm for data center racks and for low current racks
Number of (U) will be depend on the rack equipment with capacity space 25% 600x600 or 600 x 800 mm structure.
 - d. Twin vertical cable management system for front side of the rack, extending to the full height of the rack including trim plates.
 - e. Removable and lockable side panels.
 - f. Double glazed lockable front 400 mm doors.
 - g. Double plain lockable rear 400 mm doors.
 - h. Roof blanking plate with ventilation with cable holes
 - i. A pair of 300 mm basket trays for cable fixing.
 - j. Earth bus bar.
 - k. 6 way fan tray with 6 number low noise fans.
 - i. Dust proof panel with brush for cable entry openings
 - i. Multiple top panel cable entry points
 - i. Strong lightweight frame construction
 - i. Cable management for 10 Gbps cable
 - i. Fully adjustable front and rear vertical mounting
 - i. Overhead cable management
 - i. Cable Management and Routing (Copper /fiber type)
 - i. Thermal Management (FAN, Air baffles and blanking panels)
 - i. Racks shall be IP 42 to IEC 144 for indoor installation.
 - 3. Cabinets installed on raised floor shall be fitted with leveling feet.
 - 4. Cabinets installed on slab shall be fitted with 100 mm height base with 300 x 50 mm cable hole.

Cabinets are to include 19 inch power strip, flush mounted outlets with pilot lamp for rack

- 5. Used for both cabling and active parts.

6. Cabinets to have 20% space unused.

A. For 19 "Racks inside data center room

1. Rack specification is not limited to the following:- 42 U RACK 800 mm x 100 or 800x800 mm Steel Frame with Viewing Window structure.
2. Cabinets installed on slab shall be fitted with 100 mm height base with 300 x 50 mm cable hole.

B. For 19 " Racks inside IT Rooms

1. Rack specification is not limited to the following:- Number of (U) will be depend on the rack equipment with capacity space 25% (600x600 or 600 x 800 mm) structure.
2. Cabinets installed on raised floor shall be fitted with leveling feet.

C. Common Equipment to Cabinets and Racks

1. Multi-formed mounting channels shall be standard gauge cold rolled steel, with secondary chassis providing infinite front-to-back adjustment.
2. Base section shall be, as a minimum, 1.5 mm thick cold rolled steel. Blower panels shall be installed in base section of each cabinet to provide required filtered air at zero static pressure.
3. Depth of unit is to allow cable access through bottom and back of racks.
4. Finishes:
 - a. Steel cabinets and consoles shall be coat with phosphate or galvanized sheet steel box constructed with joints welded on inside 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 Employer's Representative.
5. Any system unit shall be of 19 inch type and withdraw-able and hinge-racked type.
6. Cabinets shall be of 19 inch frame, totally enclosed, with side and rear panels removable, and cable entrance at rear, top or bottom. Surface finish shall be textured and have approved color. Frames shall be anodized aluminum sections. Each frame shall be provided with ventilation rack, including automatically operated fan with thermos-tatic control.
7. Suitable ventilation openings shall be provided.
8. Enclosure shall be IP 42 to relevant IEC for indoor installation.
9. Storage: racks and cabinets shall have storage drawers for cables and accessories.
10. Mains wiring: equipment shall operate from 220 V, 50 Hz mains and shall be capable of continuous operation under any load conditions with variations of +/-10% of nominal voltage. Mains wiring inside consoles shall be totally segregated from low level signal wiring.
11. Electric connections, other than those for low level signals, shall be of push-on spade clips type or multi-connector blocks type.
12. Low Level Signal Wiring: heavily braided, PE insulated, screened cable, PVC sheathed with standard DIN plug connections. Amplifier output lines shall be twisted pairs heavily screened and fire proof type. Hum-producing earth return loops shall be avoided.
13. Equipment Racks
 - a. 19 inch rack shall be provided with the following equipment:
 1. Equipment cabinets shall comprise free standing 475 mm (19") racks inside enclosed cabinets.
 2. Standard holes shall be provided for panel mounting of control equipment and cable distribution terminal boards, which shall be easily accessible for maintenance.

D. Optical Fiber patch panel

1. The Contractor shall provide 1U, LC / SC duplex optical fiber drawers for multi- and single- mode fiber optic cables for both vertical and horizontal distribution.
2. Optical fiber patch panel shall consist of:
 - a. 19-inch rack-able set,
 - b. 1U height enclosure,
 - c. Loop module,
 - d. Cable back entries including bushing,
 - e. Adjustable fixing devices,
 - f. Adjustable front panel,
 - h. Label holder.
3. All ports receiving fiber optic cable shall be fitted with LC / SC duplex connectors.
4. All spare/unused ports shall be fitted with SC duplex cover.

E. RJ45 Patch Panels

1. Cooper Cat 6 RJ45 patch panels dedicated for RJ45 horizontal and vertical twisted pairs wiring shall be installed in 19 inch racks dedicated to RJ45 jacks.
2. RJ45 patch panels shall consist of:
 - a. 19-inch rack-able set,
 - b. 1U height 24 ports or 1U/2U height 48 ports,
 - c. Cable holder back plate,
 - d. Front panel with individual shutter for each port,
 - e. Label holder for each port,
 - f. Label holder for patch panel,
 - g. Earthling kit.

F. Patch Cord Guide Panels

1. Patch cord guide panels shall be installed in the racks to ensure cabling management.
2. Patch cord guide panel shall consist of:
 - a. 19-inch rack-able set,
 - b. 1U height,
 - c. Front panel set back from rack framework to avoid door opening problems,
 - d. 3 front open rings,
 - e. Storage elements for spare cable lengths on the rear.

2.4 CABLES

A. Fiber Optic Cable

1. The fiber optic cables shall be either multi-mode or single-mode depending of their function and shall meet or exceed TIA/EIA 568B specifications
2. Single mode and Multi-mode, OM3/OM4: fiber optic cables shall have the following minimum performance characteristics:

B. Multimode Fiber Optic Cable

3. Fiber optic cables installed within buildings, in conduits or trunks.
4. Fiber optic cables used for vertical / horizontal links shall have the following characteristics:
5. a. Mini-tube type structure

- A. OM3 and OM4 standard compliant multimode fibers
- B. Low attenuation values of 3.0 dB/km @ 850 nm
- C. 10 Gb/s Ethernet serial transmission over 550 m
- D. Installed cable shall be 850 (nm), multimode, and graded index glass fiber.
- E. Cable shall comply with the following standards
IEC 60793-2-10, ITU-T G651/G652 D, ANSI/TIA 568-B.3, IEC-794, RoHS
- A. The optical fiber multimode cable shall be multicore 2,4,8,12,16 ,24,48..... etc
- B. All materials in the cable are to be dielectric.
- C. Protective coatings are applied over the glass cladding to provide the necessary maximum fiber lifetime.
- D. fiber cables should be, UV resistant, Low Smoke, Zero Halogen (LSZH) compound outer jacket is extruded over the cable core
- E. Installed optical fiber cabling and connection hardware shall meet the requirements of ANSI/TIA-568-C.3, and applicable of ANSI/TIA-568-C.
- F. Cable is commonly referred to as “low water peak” multi-mode fiber and a low attenuation
- G. Performance: Installed fiber must meet or exceed the following performance specifications.
- H. Cable must support at least the following applications :Fast Ethernet 100 base FX, Giga Ethernet 1000Base-Sx & 1000base-Lx, 10G Ethernet
- I. Temperature:
- J. Storage -40°C (-40°F) to +75°C (+167°F)
- K. Installation -30°C (-22°F) to +60°C (+140°F)
- L. Operating -40°C (-40°F) to +70°C (+158°F)

C. Single mode Fiber Optic Cable

- A. The optical fiber single mode cable is used in high speed and broadband telecommunication applications.
- B. Mini-tube type structure,
- C. 40 Gb/s Ethernet serial transmission
- D. The optical fiber single mode cable shall be multicore ,4,8,12,16 ,24,48.... etc
- E. Installed cable shall be 9/125micron core/cladding, single mode, and graded index glass fiber.
- F. Cable shall comply with the following standrads
IEC 60793-2-10, ITU-T G651/G652 D,ANSI/TIA 568-B.3 ,IEC-794, RoHS
- G. All materials in the cable are to be dielectric.
- H. Protective coatings are applied over the glass cladding to provide the necessary maximum fiber lifetime.
- I. fiber cables should be, UV resistant, Low Smoke, Zero Halogen (LSZH) compound outer jacket is extruded over the cable core
- J. Outdoor applications should be Flame Retardant Black PE.
- K. Installed optical fiber cabling and connection hardware shall meet the requirements of ANSI/TIA-568-C.3, and applicable of ANSI/TIA-568-C.Cable is commonly referred to as “low water peak” single-mode fiber and is characterized by having a low attenuation coefficient in the vicinity of 1383 nm
- L. Performance: Installed fiber must meet or exceed the following performance specifications.

Fiber cable types	Wavelength (nm)	Max. Attn. (dB/Km)
Single mode, Inside plant	1,310	1.0
	1,550	1.0

- a. Mini-tube type structure,
- b. Cable reinforced with coated glass fiber,
- c. LSZH Polyethylene outer jacket,
- d. Metric marking indicating type of cable, year, ref., number,
- e. Secondary coating: 250 um,
- f. Maximum allowable tension: 1300 N,
- g. External diameter: 7 mm,
- h. Installation temperature: 0°C / +40°C,
- i. Storage/transport temperature: -20°C / +70°C,
- j. Operating temperature: -10°C / +60°C,
- k. Minimum bending radius:
 - 1. Static: 100 mm,
 - 2. Dynamic: 140 mm.

- l. Crush resistance: 300 N/cm,
 - m. Weight: 55 kg/km,
 - n. Complies with IEC 60754-1,
 - o. Complies with IEC 60332-3C.
3. Fiber optic cables used for horizontal links shall have the following characteristics:
- a. Tight-buffer type structure,
 - b. Cable reinforced with aramid fibers,
 - c. LSZH Polyethylene outer jacket,
 - d. Metric marking indicating type of cable, year, ref., number,
 - e. Secondary coating: 900 um,
 - f. Maximum allowable tension: 1000 N,
 - g. External diameter: 6.5 mm,
 - h. Installation temperature: 0°C / +40°C,
 - i. Storage/transport temperature: -30°C / +70°C,
 - j. Operating temperature: -30°C / +60°C,
 - k. Minimum bending radius:
 1. Static: 45 mm,
 2. Dynamic: 130 mm.
- l. Crush resistance: 600 N/cm,
 - m. Weight: 45 kg/km,
 - n. Complies with IEC 60754-1,
 - o. Complies with IEC 60332-3C.

C. Category 6 Cable Unshielded Twisted Pair Cables, Voice backbone cables shall be Cat6, TIA/ EIA 568.B and shall have the following Characteristics:

- 24 AWG
- Multi pair with 4 twisted pairs.
- Typical impedance: 100 Ohms.
- Unshielded (UTP)
- Low Smoke Zero Halogen outer sheath

2. Horizontal cables used in this project shall comply, as a minimum requirement, with

Cat 6 cable performance defined by standard TIA/EIA-568.B.2.

Pairs	Wire 1	Wire 2
1	White/blue	Blue
2	White/orange	orange
3	White/Green	Green
4	White/brown	brown

3. Twisted pair cables performance shall meet the following values:

Frequency MHz	Attenuation dB/100m	NEXT dB	ELFEXT dB	PSELFEXT dB/100m	Return Loss dB/100m
1	≤ 1,8	≥ 86,3	≥ 89,1	≥ 86,0	≥ 30
4	≤ 3,5	≥ 86,9	≥ 85,4	≥ 82,0	≥ 30
10	≤ 5,5	≥ 87,2	≥ 84,8	≥ 82,0	≥ 30
16	≤ 7,0	≥ 82,3	≥ 85,2	≥ 82,0	≥ 30
20	≤ 7,9	≥ 84,5	≥ 83,5	≥ 81,0	≥ 28
31,25	≤ 9,9	≥ 82,0	≥ 81,2	≥ 78,0	≥ 26
62,5	≤ 14,0	≥ 76,8	≥ 74,5	≥ 72,0	≥ 25
100	≤ 17,8	≥ 71,7	≥ 69,5	≥ 67,0	≥ 24
155	≤ 22,3	≥ 71,0	≥ 66,0	≥ 63,0	≥ 22
200	≤ 25,4	≥ 69,9	≥ 63,2	≥ 60,0	≥ 20
250	≤ 28,5	≥ 66,2	≥ 57,8	≥ 55,0	≥ 20
300	≤ 33,0	≥ 62,0	≥ 52,0	≥ 50,0	≥ 20

4. All cables shall have the following capacities: Category 6 , UTP cable, 4 twisted-pair.

Twisted pair cables shall have the following characteristics:

- a. Nominal impedance: 100 Ohms +/- 5%, 10- 100 MHz,
- b. Low Smoke Zero Halogen outer sheath,
- c. Metric marking indicating type of cable, year, ref., number,
- d. Performance: Up to 100 MHz , 1 Gigabit
- e. Propagation speed: 72%*c*,
- f. Propagation Unbalance: 10 ns/km,
- g. Weight: less than 70 kg/km,
- h. External diameter: 8.5 mm,
- Power over Ethernet PoE /POE+ – IEEE 802.3af
- i. Installation temperature: -5°C / +40°C,
- j. Storage/transport temperature: -15°C / +70°C,
- k. Operating temperature: 0°C / +60°C.

Twisted pair cables shall be color-coded as follows:

5. The Contractor may provide other type of twisted pair cable if characteristics and performance meet the above mentioned specifications.

2.5 CONNECTION

A. Optical Fiber Connector

1. Optical fiber connectors and pigtails shall be single or duplex LC / SC single in accordance with ISO 11801.
2. Given the type of fiber, ceramic end fitting for multi-mode or single-mode shall be used.
3. Connectors shall comprise sleeve for 900 um.
4. Connectors shall be crimp-lock type without glue.
5. 900 um sleeved cables shall be directly connected on the fiber.
6. Optical access point (dual) shall be provided in dedicated 45 x 45 LC / SC duplex or single module with shutter.
7. Connection of tube type fiber optic cables shall be ensured by fusion with LC / SC duplex or single multi-mode or single-mode pigtails.
8. Each pigtail shall have the following attenuation: 0.15 dB at 850 nm for multi-mode and 1300 nm for single-mode.
9. Splicing shall be done through automatic programmable splicing system.
10. Splicing shall produce losses of 0.15 dB at 850 nm for multi-mode and at 1300 nm for single mode.

B. RJ45 Connectors/Jacks

1. The Contractor shall use RJ45 8-points connectors complying with Cat 6 – ISO 11801.
2. The Contractor shall provide 8 position / 8 conductors.
3. The connectors shall be unshielded.
4. The connectors shall be connected with simple tool allowing simultaneous connection of 4-pairs cable and control of un-twist operation.
5. The connectors shall be provided with faceplates for communication outlet in gang widths.
6. Faceplates shall be fitted with spring shutter and label holder.
7. Given their location and cable function, the faceplates shall be as follows:
 - a. Green and adapted to patch panel for vertical wiring connectors,
 - b. Blue and adapted to patch panel for horizontal wiring connectors,
 - c. White modular 45 x 45 for terminal wall or floor outlet.
8. RJ45 Patch Cords
 1. The Contractor shall provide Cat 6 patch cords complying with ISO 11801 and able to support Gigabit 1000 Base Tx.
 2. Patch cords shall have the following characteristics:
 - a. Impedance: 100 Ohms +/-5% up to 100 MHz,
 - b. Stranded conductors,
 - c. 4-pairs cable capacity,

- d. Low Smoke Zero Halogen outer sheath,
 - e. Marked at each meter,
 - f. RJ45 plugs complying with EIA/TIA 568B,
 - g. Length: 0.5, 1, 2, 3, 5 and 10 meters,
 - h. Labeling through at least 5 color inserts: blue, yellow, black, red and green.
3. The Contractor shall supply patch cords in the same quantity for each color.
 4. The Contractor shall provide patch cords in different lengths as follows:
 - a. 5% of 0.5 m patch cords,
 - b. 5% of 1 m patch cords,
 - c. 30% of 2 m patch cords,
 - d. 45% of 3 m patch cords,
 - e. 10% of 5 m patch cords,
 - f. 5% of 10 m patch cords.
 5. Almost all patch cords shall be straight connected, but the Contractor shall provide optionally 2% of cross-connected type patch cords.

D. Optical Fiber Patch Cords

1. Optical fiber patch cords shall have the following characteristics:
 - a. fibers multi-mode patch cords compatible with the type of fiber to be used,
 - b. Low Smoke Zero Halogen outer sheath,
 - c. Metric marking indicating type of cable, year, ref., number,
 - d. LC / SC single or duplex connectors at each end,
 - e. Cable reinforced with aramid fibers,
 - f. Length of 1, 2, 3, 5 and 10 meters,
 - g. Labeling with at least 5 colors,
 - h. Protected by sleeve at each end.
2. The Contractor shall provide optical fiber patch cords in the same quantity for each color.
3. The Contractor shall provide patch cords in different lengths as follows:
 - a. 5% of 1 m patch cords,
 - b. 20% of 2 m patch cords,
 - c. 50% of 3 m patch cords,
 - d. 20% of 5 m patch cords,
 - e. 5% of 10 m patch cords.

E. Fiber-Optic Splicing:

- A. Splices are critical points in the optical fiber network, as they strongly affect not only the quality of the links, but also their lifetime.
- B. The splice shall ensure high quality and stability of performance with time.
- C. High quality in splicing is usually defined as low splice loss and tensile strength near that of the fiber proof test level.
- D. Splicing technology shall be fusion or mechanical type.
- E. Splices are designed to provide permanent connections.
- F. A suitable procedure for splicing should be carefully followed in order to obtain reliable splices between optical fibers. This procedure applies both to single fibers or ribbons (mass splicing).
- G. All optical fiber splices should be suitable for indoor applications as well as for outdoor environments, when suitably protected in appropriate accessories.
- H. Optical fiber splices, fusion or mechanical, shall not exceed a maximum optical insertion loss

- of 0.3 dB when measured in accordance with ANSI/EIA/TIA-455-34-A,
Method A (factory testing) or ANSI/TIA-455-78-B (field testing)
- I. Splice losses: Extrinsic and intrinsic splice loss factors

PART 3 - EXECUTION

3.1 DESIGN

- A. The design of the Structured Cabling Network will consist of the following tasks:
 1. Needs Analysis - The Contractor shall work with the Employer's Representative, departments, tenants and any other company or organization and determine their exact requirements.
 2. Engineering and Design - With the information gathered, the Contractor should determine hardware requirements for The project Structured Cabling Network.
 3. The Contractor shall determine the exact requirements for external communications and interfacing if it is determined that such services will be required for the support of the new system.
 4. The Contractor shall coordinate with the other disciplines to ensure that environmental requirements for the Structured Cabling Network are met, and to ensure that cabling is installed at the locations specified during the needs analysis.

3.2 PROJECT MANAGEMENT

- A. The Contractor is required to supply a complete description (Project Plan) of the key activities required for the installation of the system.
- B. In the project plan, the Contractor shall include a project organization chart with the reporting relationships of project team members and other key personnel. An escalation matrix should also be included.
- C. It is essential that the installation of the new system be as transparent as possible to the users. There should be no service interruptions and no perceived degradation in the quality of service.
- D. A master project schedule must be included, along with a work responsibility matrix, identifying the tasks the Contractor will perform and the tasks The project is expected to perform to successfully implement the new system.

3.3 FACILITY REQUIREMENTS

- A. The Contractor must furnish all space, power, and environmental requirements for the system.
 1. Space - Provide the physical dimensions of the equipment.
 2. Power - All power requirements, including any special conditioning or grounding requirements.
 3. Heat - The Contractor shall provide heat dissipation calculations for the communication room(s) and the recommended safe temperature operating range for the system.
 4. Floor Loading - The Contractor must provide complete floor loading requirements.

3.4 INSTALLATION

- A. General

Acceptance of works will be restricted to the equipment and installations complying with the

1. approved submittals, approved shop drawings, and the Employer site Engineer agreement.
2. The Contractor has to carry out any site works under direct supervision of qualified technicians who are to be well trained with qualified Manufacturer experience.
3. Site workmanship of any network component has to be limited to the layout and fixation, and inter-wiring of various items of the ready made equipment.
4. In addition to the above, the Contractor is also expected to supply the following:
 - a. Coordination meetings with the Project authorities, The project departments, existing contractors, etc.
 - b. Progress reports and Progress reviews,
 - c. Insurance for the Transport of the equipment,
 - d. Quality Assurance setup and management,
 - e. Document Management,
 - f. Configuration Management for the duration of the Project,
 - g. Off-the-shelf Software updates for the duration of the warranty,
 - h. User documentation and training including textbooks,
 - i. Worksite expenses (Setup and removal of temporary offices, Worksite vehicles, Site Offices, Computers, Printers, Desks, etc.),
 - j. Archival.

B. Site Survey

1. Examine all the technical rooms where equipment are to be deployed:
 - a. Identify equipment location,
 - b. Identify links on patch panels,
 - c. Identify and check general power supply and grounding,
 - d. Procure premises environment characteristics (kW/m², air conditioning characteristics, etc.),
 - e. Make heat dissipation calculation and adjust surface to be used according to rooms environment data,
 - f. Confirm feasibility for each technical room before starting to deploy.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Examination

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

General

- a. Prior to installation, the Contractor shall mark location of cabinets on the floor and/or walls.
- b. The Contractor shall install the cabinets in full coordination with other system cabinets installed in the communication room, if any.
- c. The Contractor shall install and adjust rack enclosure to allow access and to meet standard requirements.
- d. Cables shall enter the equipments racks or enclosures in such a manner that all doors or access panels shall open and close without disturbing or damaging the cables. Cables shall be installed and fastened without causing sharp bends or rubbing of the cables against sharp edges. Cables shall be fastened with hardware that will not damage or distort them.
- e. All vertical and under floor cable trays shall be covered.
- f. The Contractor shall meet EMC requirements.
- g. The Contractor shall ground all contractor installed equipment to eliminate all

shock hazard and to minimize all ground loops, common mode returns, noise pickup, crosstalk, etc. An isolated ground bar with test clamp shall be installed in each cabinet.

- h. Cabinet shall be bonded with copper cable equivalent to at least 35 mm².
- i. The Contractor shall be in charge of any functional ground connections through physical contact with installed equipment.
- j. Cable shields shall be bonded to the cabinet with 50 mm stranded copper tape at only one end of the cable run. Cable shield shall be insulated from each other, face plates, equipment racks, enclosures or cabinets; except at the system common ground point.

2. 19" Cabinet Specific Requirements

- a. Each cabinet () shall have accessible front and rear locking panels/doors after installation.
- b. 1000 x 800 or 600 x 800 mm minimum space shall be provided on each side of access panels.
- c. When enclosures will be mounted side by side, only two outside panels shall be included. No space shall be allowed between two cabinets. Cabinet shall be bolted together and bolted to floor leaving possible removing of wooden floor module under the given cabinet.
- d. Vertical cable runway shall be installed in a manner such that it will not impede installing a future rack next to the given rack nor interfere with the installation of a cable channel.
- e. The Contractor shall cover edges of cables pass in a through hole in cabinets with protective plastic or nylon grommeting.
- f. The Contractor shall be in charge of cabinet adjusting making sure that the weight is balanced on its four feet. Enclosures/cabinets shall be installed plumb and square.

3. 19" Wall Mounted Cabinet Specific Requirements

- a. Each wall mounted enclosure/cabinet shall be permanently attached to the building structure and held firmly in place.
- b. Each wall mounted cabinet shall be hinged at the 4 wall anchor points, the up per side at 1900 mm from the floor to allow easy access to its inside. Load of 100 Kg shall be acceptable without damaging fixing devices or the enclosure.
- c. Each wall mounted cabinet shall be with standard knockout holes for conduit connection, trays or cable entrance on upper and bottom side.
- d. Associated trays or conduits shall be installed in line with cabinet entry holes.
- e. A spare space of 600 mm shall be provided on each side of the cabinet to allow access and door opening

4. Rack Mounted Equipment

- a. The Contractor shall install rack mounted equipment according to locations, elevations, and plan views developed by the Contractor and approved by the Employer's Representative.
- b. Rack mounted equipment shall be bolted with at least 4 mounting screws for support.
- c. Cable guide shall be installed between each 2U rack unit set of equipment to insure patch cable run and adequate air circulation.
- d. All rack able equipment shall be installed 150 mm from the door and securely mounted in a manner that shall provide access to the connections for testing and allow sufficient cable room for the doors or access panels to open and close without disturbing the cables.
- e. Distribution and backbone cables shall enter from rear of optical patch panels.
- f. Cables shall be maintained with D-Rings.
- g. Each cable shall enter patch panel through adequate bushings and inserts where required by Manufacturer's installation manuals/sheets.
- h. All grounding and bonding work shall comply with NEC and ANSI/TIA/EIA standards.
- i. The Contractor shall bond all metallic raceway, racks, cable runway, enclosure,

- and other metallic hardware used for SCN to the dedicated bus bar.
- j. The Contractor shall ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.
- k. All spare or unused space shall be obstructed through blank panels.

E. Equipment Data

1. Submit complete technical data including Manufacturer's catalogues and specifications, system description including operational aspects, system features, and components.

F. Shop and Construction Drawings

1. Submit drawings for approval.
2. Constraints to be studied by the Contractor as part of its necessary Shop-Drawing development:
 - a. The integration of the SCN hardware (equipment, cables, cabling routing, etc.) shall be studied in such a way to deliver on site a package ready for installation.
 - b. The Contractor shall ensure the full coordination between the SCN constraints and other systems or any other interfaced systems.
 - c. The Contractor remains responsible of the proper coordination as to avoid any technical mismatches.
 - d. All the SCN System shall be studied, installed, and tested in order to offer an easy maintenance and access.
 - e. All coordination due by the Contractor shall always cover both Hardware's and Software's. It also covers all aspects of Shop Drawing elaboration, manufacturing, construction, testing, and commissioning, to achieve comprehensive systems in proper and efficient working order.
 - f. The final coordination on site with Civil Works, Facades, Architecture, HVAC, Plumbing, Electrical and any other construction aspect, remains the duty of the

G. Detailed System Schematic Diagrams

1. Exact routing of cables, giving type and size,
2. Exact location of equipment, components, cabinets, and racks as well as patch panels, etc. in communication rooms.

H. Typical Installation Details of the System Components

1. After installation, the Employer shall be able to perform hardware configuration changes, to redefine any new mapping and modifications as desired without the services of the Installer or Manufacturer.

I. Coordination with Other Works

1. It is under the Contractor responsibility to carry out any coordination between its own installations and other Project entities and systems.
2. The layout shop drawings have to be used as a guideline and need to be improved before any site workmanship.
3. The layout shop drawings are to also reveal the measures taken therein, and every fixation principle, and are to be approved by the Employer's Representative.
4. For this purpose any starting of work shall be subject to the Employer site Engineer approval.

J. Layout of Equipment

1. Equipment is to be laid out properly in communication rooms in a way to reserve relevant space for maintenance activities. This space shall also include any future expansion of the system.
2. Equipment is to be laid out as per the approved shop drawings.

3. After the proper layout of all equipment is accomplished, all components are to be labeled, and marked according to an approved labeling designations and materials.

K. Installation Instructions

1. Install equipment to comply with Manufacturer's written instructions.
2. More precisely:
 - a. Use listed cable in environmental air spaces, including plenum ceilings.
 - b. Install cable using techniques, practices, and methods that are consistent with a Structured Cabling Network (SCN) category rating of components and that ensure SCN category performance of completed and linked signal paths, end to end. Limit amount of cable untwisting to those defined by the Standard.
 - c. Install cable without damaging conductors, shield, or jacket.
 - d. Do not bend cable in handling or in installing to smaller radii than minimums recommended by the Manufacturer.
 - e. Secure and support cable at intervals not exceeding 750 mm and not more than 150 mm from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - f. Wiring within communication rooms: Provide adequate length of conductors. Train conductors to terminal points with no excess. Use lacing bars to retri al cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by the Manufacturer.
3. Cleaning: after completing system installation, inspect premises. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

L. Wiring Method

1. Install wiring in raceway.
2. Conceal cable and raceway.

M. Splices, Taps, and Terminations

1. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.

N. Impedance and Signal Levels

1. Match input and output impedance and signal levels at signal interfaces. Provide matching networks where required.

O. Identification

1. Identify system components complying with applicable requirements and the following Specifications.
2. Use a unique hierarchical alphanumeric designation in order to label:
 - a. Structured Cabling Network equipment and components,
 - b. Ports to terminals connected to the equipment.
3. Provide an identification database.
4. Color code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.

P. Wall Mounting Outlets

1. Flush mounted.

Q. Floor Mounting Outlets

1. Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place.

Trim with carpet in carpeted areas.

R. Weatherproof Equipment

1. Install units that are mounted outdoors, in damp locations, or where exposed to weather consistent with weatherproof rating requirements as IP65 at least.

S .Cleaning

1. After completing system installation inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

T. Supervision

1. Installation shall be supervised and tested by a representative of the Manufacturer of the system equipment.
2. The work shall be performed by skilled technicians under the direction of experienced engineers, all of whom shall be properly factory trained and qualified for this work.

U. Security

1. Coordinate with the Employer to procure general security conditions during building site.
2. Check that drain conductors and equipment are grounded to eliminate shock hazard and to minimize ground loops, common mode returns, noise pickup and other impairments.
3. Patch wiring must be traceable; Keep a database of patches installation up to date.

3.5 WIRE AND CABLE

A. Principles

1. All wiring and cable shall be installed in metal raceways or within equipment.
2. Conductors within equipment enclosures shall be carefully cabled and laced.
3. Individual conductors shall be tagged with markers indicating the function, source, and destination of all cabling, wiring and terminals.
4. All cables and wires shall be identified, utilizing heat shrink, pre-printed, wire markers.
5. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
6. Separation of Wires: Comply with standard rules for separating unshielded copper communication and data-processing equipment cables from potential EMI sources, including electrical power lines and equipment.
7. Make splices, taps, and terminations only at indicated outlets, terminals, and crossconnect and patch panels.
8. Use splice and tap connectors compatible with media types.

B. Cables Installation

1. The Contractor shall employ the latest installation practices and materials in compliance with ANSI/TIA/EIA 568B requirements.
2. Cables shall be installed in a continuous (non-spliced) manner.

3. The bending radius and pull strength requirements of all cable as detailed in ANSI/TIA/EIA 568B and the Manufacturer's installation recommendations shall be strictly observed during handling and installation.
 - a. Pull cables simultaneously where more than one cable is being installed in the same raceway.
 - b. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation.
 - c. Use pulling means, including fish tape, cable, rope, grips that will not damage media or raceway.
4. Cables shall be installed and fastened without causing sharp bends or rubbing of the cables against sharp edges. Cables shall be fastened with hardware that will not damage or distort them at intervals not exceeding 3 rings/meters. Cables shall be tied or clamped. Attaching cables to pipes, electrical conduits, mechanical items, or ceiling support system is not acceptable. Tie wraps shall conform to Manufacturer's installation recommendations.
5. The Contractor shall lay cables via the shortest route directly to the distribution node.
6. The Contractor shall lay and dress all cables to allow other cables to enter raceway (conduit or otherwise) without difficulty at a later time by maintaining a working distance.
7. Backbone cables shall be separately routed using different trays.

C. Cable Termination

1. RJ45 termination shall conform to EIA/TIA 568B.
2. RJ45 terminations shall be connected as per the following requirements:
 - a. Use of adapted connection tool,
 - b. Withdraw cable jacket up to 20 mm,
 - c. Untwist pairs up to 13 mm,
 - d. Length of conductor after contact shall not exceed 1 mm,
 - e. Screen shall be left around pairs up to 5 mm,
 - f. Loops of cables in racks are not allowed, only enough spare length for connector replacement shall be provided.

D. Optical Fiber Connection

1. All connectors shall be of high quality materials and construction.
2. All single-mode or multimode fiber strands of backbone shall be terminated with LC/ SC connector through fusion splice.
3. Connectors shall be crimp lock-style and terminated as per Manufacturer's recommendations.
4. Connectors shall provide minimal signal reflection and low loss connections.
5. Provide 1 to 2 meters service loop at each end.

E Number of Conductors

1. As recommended by system Manufacturer for functions indicated.

F. Check-In and Tests

1. After installation, and before termination, all wiring and cabling shall be checked and tested to ensure that there are no grounds, opens, or shorts on any conductors or shields.

A V.O.M. shall be utilized to accomplish these tests and a reading of greater than 20 Mega ohms

2. shall be required to successfully complete the test.

G. Visual Inspection

1. Visually inspect wire and cable for faulty insulation prior to installation.
2. Protect cable ends at all times with acceptable end caps except during actual termination.
3. At no time shall any optical fiber be subjected to a bend less than a 150 mm radius.

H. Protection

1. Protect wire and cable from kinks.
2. Provide grommets and strain relief material where necessary, to avoid abrasion of wire and excess tension on wire and cable.

I. Splices, Taps, and Terminations

1. Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

J. Identification

1. Identify components, conductors, and cables.
2. Color code conductors, and apply wire and cable marking tape to designate wires and cables so media are identified and in coordination with system wiring diagrams.

3.6 RACEWAYS AND CABLE TRYS

A. Raceways

1. Requirements:
 - a. Surface raceway shall be constructed and installed for all exposed communications outlets. The Contractor shall match as closely as possible the existing wall finish but shall not paint surface raceway. Surface raceway shall be:
 1. Constructed and installed per relevant IEC standard, mechanically and electrically continuous and shall be bonded in accordance with relevant IEC and ANSI/TIA/EIA-607 codes and standards.
 2. Constructed and installed according to ANSI/TIA/568B and 569 standards and shall have a radius control at all bend points in accordance with the cable's Manufacturer recommendation.
 3. Securely supported at intervals not exceeding 3 meters or in accordance with Manufacturer's installation sheets.
2. Use communications cable tray wherever possible for low voltage cabling.
3. Exposed raceway below 2.4 meters and in dry locations shall be rigid steel conduit. B.

Cable Trays

1. No telecommunications containment including cable trucking, ducts etc. shall be loaded more than 60% of the available space. The Contractor is responsible to size the containment appropriately taking into account all systems and the type of cables to be used based on selected Manufacturer for each system.
2. In general, telecommunications containment route shall follow the electrical containment route with sufficient clearance. However, any other routes followed shall be to the approval of the

Employer's Representative.

3.7 FIELD QUALITY CONTROL

- A. The Contractor shall submit to the Employer the manufacturing and shipment schedules for all equipment and/or materials at least one month prior to the time of packing for shipment as long as the lead time available is sufficient or such shorter period as may fit the actual circumstances. Should the Employer's Representative fail to attend on the specified date for inspection, the Contractor shall proceed with shipment and carry out the relevant tests itself. The Contractor shall provide the Employer a copy of the recorded factory results made under its cognizance before shipment. If the test results show that the equipment and/or materials do not comply with the Specifications, such non-complying equipment and/or materials shall be rejected and shall not be shipped until repaired or replaced and tested again. In such case, the Contractor shall be held liable for any resulting delay. In all cases, the Contractor shall be responsible for the compliance of his equipment and materials with the Contract's specifications.
- B. Testing: On installation of network components, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
- C. Correct malfunctioning units at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.8 LABELING AND ADMINISTRATION

- A. Labels
 - 1. They are required for equipment, cabinets, racks, bonding conductors, riser cables, access points, etc. Labels shall comply with EIA/TIA 606.
- B. Rack Labeling
 - 1. Rack labeling shall be labeled sequentially and shall be of the form "01" to "0 xs".
 - 2. Labels shall be of the minimum size of 100 x 50 mm, screwed yellow unit with 15 mm black letters/numbers.
- C. Rack Mounted Equipment Labeling
 - 1. RJ45 and fiber patch panel for horizontal distribution shall be labeled sequentially within a given rack and shall be of the form "01" to "0 xs" from the top to the bottom. Labels shall be of the size of 20 x 15 mm, adhesive yellow unit with 10 mm black letters/numbers or other prefabricated label system depending of the Manufacturer.
 - a. Fiber LC/ SC single or duplex ports shall be labeled sequentially within a given fiber patch panel and shall be of the form of 8 mm twin number; 01 to 12.
 - b. RJ45 ports shall be labeled on the dedicated label holder with 8 mm numbers; 01 to 24 for 24 ports patch panel or 01 to 48 for 48 ports patch panels.
 - 2. Fiber patch panel for vertical distribution shall be labeled sequentially within a given rack using red label for multi-mode fiber optic cable and black label for single-mode fiber optic cable, with 8 mm white number 01 to 12, to each LC/ SC single or duplex port. Each panel shall be labeled with "Fiber Optic cable" 80 x 10mm, 8 mm number, black or red label.
 - 3. Outlet Labeling:
 - a. All RJ45 and LC/ SC single or duplex outlets shall be labeled.
 - b. Final outlet label shall be submitted and approved at construction stage.
 - 4. Backbone/Riser Cable Labeling:

- a. Cables shall have labels affixed at each end.
 - b. Labels shall be of permanent identification type, adhesive, using indelible ink on white print-on material for outdoor and high temperature applications.
5. Termination Cable Labeling:
 - a. All cables shall have labels affixed at each end as per EIA/TIA 606 standard.
 - b. Labels shall be of permanent identification type, adhesive, using indelible ink on white print-on material for outdoor and high temperature applications.
6. Cable Tray Labeling:
 - a. Cable trays shall be labeled at 5 meters intervals with engraved adhesive yellow with black letters label as per the following example:
 - b. Conduits and ductwork dedicated to SCN shall be labeled at 5 meters intervals with adhesive yellow label (60 x 60 mm) as per the following example:

3.9. GROUNDING

A. Precaution

1. Properly ground each piece of electronic equipment prior to applying power.
2. Properly ground all shielded wire shields to the appropriate clean earth ground at the equipment end only, not at the remote or device end.

B. Principles

1. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common mode returns, noise pickup, cross talk, and other impairments.

C. Grounding Considerations

1. General
 - a. Grounding systems are normally an integral part of the specific signal and telecommunications wiring system that they protect. Besides helping protect personnel and equipment from hazardous voltages, the grounding system may reduce the effect of electromagnetic interference (EMI) on the structured cabling network. Improper grounding can produce induced voltages and those voltages can disrupt other data or telecommunications circuits.
 - b. When compatible with required electrical codes, the grounding instructions and requirements of the equipment Manufacturer should also be followed. The grounding requirements of the EIA/TIA 607 shall be followed.
2. Considerations
 - a. Ensure that the installation conforms to proper practices and requirements.
 - b. Ensure that each SCN cabinet and rack has an appropriate grounding bus bar that is connected to the dedicated building ground by a 35 mm² ground wire.
 - c. Ensure that grounding is available for all system equipment and components and equipment required for maintenance and testing.
 - d. Ensure that all metal cable trays shall be bonded to ground. Cable tray shall not be used for a ground path.

3.10 FACTORY TESTS A.

Factory Acceptance Tests

1. The Factory Acceptance Tests shall be carried out in a hardware and software environment, which simulates the final configuration of the system.
1. The Contractor shall carry out any Factory Acceptance Tests, in Manufacturer's factory itself, before any site delivery, in order to show to the Employer site Engineer that the system is able to satisfy site technical requirements of the equipment specifications.

2. Some of the functional or performance tests, which cannot be conducted in a simulated environment, due to their nature and complications, may subject to the Employer's Representative's approval be combined with the On Site Tests.
4. All travels and trips costs shall be provided by the Contractor for five (5) representatives to be nominated by the Employer.

B. Test Specifications

3. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.
4. The tests are to cover every aspect related to the specification of the system and its operation; including, but not limited to, visual inspections, measurements, and operation.
5. Operational functions available at the workstation level shall be demonstrated at factory based on a simulation.
6. All Factory Acceptance Tests need to be carried out in the presence of the Employer's Representative unless otherwise agreed by the Employer's Representative. The Employer's Representative will sign off the testing document on satisfactory completion of the tests.
7. The results of the Factory Acceptance Tests, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representative.

C. Equipment Tests

1. Equipment is to be tested for quality and operation at the factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Employer's Representative before dispatch of equipment to site.

3.11 ON SITE TESTS AND INSPECTION

A. On Site Assembly Verification

1. The purpose of this phase is to check the assembly and the connection of the equipment without any power supply.
2. Any verification can give raise to a punch list item either because of an anomaly or a none-conformity with the tender documents.
3. The punch lists are collated for each module and the phase report is only released when all the stipulations on the punch lists are cleared.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.
2. The tests are to cover every aspect related to the specification of the system and its operation including, but not limited to, visual inspections, measurements, and operation.

C. On Site Cable Tests

1. Cables shall be tested to ensure that no damage have occurred to them during transportation to site and/or during the course of pulling in and laying.
2. Test records shall be provided on a form approved by the Employer's Representative. The form

shall include test result for each cable in the system.

3. Each cable tested shall be submitted on the form with identifications as discussed under Labeling and Administration above.
4. The form shall include the ID, outcome of the test, indication of errors found, cable length, re-test results, and signature of technician completing the tests.

D. Twisted Pair Cables

1. Test Cat 6 cables for compliance to ANSI/TIA/EIA 568B and ISO/IEC 11801 25N780 Standards.
2. Test each end-to-end link, utilizing 0-100 MHz sweep tests, for continuity, polarity, NEXT, attenuation, installed length, wire map, impedance, resistance, ELFEXT, and ACR. Each cable shall be tested in both directions.
3. Test with building electrical systems powered on (i.e. lights, HVAC, etc.)
4. Testing device shall be Level 3 testing instrument, re-calibrated within the last 6 months, with the most current software revision based upon the most current EIA/TIA testing guidelines, 250 MHz rated, capable of storing and printing test records for each records for each cable within the system.

E. Fiber Optic Cables

1. Test fiber optic cable strands (with terminations) in accordance with EIA/TIA methods, procedures, and standards.
2. Single -mode Cable: Test at both 1300 and 1550 nm. Test each end-to-end link. Multi-mode fiber optic cables shall be tested for correctness of termination, compliance to attenuation values and acceptable dB loss.
3. Multi-mode Cable: Test at both 850 and 1300 nm. Test each end-to-end link. Single-mode fiber optic cables shall be tested for correctness of termination, compliance to attenuation values and acceptable dB loss (less than 0.5 dB) in accordance with ISO 11801 25N780.
4. Patch cables shall also be tested according to the above criteria.
5. Testing device shall be an approved fiber optic Transmission Loss Test Instrument (OTDR).

F. Inspection

1. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

G. Pre-Testing

1. Align and adjust system and perform pre-testing of all components, wiring, and functions to verify compliance with specified requirements.

2. Correct all deficiencies by replacing malfunctioning or damaged items with new items.

H. Manufacturer's Field Services

1. Engage a factory authorized service representative to inspect field assembled components and equipment installations and perform system pre-testing, testing, adjustment and programming.
2. Report results in writing.

I. Procedure

1. Notify the Employer's Representative not less than 30 days in advance, of proposed

schedule, procedures and tests to be used in operational testing.

2. Conduct operational tests only with the Employer's Representative present.

J. Report

1. Prepare a written report of observations, inspections, tests, and results, including:
 - a. A complete listing of every device and circuit,
 - b. Date of each test and retest, and by whom,
 - c. Results of each test and, if failure occurred, corrective action taken prior to retest.

K. Certification

1. The Contract shall certify that all devices, circuits, and total system are finally tested successfully.

L. Operational Tests

1. Schedule tests after pre-testing has been successfully completed.
2. Perform operational system tests to verify compliance with Specifications.
3. Test all modes of system operation including:
 - a. Functional operation of each field mounted device,
 - b. Functional operation of each control circuit,
 - c. Supervision function of each initiating, indicating, monitoring, and control circuit,
 - d. Perform tests that include originating program and counting material at final outlets, controller inputs, and other inputs,
 - e. Signal Ground Test: Measure and report ground resistance at each global equipment pin.
 - f. Re-testing: Correct deficiencies, and re-test. Prepare written record tests.
 - g. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
4. Schedule tests with at least seven days advance notice of test performance.

M. Integrated Tests with Other Contractors

1. The Contractor shall make equipment available for testing and demonstrating various features specified.
2. The test procedures shall reflect the sequence of tests to be performed.
3. Typical test segments shall include but shall not be limited to the following:
 - a. Communication Tests shall be performed for the serial or LAN interface to ensure that proper communication can be established between data network equipment and the interfacing systems.
 - b. Point-to-Point Tests shall be performed on the Structured Cabling Network to the interfacing systems in order to verify the functionality.
4. Retesting: Correct deficiencies and retest until total system meets requirements of the Specifications and complies with applicable standards. Prepare written records of tests.
5. Schedule testing with at least seven days advance notice.

3.12 TRAINING

- A. The Contractor is required to conduct end-user training on The project premises, tailored specifically to The project 's particular requirements in the use, configuration and maintenance of the Structured Cabling Network equipment and components.
- B. Training shall be provided for Technical Staff of the Employer in the Testing, Maintenance and Fault Location of the Structured cabling Network.
- C. For each product and/or application, the Contractor shall provide a detailed description of the training the Manufacturer will provide.
- D. Trainers
 1. All training shall be certified training by Manufacturer and trainers shall be approved by the project before starting.
 2. Engage a factory authorized service representative to explain programming and operation of system and to train Employer's personnel on procedures and schedules for maintaining, programming, operating, adjusting, troubleshooting, and servicing the system.
- E. Trainees
 1. Training for engineers on SCN operation and maintenance shall be for a minimum of six (6) engineers for two weeks.
 2. Training for engineers on SCN hardware shall be for a minimum of four (4) engineers.
- F. Training Program
 1. Scope
 - a. Training shall be in sufficient scope to ensure that all trainees who complete the program will be certified as capable to operate and/or maintain the equip-

ment, systems, and facilities provided and installed under this Contract, and to ensure a smooth transition between construction and operations activities.

2. Language

- a. Training shall be conducted in English and Arabic.

3. Training Aids

- a. Training aids shall include:

1. Approved Operation and Maintenance (O & M) manual(s) prepared by the Contractor as part of this Contract,
2. Training manuals, including course outline, basic text of instructions modules, and trainee workbook,
3. Films, slides, video tape(s),
4. Charts, models, hand-outs, catalogues,
5. Samples and other visual,
6. Written aids to complement instruction.

- b. In addition, spare parts and other special hardware shall be provided to support “hands-on” familiarization with the equipment or systems.

4. Training Manuals

- a. Training manuals shall be provided for each training course covering both the classroom and on-the-job phases.
- b. The organization of the manuals shall follow the same sequence as the course’s scheduled presentation of material, providing such additional background and supplementary information, as a trainee may need to understand the O & M manuals.
- c. There shall be as many Training Manual types as Trainees categories.

5. Training Execution

- a. Scope

1. Training shall be performed in accordance with an approved training program. All training aids shall be available and approved prior to start of training.

- b. Contents

1. Training course can be broken down into modules either classroom lecture or “On-the-job” training.
2. In case of lecture, it is the Employer responsibility to provide the classroom for the duration of the course.
3. No lecture module should exceed 2 hours time.
4. “On-the-job” training can be scheduled for entire 8 hour shift.
5. Handouts must support each module; the collation of the Handouts forms the Training Manual.
6. Laboratory equipment, spare parts, and mock-up models may be used for theoretical orientation.
7. However, practical “hands-on” familiarization shall be provided on equipment that is either installed and operable or ready to be installed

and capable of being operated. System spares of special hardware items may be used to support “hands-on” familiarization as long as said spares are returned to inventory in satisfactory condition in accordance with approved procedures.

c. Proficiency

1. At designated intervals each trainee’s proficiency levels shall be determined by written, oral and practical performance tests.

d. Operations Training

1. Operators shall be provided with a thorough training in all aspects of system/sub-system operation under both normal and abnormal conditions. This training shall include, but not be limited to:
 - a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
 - b) Terminology,
 - c) Operations theory and interface,
 - d) Equipment appearance, functions, concepts and operations,
 - e) Operating mode, practices, and procedures under normal and emergency conditions,
 - f) Safety precautions,
 - g) On-the-job operating experience covering all system/sub-system operating functions, activities, and tasks including those associated with degraded operating modes, failure recognition, and recovery processes,
 - h) Familiarity with content and use of O & M manuals and related reference publications.

e. Maintenance Training

1. Maintenance training shall cover all on-site routine, preventive, and remedial maintenance of the system/sub-system.
2. This training shall include, but not be limited to:
 - a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
 - b) Terminology,
 - c) Operations theory and interfaces,
 - d) Equipment appearance, layout, functions, concepts and operations,
 - e) Operating modes, practice, and procedures under normal and emergency conditions,
 - f) Safety precautions,
 - g) Use of tools and test equipment,
 - h) Preventive maintenance,
 - i) Troubleshooting, diagnostics, and testing,
 - j) Assembly and disassembly,
 - k) Repair and parts replacement,
 - l) Parts ordering practices and storage,
 - m) Failure and recovery procedures,
 - n) System/sub-system cabling,

- o) Familiarization with and use of O & M manuals and other reference materials.

3.14 LOGISTICAL SUPPORT

- A. The Contractor should identify the address of the Manufacturer's local service centers and the number of service personnel trained on the system.

3.15 GUIDELINES FOR DOCUMENTATION TRANSMITTAL

A. Content of the Transmittals

1. Contractor to prepare detail drawings, design calculations, technical data sheets and samples and submit the same for review by the Employer's Representative. The Contractor shall submit the following key elements to the Employer's Representative for review:
 - a. Detailed layout showing the marking and/or the equipment as required,
 - b. Manufacturers' Catalogues,
 - c. Provide all relevant Testing Certificates,
 - d. Inventory label for each item supplied under this Contract. Labels shall be submitted for review by the Employer's Representative and shall be attached to each individual item for easy reference.
2. The following documents are to be submitted to the owner prior to handing over:
 - a. As-built drawings for the relevant areas,
 - b. Complete inventory list,
 - c. Three sets of the Maintenance Manuals are to be provided. Such manuals shall include a full technical description with block and schematic diagrams to allow the Employer staff to maintain the system equipment and components,
 - d. Three sets of the Operation Manuals are to be provided.

B. Drawings

1. The Contractor will have to establish plans to scale and diagrams as per the following presentation:
 - a. Structured Cabling Network schematic diagrams, detailed design, connection diagrams, etc.
 - b. Floor layout of each building and raceways will have to be on scale 1/100.
 - c. Equipment room layout will have to be on scale 1/50.
 - d. Racks and cabinet configuration, front and back view, as well as the plans of detail and service shafts, will have to be on scale 1/10.
2. All Design Development drawings, Construction Drawings, and As-Built Drawings shall be submitted in hard copy format as well as in electronic format in the quantities specified below.
3. Quantity of Submittals:
 - a. Electronic Files: 1 set.
 - b. Reproducible hardcopies: 1 set.
 - c. Prints: 3 sets.

END OF SECTION 271000

SECTION 27 20 00 - DATA COMMUNICATION AND NETWORK EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Related sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Raceways and Boxes".
 - 3. Division 26 Section "Cable trays for electrical systems".
 - 4. Division 26 Section "Grounding and Bonding".

1.2 SUMMARY

A. Work comprise complete communication and active data processing equipment system includes, but not limited to, the following:-

- 1. Network active switches/router/modem , Wireless controller, Wireless access units, servers/ storages array , and the Contractors will be responsible for verifying all the network devices sizing like switches, servers and storages size according to software applications that will be run on the mall and the operator /client requirements.

1.3 SUBMITTALS

- A. Product Data: include detailed manufacturer's specifications for each component specified. Include data on features, ratings and performance.
- B. Shop Drawings: include plans, elevations, sections, details and attachments to other Work.
- C. Samples: full size, for each outlet and finish plate, for colors and textures.
- D. Product Certificates: signed by manufacturers of communication and active data processing equipment and components certifying that products furnished comply with requirements.
- E. Installer Certificates: signed by manufacturer certifying that installers comply with requirements.
- F. Field Test Reports: indicate and interpret test results for compliance with performance requirements of installed systems.
- G. Maintenance Data: for communication and active data processing equipment and components to include in maintenance manuals specified in the general and special conditions of contract. In addition to requirements specified in the general and special conditions of contract Section "Contract Closeout," include the following:
 - 1. Detailed operating instructions covering operation under both normal and

- abnormal conditions.
- 2. Routine maintenance requirements for system components.
- 3. Lists of spare parts and replacement components recommended being stored at the site for ready access.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: an experienced installer who is an authorized representative of the communication and active data processing equipment manufacturer, for both installation and maintenance of units required for this Project, to supervise installation of the system.
- B. Systems installations are to comply with the respective local regulations communication and active data processing equipment System materials, outlets and equipment are to be the standard products of manufacturers and compatible with TIA standard and IEC standards for electronic circuitry and components, and/or Local Standards.

1.5 PROJECT CONDITIONS

- A. Environmental Limitations: system components are equipped and to be rated for the environments where installed.
 - 1. Service Conditions for Outdoor Equipment: rate equipment for continuous operation under the following environmental conditions, unless otherwise indicated:
 - b. Relative Humidity: 50percent.
 - c. Weather: wet and corrosive.
 - 2. Service Conditions for Indoor Equipment: rate equipment for continuous operation under the following environmental conditions, unless otherwise indicated:
 - a. Temperature: - 15 deg C to 70 deg C.
 - b. Relative Humidity: 50 percent.

1.6 COORDINATION

- A. Coordinate layout and installation of communication and active data processing equipment and suspension system components with other construction that penetrates ceilings or is supported by them.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 related Sections.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 related Sections.
- B. Work shall include supplying 2 years spare parts for the system as per manufacture recommendations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Manufacturers shall provide the products in compliance with the requirements of the specifications and to be incorporated with the Work are listed below:

- CISCO
- HP
- DELL
- CITRIX
- VMWARE
- VEEAM
- FORTINET

2.2 SYSTEM DESCRIPTION

2.2.1 NETWORK SWITCH.

- Number /Rate of the Ethernet ports / uplinks according to riser diagram and the contractor responsible for the verifying the actual sizing according to the design configuration and client/operator/engineer requirements
- Switches shall support (POE /POE+/UPOE).
Access switches shall support features like:-
 - Security levels.
 - DHCP snooping
 - Dynamic ARP inspection (DAI).
 - IP source guard.
 - The Unicast Reverse Path Forwarding (uRPF).
 - Flexible authentication.
 - RADIUS change of authorization and downloadable calls for comprehensive policy management capabilities.
 - Private VLAN.
 - Multi-domain authentication. Allows an IP phone and a PC to authenticate on the same switch port while placing them on appropriate voice and data VLAN.
 - IGMP filtering provides multicast authentication by filtering out nonsubscribers and limits the number of concurrent multicast streams available per port.
 - Multilevel security on console access.
 - Bridge protocol data unit (BPDU) Guard
 - Spanning Tree Root Guard (STRG).
 - Access switch shall support Application visibility features like:-
 - Delivers next-generation flow technology.
 - Flow data collected can be exported to an external collector for analysis and reporting or tracked by the embedded event manager.

2.2.2 STACKING SWITCHES WITH UPLINKS PORTS

- Number /Rate of the Ethernet ports / uplinks according to riser diagram and the contractor responsible for the verifying the actual sizing according to the design configuration and client/operator/engineer requirements.
- Switches shall support (PoE/POE+/UPOE).
Access switches shall support features like:-
 - Security levels.
 - DHCP snooping
 - Dynamic ARP inspection (DAI).
 - IP source guard.
 - The Unicast Reverse Path Forwarding (uRPF).
 - Flexible authentication.
 - RADIUS change of authorization and downloadable calls for comprehensive policy management capabilities.
 - Private VLAN.
 - Multi-domain authentication. Allows an IP phone and a PC to authenticate on the same switch port while placing them on appropriate voice and data VLAN.
 - IGMP filtering provides multicast authentication by filtering out nonsubscribers and limits the number of concurrent multicast streams available per port.
 - Multilevel security on console access.
 - Bridge protocol data unit (BPDU) Guard
 - Spanning Tree Root Guard (STRG).
 - Access switch shall support Application visibility features like:-
 - Delivers next-generation flow technology.
 - Flow data collected can be exported to an external collector for analysis and reporting or tracked by the embedded event manager.

2.2.3 MODULAR DISTRIBUTION SWITCH:-

The switch is modular should have the ability to aggregate the whole Uplinks main and redundant.

The switch should be feature rich switch to provide reliability, scalability and security for building media traffic.

- Modular switches should support:-

- Number /Rate of the fiber ports / uplinks according to riser diagram and the contractor responsible for verifying the actual sizing according to the design configuration and client/operator/engineer requirements
- Line-rate virtual extensible LAN (VXLAN) bridging and routing to support flexibility.
- Segment routing for increased network scalability and virtualization.
- Advanced reboot capabilities include hot and cold patching and fast-reboot capabilities
- Open APIs to manage the switch through remote-procedure calls
- Onboard Python scripting engine enables automation and remote operations in the data center.
- Complete Layer 3 unicast and multicast routing protocol suites are supported, including BGP, Open Shortest Path First (OSPF), Enhanced Interior Gateway Routing Protocol (EIGRP), Routing Information Protocol Version 2 (RIPv2), Protocol Independent Multicast sparse mode (PIM-SM), Source-Specific Multicast (SSM), and Multicast Source Discovery Protocol (MSDP).

- Segment routing allows the network to forward Multiprotocol Label Switching (MPLS) packets and perform traffic engineering without Resource Reservation Protocol (RSVP) traffic engineering (TE).
- Built-in Ether Analyzer for monitoring and troubleshooting control-plane traffic.

2.2.4 MODULAR CORE SWITCH

- Number /Rate of the Ethernet ports / uplinks according to riser diagram and the contractor responsible for the actual sizing according to the design configuration and client/operator/engineer requirements
- Scales to high-density Gigabit Ethernet, 10, 20, 40 and 100 Gigabit Ethernet and configurations.
- Support redundant
- Wire-rate Layer 2 and 3 switching on all ports
- Line-rate virtual extensible LAN (VXLAN) bridging and routing to support flexibility.
- Border Gateway Protocol Ethernet VPN (BGP EVPN) control plane for scalable multitenancy and host mobility.
- Segment routing for increased network scalability and virtualization.
- Advanced reboot capabilities include hot and cold patching and fast-reboot capabilities
- 1+1 redundant, hot-swappable.
- Built-in Ether Analyzer for monitoring and troubleshooting control-plane traffic.

2.2.5 ROUTER

- Number /Rate of the Ethernet ports / uplinks according to riser diagram and the contractor responsible for the actual sizing according to the design configuration and client/operator/engineer requirements
- Dynamic Multipoint VPN (DMVPN), zone-based firewalls, intrusion prevention (Snort and Umbrella and content management
- Secure boot feature performs hardware-based authentication of the bootloader software to prevent malicious or unintended software from booting on the system.
- Code signing verifies digital signatures of executables prior to loading to prevent execution of altered or corrupted code.
- Hardware authentication protects against hardware counterfeiting by using an on-board tamper-proof silicon, including field replaceable modules.

2.2.9 APPLICATION SOFTWARE / SERVERS /STORAGES/FIREWALL

- Servers /storages should be according latest technology and the contractor is responsible for resizing them according to the required software application and the engineer / operator / client IT engineer requirements.
- Contractor is responsible for collect the final data regarding (Servers, Applications, No. of users, ...etc) and all needed data to be able to provide total solution for the data center.
- Contractor is responsible to coordinate with the client/ operator/ Engineer for all IT data system.
- All servers/storages / firewalls should be comply with the client / IT engineer and site engineer requirements in construction phase stage.
- Physical Server for Domain Controller with DHCP and DNS services
- Security Fire wall server includes internet/ email / web security gateways.
- Data center firewall server.

- Servers should be (with 25% future expansion) achieving redundancy and high availability with x- Giga LAN interfaces for the following Service, list of required applications/servers
- Microsoft windows application/server.
- Active directory application/server.
- Exchange mail box application/server.
- Dynamic Host Configuration Protocol (DHCP) application/server.
- Domain Name Server (DNS) application/server.
- Anti-virus Server
- SQL application/server.
- File Server.
- Storage with the min following requirements:
- Must support at least 100 drive
- Network storage should in TB –HDD.
- Application software will include oracle, Microsoft Office application software.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cable. Check raceways, cables trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- C. Examine walls, floors, equipment bases supports for suitable conditions where communication and active data processing equipment is to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate with other work as necessary to interface installation of communication and active data processing equipment work with other works.
- B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment. Where manufacturer's torque requirements are not indicated,
- C. Anchor mounting hardware firmly to walls, floors, or ceilings, to ensure enclosures are permanently and mechanically secured. Provide all hardware and accessories for proper mounting.

3.3 FIELD QUALITY CONTROL

- A. Inspection: verify that units and controls are properly installed, connected, and labeled and that interconnecting wires and terminals are identified.
- B. Pretesting: align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Replace malfunctioning or damaged items. Retest until satisfactory performance and conditions are achieved. Prepare equipment for acceptance and operational testing as follows:

- C. Test Schedule: schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
- D. Operational Tests: perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
- E. System Acceptance Tests: include the following:

3.4 CLEANING

- A. Clean installed items using methods and materials recommended by manufacturer.
- B. Clean system components, including antennas and supports, head-end equipment, distribution components, and outlets.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain television equipment.
 - 1. Train Owner's maintenance personnel on procedures and schedules for troubleshooting, servicing, and maintaining equipment.
 - 2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.
 - 3. Demonstrate programming and tuning of satellite receivers.
 - 4. Review data in maintenance manuals. Refer to the general and special

conditions of contract Section "Operation and Maintenance Data."

- 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
- 6. Conduct a minimum of eight hours' training as specified in instructions to Owner's employees in the general and special conditions of contract Section "Contract Closeout."

3.6 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: when requested by Owner within one year of date of Substantial Completion, provide on-site assistance in tuning and adjusting the system to suit actual occupied conditions and to optimize performance. Provide up to two adjustments at Project site for this purpose, without additional cost.

END OF SECTION 27 20 00

SECTION 27 30 00 VOICE COMMUNICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Contract

1. General provisions of the Contract, including Conditions of Contract, apply to this Section.
2. In particular, refer to these documents for all elements related to costs and responsibility related to delivery, storage, and roll-out phase.

B. Related Sections

1. Requirements of the following applies to this Section:
 - a. Division 26 Section "Basic Materials and Methods".
 - b. Division 26 Section "Grounding & Bonding".
 - c. Division 26 Section "Raceways & Boxes".
 - d. Division 26 Section "Cable trays & Ladders".

1.2 DEFINITIONS

- A. ACL: Access Control List.
- B. AD: Active Directory.
- C. ASR: Automatic Speech Recognition.
- D. AMIS: Audio Messaging Interchange Specification.
- E. CDR: Call Data Recording.
- F. CLI: Command Line Interface.
- G. CLID: Calling Line ID.
- H. CRTP: Compressed Real-Time Transport Protocol
- I. CTI: Computer Telephony Integration.
- J. DID: Direct Inward Dial.
- K. DTMF: Dual Tone Multi-Frequency.
- L. EMI: Electromagnetic Interference.
- M. EN: European Standard.
- N. GUI: Graphical User Interface.
- O. HTTP: Hyper Text Transfer Protocol.
- P. IP: Internet Protocol.

- Q. IP Sec: IP Security Protocol.
- R. IVR: Interactive Voice Response.
- S. ISO: International Standard Organization.
- T. JTAPI: Java Telephony Application Programming Interface.
- U. LADP: Lightweight Directory Access Protocol.
- V. LAN: Local Area Network.
- W. MTTR: Mean Time To Repair.
- X. MTBF: Mean Time Between Failures.
- Y. PRI: Primary Rate Interface.
- Z. PSTN: Public Switched Telephone Network.
- AA. QoS: Quality of Service.
- BB. SIP: Session Initialization Protocol.
- CC. SLA: Service Level Agreement.
- DD. SNMP: Simple Network Management Protocol.
- EE. TAPI: Telephony Application Programming Interface.
- FF. TDM: Time Division Multiplexing.
- GG. TFTP: Trivial File Transfer Protocol.
- HH. UTP: Unshielded Twisted Pair.
- II. VLAN: Virtual Local Area Network.
- JJ. VPIM: Voice Profile for Internet Mail.
- KK. VPN: Virtual Private Network.
- LL. WAN: Wide Area Network.
- M. WWW: World Wide Web.

1.3 SUMMARY

- A. This Section includes the electronic components required to provide and operate a carrier grade IP-based Telephony Communications System which include central switching equipment and telephone instruments for use on communication and data-processing equipment.
- B. All hardware shall be current offering of the Manufacturer, and be receiving the highest level of support offered by the Manufacturer.
- C. All hardware shall be new equipment.
- D. The scope of work consists of the design, engineering, procurement, and installation of components required for the operation of an IP-based Telephony Communications System

and are based on, but not limited to, the following:

1. Call Processing Unit and software.
2. Gateways.
3. Signalling Servers primary and secondary
4. IP terminals and client devices.
5. Applications and network management.

1.4 SYSTEM DESCRIPTION

- A. Overview of Current Environment
- B. Requirements of IP-based Telephony Communications System
- C. Purposes
 1. The present document is to describe the IP-based Telephony Communications System to be installed as part of IT systems.
 2. 25% spare capacity is required at all levels of the system.
 3. The software licensing shall be for the entire system with no limitation on the number of workstations or standard end-users.
- D. Due to the criticality of information systems that may reside on it, the IP-based Telephony Communications System shall be a fully managed and monitored system. This system shall provide the ability to manage accounts and security as well as performance, configuration and faults.
- E. Scope of Works
 1. The Scope of Works shall include, but not limited to, detailed engineering, coordination, manufacture, supply, transportation, delivery, installation, testing, commissioning, setting to work, training and maintenance services during the 24-month Warranty Period, Operation and Maintenance services for the IP-based Telephony Communications System .This shall include at least the following tasks:

- a. Coordination with contractors, and providers of interfaced systems,
 - b. Project management,
 - c. Planning management,
 - d. Detailed functional analysis until approval by client,
 - e. Finalization of system to the approval by client
 - f. Detailed software specification to the approval of client,
 - g. Delivery of the interface control document to the approval of client,
 - h. Software development, complying with the detailed software specification,
 - i. Supply of needed IP-based Telephony Communications System equipment and components,
 - j. Transport, unloading, and storage on the site of the required equipment and components,
 - k. Coordinating with local and long distance carriers to address the system requirements, if required.
 - l. Equipment installation,
 - m. Software installation,
 - n. System installation and configuration,
 - o. System integration with interfaced and existing systems,
 - p. Complete testing of the system (unit tests, integration tests, final acceptance tests, users' tests, etc.),
 - q. Training,
 - r. System implementation in project premises,
 - s. System roll-out,
 - t. System maintenance after successful initial proving period during warranty,
 - u. Supply of spare parts for 2 years,
 - v. System maintenance tools delivery,
 - w. Writing and delivering of documentation (user's manual, maintenance manual, test reports, etc.),
 - x. Operation and Maintenance as an option to client
2. Technical specifications and architecture principles are generic and can be used to future extensions.
 3. Details of the elements included:
 - a. Request for Proposal of the following elements is explicitly specified in this Section.
 1. Provision, delivery and installation of the following equipment, but not limited to:
 - a) Call Processing System,
 - b) Public Media Gateways,
 - c) Signaling Servers,
 - d) IP Terminals and Client Devices,
 - e) Applications (unified messaging, IP contact center, Conferencing, web collaboration, etc.) as options to client
 - f) Associated element and/or network management tools with duly dimensioned hardware.
 2. Integration and support services.
 3. Warranty of the above equipment.
 4. Operation and Maintenance services as an option to client
 4. Specific Requirements:
 - a. Integration with existing network elements with full responsibility to the Con

tractor in order to make a coherent system. This work shall be carried out in close coordination with client IT Department.

- b. Manufacturer technical validation and endorsement of the design documentation and implementation shall be provided.
- c. Risk analysis on the design with advantages and drawbacks will have to come from the Manufacturer.
- d. Post deployment auditing by Manufacturers shall be specified in the documents,
- e. Submission of credential of the trainers shall be approved by the Manufacturer and by client

5. The Contractor shall be responsible for the provision of the licenses for all software, programs and modules provided for the Works including those developed and modified by the Contractor. The appropriate licenses supplied by the Contractor shall enable the Employer to use, modify, and develop the software, programs and modules for the works supplied under this Contract. The software licensing shall be for the entire project with no limitation on the number of workstations or standard end-users.

F. Coordination

1. Coordinate Works of this Section with the Employer's:
 - a. Departments, contractors, organization, etc.
 - b. Construction and implementation works.
 - c. Structured cabling network, both for communication room configurations and for connectors' type (electrical and optical).
 - d. Fiber optic cabling infrastructure.
 - e. Active communication and data processing equipment.
 - f. Workstations and servers suppliers.
 - g. IT systems providers using the IP-based Telephony Communications System.
 - h. Others (list given above not exhaustive).
2. Meet jointly with representatives of concerned organizations, contractors, and Employer's Representatives to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.
3. Record agreements reached in meetings and distribute record to other participants.
4. Adjust arrangements and locations of equipment in technical rooms and way of wiring closets to accommodate and optimize arrangement and space requirements.

G. Variant and Options

1. The Contractor should propose no variant.
2. Options consisting in additional provisions to the basic system may be submitted to the Employer for approval, with specifications, characteristics, aiming and full particulars of calculations and equipment selections. All options shall be priced separately.
3. GENERAL
 - a. The availability performance shall be 99.999% on a monthly average combined for all interdependent systems and it shall be the responsibility of the Contractor to ensure the overall availability.
 - b. The maximum time between detection of an event and its display on a workstation shall be of 3 seconds, under normal operating mode (for a mean load on network and on servers).
 - c. The MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on site,

but shall exclude the response time.

- d. The Contractor's response time shall not exceed 1 hour. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.
- e. In order to reach the requested MTTR and MTBF, modular conception and quick interchange of modules are required for the Data Network components.
- f. Redundancy:
 - 1. At all levels of the architecture, data redundancy shall be ensured. The detailed design of the Contractor shall highlight the actions adopted to implement this redundancy.

4. SOFTWARE REQUIREMENTS

- a. The Contractor shall refer to IEEE 610.12 "IEEE Standard Glossary of Software Engineering Terminology" for the definition of software related terms.
- b. Software Availability (SA) is defined as the probability that the program is performing successfully, according to specifications, at a given point in time. The Software Availability shall be better than 99.999%.
- c. Task Crash, which is defined as the unexpected termination of an executing task resulting in the system not being able to perform the task functions successfully according to specifications, for any reason, is not allowed.
- d. System Crash, which is defined as the unexpected system halt resulting in the system not being able to continue the operation of the machine, for any reason, is not allowed.
- e. The Contractor shall adhere to recognized structured analysis and design methods throughout the design process.
- f. All compilers and code generators shall be of the latest version and in compliance with international standards. No undocumented or non-standard feature of the language or operating system shall be used. Main and disk memory requirements shall be minimized.
- g. The Contractor shall ensure that all software delivered to site shall be accompanied by evidence that the media is free of viruses.
- h. No software Beta version shall be used in the network unless specifically authorized

5. DESIGN CONSIDERATIONS

- a. The Contractor shall use a suitable module design method to enable the software to be easily modified to cope with additional functionality providing I/O dialogues, billing equipment and controlling equipment. These additional functionalities are to be proposed as optional.
- b. Network management software to be provided with, but not limited to, impact analysis, event resolution, policy management, problem diagnosis, real time

trending, service monitoring, SLA compliance, and reporting and out-of-band management stress as per community SLA reporting capabilities.

- c. The expansion of software shall not cause any degradation of the performance of the system.

6. SOFTWARE EXPANSION REQUIREMENTS

- a. Software databases working in an off-line or on-line mode of operation should be designed to allow for ease of expansion. Where new database structures are implemented with fixed sizes then at least 30% spare capacity of each entry type and attribute shall be provided.
- b. The Contractor should develop software with possible expansion provision of porting to other hardware platforms, where practicable. To achieve this, a structured language and compiler should be used, subject to the approval of the

Employer's Representative.

7. HARDWARE EXPANSION REQUIREMENTS

- a. The hardware shall meet performance requirements considering that at least 25% spare capacity shall be provided.

8. SERVICE LIFE

- a. The system should have been designed for a service life of ten years.

9. Operational Constraints

- 1. The system will run 24 hours per day, all the days of the year.

1.5 SUBMITTALS

A. Design Submission: Shall include, but not limited to:

- 1. Equipment Datasheets must include (at least) the following information:
 - a. Product performance and existing features,
 - b. Environment requirements (Power, temperature, etc.),
 - c. Features, software and hardware releases roadmap on the next two years,
 - d. Standardized tests passed and results and available product certificates,
 - e. Product compatibility matrix with other manufacturers/vendors (specify level of testing in operation, lab test, declarative or theoretical),
 - f. MTBF.
- 2. System Requirement and Design Specification
 - a. System Architecture and justification.
 - b. Justification of performance requirements.
- 3. Management software datasheets must include (at least) the following information:
 - a. Product performance and existing features,
 - b. Known limitations (number of network elements managed, number of administrators, number of clients, size of the database, etc.),
 - c. Hardware requirements (storage, computation, processor needs, operating system, display, etc.),
 - d. Features and software releases for the next two years,
 - e. Standardized tests passed and results and available product certificates,
 - f. Product compatibility matrix with other Manufacturers/Vendors (specify level of testing in operation, lab test, declarative or theoretical).
- 4. Installation, configuration, integration and support offers must detail:
 - a. Level of qualification of the personnel involved. Detail if some parts shall be subcontracted.
 - b. Training program provided by the Manufacturer to the Contractor teams and related certificates.
 - c. Project structure and localization during operations (distinguish local and remote teams).
 - d. Detailed responsibility matrix for a task by task responsibility assignment.
- 5. Technical documentation and trouble shooting guides shall be provided in English, both paper and electronic version, for each type of equipment in the offer.

6. Product Certificates: Signed by Manufacturers certifying that products furnished comply with requirements.
7. Human Machine Interface (HMI) Design:
 - a. For dedicated Workstation users.
 - b. For standard end users.
8. Software Requirement and Design Specification:
 - a. Software Architecture and justification (e.g.: off-the-shelf and specific software, etc.).
 - b. Justification of performance requirements.
9. Test Plan:
 - a. The Contractor shall provide Test Plan on the testing methodologies used for various tests involved throughout different stages of the Works. This shall also include the plan for integrated tests for interface with other systems. The Contractor shall submit the Test Plan for approval by the Employer's Representative.
 - b. Test program shall be part of the test plan.
 - c. In establishing the test program, the Contractor and the Employer's Representative shall agree which activities shall be attended by the Employer's Representative.
 - d. After approval, the Test Plan shall be amended as required during the life of the Project to reflect changes in system design and the identification of additional testing requirements.
10. Maintenance and Warranty offers must detail:
 - a. Comprehensive cost structure according to committed GTI, GTR and MTBF.
 - b. Maintenance stock dimensioning.
 - c. Distinguish maintenance during warranty period and after.
 - d. Teams' organizations (distinguish local and remote teams, give associated manpower).
 - e. Hardware repairs and software patch support procedures.

B. Project Schedule

1. Provide a detailed Build Plan that includes, but is not limited to:
 - a. All activities required to deliver a production ready system
 1. The duration of each activity in days,
 2. The resources required to complete each activity,
 3. Any dependencies amongst activities.

C. Product Data

1. Include detailed Manufacturer's specifications and data sheets for each system component.
2. Include data on features, ratings, and performance for each component specified.
3. For each type of equipment, submit data for approval including catalogues and literature, sufficiently detailed for engineering purposes, and with full description of components and operating parameters.

D. Shop Drawings

1. Indicate layout, wiring diagrams, and dimensions.
 2. Locate devices and components on drawings.
 3. Submit drawings for approval including, but not limited to, the following:
 - a. Detailed system schematic diagram,
 - b. Layout of network components, network management system, etc.
 - c. System labeling schedules, including electronic copy of labeling schedules in software and format selected by the Employer's Representative.
 4. Complete electrical and physical characteristics of network components, network management system, etc.
 5. Complete system wiring diagrams, size and type of cables, enclosures, and terminal, splice boxes etc., and routing plans of wiring system.
 6. Include dimensioned plan and elevation views of components. Show access and workspace requirements.
- E. Manufacturer's Installation Instructions
1. Provide Manufacturer's installation instructions.
 2. Certificates signed by Manufacturers of equipment certifying that the provided products comply with contract specified requirements.
- F. System Operation Description
1. Include method of operation and supervision of each component and each type of circuit, and sequence of operations for manually and automatically initiated system inputs
 2. Description must cover this specific Project; Manufacturer's standard descriptions for generic systems are not acceptable.
- G. Product Certificates
1. The Contractor shall provide certificates signed by Manufacturers of components certifying that the provided products comply with requirements.
- H. Qualification Data
1. For firms and persons specified in "Quality Assurance" an article shall be written to explain and demonstrate their capabilities and experience.
 2. To 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 the Employer's Representative.
 3. An experienced Contractor, which is an authorized representative of the Manufacturer, for both installation and maintenance purpose, is formally required for this Section.
- I. Tests and Certificates
1. Test Specifications as defined in the Test Plan shall be submitted for Approval.
 2. Submit complete certified Manufacturer's type and routine test records, in accordance with the Standards specified in "Quality Assurance" Article.
 3. It shall specify test results for compliance with performance contract requirements.

4. Include record of signal ground resistance measurement certified by the Contractor.

J. Field Test Reports

1. As specified in "On-Site Tests and Inspections" Article of this Section, the Contractor shall indicate and interpret test results for compliance with system description and performance requirements.

K. Record (As-Built) Drawings

1. Complete wiring diagrams, including complete terminal strip layout and identification, and wire termination and tagging for all conductors.
2. Locations for all components installed and/or connected to under this Specification.

L. Sample Warranty

1. Copy of Manufacturer's warranty, stating obligations, remedies, limitations, and exclusions.
2. Provide copy of sub-contractor's warranty certificates.
3. Provide Contractor's warranty certificates.

M. Maintenance Data

1. For products and systems, the Contractor shall include maintenance manuals.
2. The Contractor shall include data for each type of product, including all features and operating sequences, both automatic and manual.
3. The Contractor shall include user's software data and recommendations for spare parts and components to be stocked at Project site.

1.6 REGULATIONS AND STANDARDS

A. Rules

1. The Works shall be conformed to requirements of referenced industry standards, applicable Sections.
2. The Works shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Employer's Representative, in writing.
3. Conflict: Should an instance occur in this Specification and referenced Sections in which equipment, components, material or construction methods called for is less than minimum requirement of the referenced industry standards, rules, local regulations, etc., the Employer's Representative shall be immediately informed in writing. Consequent to the Employer's Representative's approval, supply equipment, components, material and perform the work as through called for to minimum code standards.

B. Standards

1. Standards to be used is the IEC or other equal and approved codes, taking into account that network cables with fitted accessories and connector and wiring have to be of fire rated type in accordance with all NFPA requirements codes (NFPA72 and extensions).

2. System components, parts, and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).

C. Precautions

1. The above list is a partial list issued from standard organizations. Additional consideration may be required to provide protection of communication equipment, data processing equipment and protection of data from intrusion, induced noise or other events that can disrupt vital operation.

1.7 QUALITY ASSURANCE

A. Requirements

1. All Works shall be executed and controlled by a quality management system in accordance with the requirements of ISO 9001.
2. system shall comprise all the participants to the Contract within the Contractor's teams and its sub-contractors.

The Quality Assurance Plan is based on quality manuals of the Contractor and subcontractors.

3. The Contractor nominates from the beginning of the Project, the person in charge of quality assurance of the whole project, who is directly linked to the Project Director.
4. The Contractor should establish from the beginning of the Project, the Quality Assurance Plan based on Contractor's quality system that should define:
 - a. Scope of Quality Assurance Plan, with conditions of validity and revision,
 - b. Approach and structure of the Contractor's quality management system to fulfill the requirements of the Contract and ISO 9001,
 - c. Organization retained for the Project with sub-contractors list,
 - d. Details of how the Contractor proposes to manage sub-contractors and to ensure that the relevant quality system requirements of ISO 9001/2 are observed and implemented by the sub-contractors in the execution of the works subcontracted,
 - e. The quality plans of the Contractor.

B. Manufacturer Qualifications

1. A firm specializing in providing IP-based Telephony Communications System, similar to that indicated for this Project and with a record of successful in-service performance.
2. Manufacturer's systems shall be, as often as possible, a standard "off-the-shelf package utilizing the latest hardware and software technology. Any major system development effort necessary to meet specified requirements is unacceptable. Even if this system is a new concept, it should not require huge development and shall be based on existing and proven technologies.
3. Manufacturer or factory-authorized agency shall maintain a service center capable of providing training, parts, and emergency maintenance and repairs for overall system at Project site with eight hours of maximum response time.

C. Installer Qualifications

1. An experienced Installer who is an authorized representative of the equipment Manufacturer for both installation and maintenance of Manufacturer's equipment, and who has completed system installations similar in design and extent to that indicated for this Project, with a record of successful in-service performance.

D. Materials and Workmanship

1. They shall conform to the latest issue of all industry standards, publications, or regulations referenced in this Section, including the following, as applicable:
 - a. Regulations and Standards: System components, parts, and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).
 - b. Compliance with Local Requirements: Comply with applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Employer's Representative, in writing.
 - c. Conform to requirements of referenced industry standards, applicable Sections.

E. Source Limitations

1. For each category of technology used for the IP-based Telephony Communications System, obtain system components from one Manufacturer who shall assume responsibility for the system components and for their compatibility.

1.8 COORDINATION

- A. Coordinate with client to confirm location of equipment, power supply, air-conditioning and ventilation of equipment in room.
- B. Meet jointly with representatives of concerned organizations, contractors, and Employer's Representatives to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.
- C. Record agreements reached in meetings and distribute record to other participants.

1.9 TESTING AND REPORTS

- A. The Contractor shall test all components and circuits of the IP-based Telephony Communications System after installation to ensure functionality and performance within industry approved guidelines.
- B. A written report shall be submitted describing testing procedure and detailing test results.
- C. The Contractor shall provide and supply all necessary technical and skilled manpower, tools, test equipment, materials and transportation required for performing system and components testing.

1.10 RECORD DOCUMENTATION

- A. Operation and Maintenance manuals:
 1. The Contractor shall submit full system documentation for the installed IP-based Telephony Communications System and all ancillary equipment such as the Network Management System.
 2. System documentation shall consist of:
 - a. A complete set of product data for all component parts.
 - b. A complete set of operations manuals for all components of the system.
 - c. Maintenance manuals for all components of the system and for the system as a whole.

- B. Test procedure, data and results from acceptance testing.

1.11 WARRANTY

A. General Special Warranty

1. Manufacturer's Warranty: Provide written warranty, signed by the Manufacturer and the Installer agreeing to replace system devices and equipment that fail in materials or workmanship within specified warranty period.

B. Experimental Period

1. There shall be an experimental period of 90 days after successful testing and commissioning of the system, but before issuance of substantial completion certificate. During this period, the Contractor shall undertake supervision and responsibility for operation of the system under actual site conditions. If any malfunctioning or anomaly noted on the system during this period, it shall be attended immediately. The experimental period will restart automatically from the date of clearing such troubles and start normal operation.
2. During this period, the Contractor shall fully demonstrate the system performance under actual operation conditions. This demonstration is to confirm, to the satisfaction of the Employer's Representative, that the system is free of remarks and is ready for provisional taking over.
3. After the satisfactory completion of this period, the system is to be taken over by the Employer, as per Contract Conditions, whereby the Warranty Period is to commence.

C. Warranty Period

1. Two years from the satisfactory completion of the Experimental Period.
2. During the Warranty Period, the Contractor shall undertake Maintenance actions as defined in the Maintenance and Warranty Article.
3. During the Warranty Period, the Contractor shall provide, at its own cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.

D. Manufacturer Product Performance

1. The Contractor shall provide a Manufacturer endorsed and backed extended 10-years product, performance, application, and labor warranty which shall:
 - a. Warrant against defects in materials and workmanship (extended product warranty) for a period of 10 years.
 - b. Warrant that all cabling components of the installed system will meet or exceed the specifications of TIA/EIA 568B and ISO/IEC IS 11801 (performance warranty) for a period of 10 years.
 - c. Warrant that all unshielded/shielded twisted pair cabling links/channels will meet or exceed the attenuation and NEXT requirements of TIA/EIA TSB 67 and ISO/IEC 11801 (performance warranty) for a period of 10 years.

1.12 COMMISSIONING

A. Purpose

1. In-System Commissioning

- a. The Contractor is responsible for the equipment installation in the system, so that the system stays globally functional. Therefore, equipment commissioning must be done through demonstration of product capability and compliance with requirements when wired and configured in the system.
 - b. Test link system and power supply redundancies by unplugging redundant links.
 - c. Check recovery times.
2. The Contractor shall be required to perform a range of Site Acceptance Tests on site for each individual sub-system to demonstrate that all items have been correctly installed and adjusted on a location by location basis and that the sub-system operates in every respect in accordance with the Specifications.
 3. During this phase the equipment are powered and the automation and networking are gradually integrated layer by layer.
 4. The tests shall be performed by the Contractor and witnessed by the Employer's Representative.
 5. Any defects, which may become apparent during the course of these tests, shall be immediately rectified by the Contractor at his expense.
 6. The Site Acceptance Test Specifications shall be prepared by the Contractor and submitted for Approval.
 7. All Site Acceptance Tests shall be carried out in the presence of the Employer's Representatives who shall sign off the testing documentation on satisfactory completion of the tests.
 8. The Site Acceptance Test Specifications, at every level, shall be subjected to configuration management and change control by the Contractor.
 9. If modification or reprogramming is required as a result of the tests, all affected parts of the Site Acceptance Tests, as determined by the Employer's Representative, shall be re-tested.
 10. The results of the Site Acceptance Tests, version of software and hardware tested, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representatives.

B. Tests

1. Those tests are divided into 2 sub-phases.
2. Preliminary Testing:
 - a. Mechanical:
 1. Mechanical tests,
 2. Calibration of the components.
 - b. Automatism / Electrical:
 1. Powering Tests with electricity,
 2. Control of Input/Output,

3. Control of the safety measure either personal or material,
 4. Test of local mode operation.
- c. System / Software Tests:
1. Test of the System,
 2. Test of the Supervision Workstation user interface,
 3. Test of the portable Terminal user interface.
3. Test of the System:
- a. The tests performed during this phase are performed with and without loading conditions.
 1. Testing the crippled mode (Safe shut down consecutive to loss of energy, etc.),

1.13 MAINTENANCE

A. Support

1. The Contractor must offer a comprehensive explanation of its Service Level Agreement (SLA) policy. The SLA should cover at least the following performance terms:
 - a. 99.999% availability. GTI and GTR should be guaranteed accordingly.
 - b. Emergency level 24/24, 7/7 phone support shall be available. Distant intervention on system must be offered.
 - c. High-level problem investigation support must be offered 5/7 during working hours.
 - d. Maintenance stocks must be properly sized by the Contractor in order to match operational quantities replacement needs given Manufacturers MTBFs for each equipment and components within the system.
2. Maintenance service must include:
 - a. Contract lifetime software patching for revealed problems during operations.
 - b. Contract lifetime hardware replacements on established malfunctions or weaknesses generating repetitive loss of service quality
 - c. Repairs in reasonable time for factory returned equipment.

B. Maintenance Service

1. During the Warranty Period, Manufacturer or factory-authorized agency shall maintain a service center capable of providing spare parts and emergency maintenance and repairs for the overall system at Project site 7 days a week and 24 hours a day. Competent personnel shall be dispatched to rectify stoppages at any time during the day or night when being called on by the Employer.
2. The Contractor shall submit a Service-Call Report to be sent to the Employer immediately following every call out, indicating the time of call out visit, cause, remedial action taken and the time that the service was restored.
3. A Maintenance Manpower Plan shall demonstrate the Contractor's committed resource level available for all types of activities to be carried out within the Warranty Period. Such plan shall be submitted for Approval six months before commencement of the Warranty Period.

4. The Contractor's response time, during the Warranty Period, shall not exceed 1 hour. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.
5. During the Warranty Period, the MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on site, but shall exclude the response time.
6. During the Warranty Period, the monthly average of the Repair Time shall be lower or equal to six minutes for each device. This performance will be checked.
7. The Contractor shall liaise with the Employer's Representative and carry out safety and performance inspections for the installation on site. Any necessary adjustments to the installation shall be made within 14 days of completion of such checks. A Safety and Quality Report shall be submitted, no later than 14 Days after such safety and performance checks, for the Employer's Representative's approval.
8. The Contractor shall provide at least four inspection visits at six-month interval during the Warranty Period.
9. The Contractor shall be responsible to clear away from the Site all surplus materials, rubbish, temporary works of every kind and leave the whole of the Site and installation clean and in a workmanlike condition to the satisfaction of the Employer's Representative, upon completion of each item of the repair, and maintenance works.

C. Maintenance Performance Data

1. Updates
 - a. The system will have to be conceived to facilitate the updates that will take place throughout its life. The replacement in exploitation of a version of software by the following one must be an easy operation, without risk, rapid and reversible.
 - b. This update shall be transparent for the user and shall be done without interruption of the service.
2. Corrections
 - a. In the event of error, the system shall have, as soon as possible, to store in a file a certain number of information allowing the correction of this error, e.g. entries in the transactions, faulty operations of the statistics, etc.

1.14 GLOBAL SYSTEM REQUIREMENTS

A. General

1. Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance.

B. Expansion Capability

1. Unless otherwise indicated, provide equipment extensions capabilities for five years after each equipment delivery. The Contractor shall inform the Employer when extension limit is to be reached. Extension limit means:
2. Equipment in a given area unable to accommodate 20% further increase in network elements to connect. Limitation shall be made specific. System management tools are unable to accommodate 20% further increase in number of ports or elements. Limitation shall be made specific.

1.15 SPARE PARTS AND EXTRA MATERIALS

- A. Contractor shall provide Manufacturer recommended spare parts for all major components in the system for two years fault free operation.
- B. However, a minimum of 2% peripherals of each type installed, but not less than one from each type shall be included in the deliverable irrespective of Manufacturer recommendation.
- C. During the Warranty Period, the Contractor shall provide, at his cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.
- D. The Contractor shall guarantee the flow and availability of the spare parts without a major design change for at least ten years period.

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:
 - 1. Alcatel.
 - 2. Avaya.
 - 3. Cisco international.
 - 4. MITEL

SYSTEM ARCHITECTURE

- A. The Contractor shall provide a full description of the proposed system architecture. This shall be structured so anyone reading only this section has a clear understanding of the system. Diagrams explaining this architecture shall be included. The Contractor shall also specify the model names and version numbers of all relevant components of the system.
- C. The solution shall be centralized from a call processing and signalling perspectives into redundant and contingent data centres.
- D. The system architecture shall support multi-Manufacturer interoperability with other Manufacturer's products and across any QoS infrastructure.
- E. The system architecture shall support end-to-end QoS. This shall include but not limited to traffic marking, enhanced queuing services, link fragmentation and interleaving, CRTP, low latency queuing, link efficiency, traffic shaping, and call admission control.
- F. The system architecture shall provide bandwidth management and call admission control to guarantee at all times that the network and LAN/WAN links are not over subscribed.
- G. The system architecture shall be able to support open industry standard devices such as H.323, SIP, etc. This shall include the support of analogue and digital phones.

- H. The system architecture shall support remote office phones from a centralized phone system. The Contractor shall state any additional equipment that maybe required at the remote site.
- I. The system architecture shall have local survivability capabilities provided for remote sites during a WAN outage
- J. The system architecture shall be able to provide easy addressing scheme of the IP phones, such as Dynamic Host Control Protocol (DHCP), without having to change the addressing scheme of the existing IP data network.
- K. The system shall support all relevant industry standards listed below. The Contractor shall state any standards that are not supported indicating when he is expecting to support it:
 - 1. Class Based Weighted Fair Queuing (CBWFQ).
 - 2. Committed Access Rate.
 - 3. Compressed Real Time Protocol (CRTP).
 - 4. DCL.
 - 5. Dynamic Host Configuration Protocol (DHCP).
 - 6. Differentiated Services.
 - 7. Domain Name Service (DNS).
 - 8. FAX - Group 3 (ITU-T recommendation T.4 Fax group 3 is the most common type of fax machine transmitting on A4 paper. He machine scanning format is digital and operates at rates between 9.6 and 14.4 Kbps).
 - 9. FAX - Group 4 (IUT-T recommendation T.6 and supports two-dimensional image compression, compressing the line width as well as the line length).
 - 10. G.711 Pulse Code Modulation (PCM) of Voice Frequencies.
 - 11. G.726 Adaptive Differential Pulse Code Modulation (ADPCM).
 - 12. G.728 Coding of Speech at 16 Kbps using Low-Delay Algebraic Code Excited Linear Prediction (LD-ACELP).
 - 13. G.729 Coding of Speech at 8 Kbps using Conjugate Structure Algebraic Code Excited Linear Prediction (CS-ACELP).
 - 14. G.729a Annex A Reduced Complexity 8 Kbps CS-ACELP Speech Codec.
 - 15. H.225 Call Signaling Protocols and Media Stream Packetization for Packet based Multimedia.
 - 16. H.245 Control Protocol for Multimedia Communications.
 - 17. H.323 Packet Based Multimedia Communication Systems.
 - 18. IP Precedence.
 - 19. PABX must be supporting auto attending console.
 - 20. PABX must be able to offer soft phones on PC and PDA.
 - 21. The PABX must be able to support different codes either in A or μ law G.711, G. 729A, G729B,

G726.

22. PABX must be able to support 3 times the number of delayed extensions without any major changes other than software licenses.
23. The PABX must be able to support wireless Wi-Fi phones and offer enhanced security functionalities specific to this kind of handset.
24. When IP phones are used it should be possible to intensively customize the look and feel using XML based contents / configurations.
25. The PABX must be able to interface with external software to offer enhanced Multimedia services.
26. PABX must be delivered with an easy to use secured web based management interface.
27. The management solution should be able to report by syslog or SNMP any failed components of the voice services either it is a core / gateway / ICD or IP Phone.
28. PABX must be able to deliver usage CDR and to store / buffer them inside the PABX.
29. Internet Protocol version 6 (IPv6).
30. Lightweight Directory Access Protocol (LDAP).
31. Media Gateway Control Protocol (MGCP).
32. Policy Based Routing.
33. Q.931 Manages Call Setup and Termination.
34. Priority Queue Weighted fair Queuing (PQWFQ).
35. Random Early Discard (RED).
36. Resource ReSerVation setup Protocol (RSVP).
37. RTP Control Protocol (RTCP).
38. Real-time Transport Protocol (RTP).
39. Real-time Streaming Protocol (RTSP).
40. Session Initiation Protocol (SIP).
41. T. 120 Data Protocols for Multimedia Conferencing.
42. Simple Network Management Protocol (SNMP).
43. Transmission Control Protocol / Internet Protocol (TCP/IP).
44. T.38 IP Based Fax Service Maps.
45. User Datagram Protocol / Internet Protocol (UDP/IP).
46. Voice Profile for Internet Mail (VPIM).
39. Weighted Queuing.
40. Weighted RED.

- 41. IEEE 802.1 d Spanning Tree Protocol.
- 42. IEEE 802. Ip Prioritization Technique/Layer 2 QoS.
- 43. IEEE 802.1 q VLAN Tagging.
- 47. IEEE 802.3 Ethernet (CSMA/CD).
- 44. IEEE 802.3af Power over Ethernet.
- 45. IEEE 802.lx.

2.3 SYSTEM RELIABILITY, SECURITY AND AVAILABILITY

- A. The system shall be capable to provide high availability, redundancy and fault tolerance. The Contractor shall specify the components that can be duplicated in the system. In addition, a full description of the system's redundancy capabilities shall be provided.
- B. The system shall include all components, features and facilities to deliver 99.999% uptime. This shall address as a minimum bandwidth, packet loss, round trip delay and jitter.
- C. The IP-based Telephony Communications System shall provide as a minimum password protection, session encryption, IP address filters, log information about failed password attempts, etc. to prevent un-authorized modifications to the system servers, to the system gateways, and to the system IP phones.
- D. The system shall have advanced built-in security features such as external firewalls/Network Address Translation (NAT), personal firewalls, VPN, etc. The system shall also be able to accept third party monitoring software that can be used to detect system status.
- E. The system shall be able to track failed password entries in a single session and across multiple sessions. The system shall also automatically disconnect the caller and/or lock out the user after a configurable number of failed attempts.
- F. The system architecture shall support operator system and server clustering for redundancy. The Contractor shall specify the maximum number of clusters his system can support and the maximum number of active users supported per cluster.
- G. The Contractor shall specify the highest number of IP devices currently supported under a single instance of the software and the number of IP devices supported by a cluster.
- H. The system shall have a web-based or GUI-based administration tool. This administration tool shall have the capability to manage all systems within an enterprise simultaneously using a single interface.
- I. In case of hardware and/or software failure, the switchover in a redundant system should smoothly occur without interruptions of users. The system should also be able to synchronize the database in a manner that would guarantee correct operation and transfer of data after switchover.
- J. The system shall have protection mechanisms against viruses and other attacks, and intrusion detection to insure the proper operation of all components.
- K. The system shall have toll fraud protection capabilities.
- L. The Contractor shall guarantee the continuous operation of the system by provisioning for UPS or "battery" back-up systems.

2.3 SYSTEM COMPONENTT

2.3.1 PBX

- A. Unified PBX to be the media-processing engine of IPT System, extending telephony features and capabilities to packet telephony network devices such as IP phones, media-processing devices, voice-over-IP (VoIP) gateways, and multimedia applications. Additional services such as multimedia conferencing, collaborative contact centers, and interactive multimedia response systems through the open telephony application programming interfaces (APIs).
- B. The whole collaboration solution including all the applications should be installed on virtual machines reside on the top of one rack mounted servers, with another redundant server, the solution should be flexible to be installed as Active/Active or Active/Standby
- C. Simplified deployment and management: Preconfigured virtualized servers with ready-to-run virtualization software and ready-to-activate collaboration applications make setup quick and easy
- D. The system should support the following capacity:
- E. Max number of users is 600 users for service areas IP telephones.
- F. Each tenant area will be served by 5 lines IP –BASED (up to 1000 user) as initial lines and, the tenant shall coordinate with the client for additional services.
- G. Scalability to 5000 users in modular fashion
- H. Integrated IP gateways
- I. Unified Messaging Platform (VM activated by default, Email/Fax integration – license based)
- J. Unmatched Quality of Service and survivability capabilities
- K. Support for DECT, Video, VoWLAN
- L. Clients – IP soft phones, video soft phones
- M. The license should be user based license with the ability of having central license manager that can provide centralized, at-a-glance view of compliance and allows for redistribution of licensing among supported products.
- N. Support 64-bit architecture with native support for IPv6
- O. Support range of fixed and mobile end-user devices
- P. The system should support the following new features:
 - a) Enhancements: Collaboration Edge with integrated firewall traversal and interworking that support simple and highly secure access to video, voice, content, instant messaging, and presence outside our enterprise firewall
 - b) Call Control
 - Access protocols for administration interfaces should be via https and snmp.
 - the solution should provide Batch provisioning that increases operating efficiencies and reduces costs with scheduled scripts and templates that let an operator rapidly and consistently add or modify a large number of users or a large number of endpoints or device profiles (and the corresponding configuration settings)
 - The Communication Server/Call Server would be deployed in an active-active configuration over the distributed IP infrastructure (LAN/WAN). The call control system should be fully redundant solution with no single point of failure & should provide 1:1 redundancy. All the servers should do call processing all the time and act as backup in case of the failure of one server
 - The IP Phones should retrieve their configuration from the Call Control (VLAN, DHCP, firmware download) with no external intervention
 - Call control should support E.164 and URI dialling
 - The offered solution must provide a standard based mechanism for QoS implementation.
 - Whenever not enough bandwidth is available, sessions have to be rerouted on an alternative path or blocked depending of the service.

- In progress PSTN Calls at each of the locations should not be interrupted in the event of any WAN link failure or a call control server failure.
- Quality of Services (QoS) would be configured to administer the call and ensure voice traffic get priority over normal traffic, and provide adequate measures to ensure Quality of Service on softphones running on computers.
- The System should support Call Admission Control to configure number of calls that can be active between locations with the ability of supporting multiple codecs at the same time.

c) Directory

The solution should support importing user accounts from an LDAP and Active Directory. Thus the creation or deletion of an account in the directory will be replicated communication solution. The user name and password LDAP / AD should be used when the authentication to access the web pages of the solution.

The solution should enable centralized deployment of 802.1x authentication on the terminal Should support user synchronization and authentication with the following LDAP directories:

- Microsoft Active Directory 2003 R1/R2
- Microsoft Active Directory Application Mode (ADAM) 2003 R1/R2
- Microsoft Active Directory 2008 R1/R2
- Microsoft Lightweight Directory Services 2008 R1/R2
- Microsoft Active Directory 2012 R1/R2
- Microsoft Lightweight Directory Services 2012 R1/R2
- Sun One 6.x
- Sun Directory Services 7.0
- Oracle Directory Services Enterprise Edition 11gR1 (v11.1.1.5.0)
- OpenLDAP 2.3.39 & 2.4.x

call control should support daylight savings time (DST) changes for a time zone. DST rules should describe DST start and end dates for a time zone annually.

- The Call Control should support call recording without regard to device capabilities or location, including mobility calls using Single Number Reach or Extend and Connect. The system should automatically select the best point at which to replicate audio media: Session Border Controller, Session Initiation Protocol (SIP) voice gateway, or any IP phone device. The call control should integrate with any commercial call recording servers, in centralized or distributed deployments (Future needs)
- system should support Unified administration of IM&P, voice and video call control users reduces time and effort to add, change, and verify user configuration. The System should offer a common portal to make it easy for end users to manage their options and preferences for voice and video.
- Call Control should offer an expanded portfolio of IPv6-capable endpoints that will be compatible with future versions and with future endpoints
the Call Control should provide video and presentation-sharing capability for IPv6 endpoints.
system should support Provisioning templates that enable administrators to define user configuration once and apply it automatically to new users discovered through directory integration.
- system should allow the End users to complete the provisioning process without administrative assistance, configuring their personal device through an application or Interactive Voice Response (IVR) interaction. the Solution should support new self-care interface to makes it easy for end users to manage their options and preferences for all devices.
- The Call Control should support native call queuing natively to users so that callers can be held in a queue until hunt members are available to answer them. Callers in a queue receive an initial

greeting announcement followed by music on hold or tone on hold. If the caller remains in queue for a period of time, a secondary announcement is played at a configured interval until the call can be answered—or until the maximum wait timer expire

User self-care interface

- Call forwarding/ Follow me
- Reach me anywhere (Single Number Reach)
- Web Dialer
- mobility
- Do Not Disturb
- Speed Dial – This feature facilitates dialing of frequently called numbers. Users assign number strings to free keys on their telephone handsets.
- Locale selection
- ACD – Internal users via a dial plan should be able to register their handsets into specific groups created in the ACD. The ACD will then route incoming calls to registered handsets in these groups based on various details, such as dialed number or selected options from a menu.
- Music on Hold selection
- Backup and restore of configuration
- Entering user-phone information in bulk through spreadsheets
- Debug traces and system diagnostics
- Call detail records
- Configuration export

d) Services Mobility

- Reach Me Anywhere or Single Number Reach
- system should support move a call from desk phone to mobile phone, and conversely
- Corporate Directory: system should support viewing a list of users with phone numbers
- Mobility system should support the log in to any IP phone
- Support Smart Phone voice clients

g) Internal mobility

The system should support the extension mobility feature or free seating allows users to save and retrieve their telephone profile

h) External mobility

The system should support dialing function when receiving a call on the user landline to ring multiple devices (including mobile phones) and switch the call between the terminals. This feature should be available to all users..

i) The solution should support voice over Wi-Fi to GSM / Wifi equipped with a SIP client. Also it should Offers ability to receive video or participate in a video call in both Wi-Fi and cellular modes, allowing users to move voice and video sessions between mobile and desk phones, more details hereunder:

The proposed solution should offer a unified soft client for the iPad, iPhone and Android phones with the following features:

l) Video

- The Call Control should support unified voice and video capabilities on one platform.
- The call control should support Directory Uniform Resource Identifier (URI) Dialing which extends reachability to users and devices by enabling dialing using email addresses.
- The call control should support SIP normalization and transparency enhancements that allow

n) Servers:

- The whole entire solution should be installed in a maximum of 2 rack mounted servers with the minimum Specs Below per server:
- The following exception can be applied:
- Latest server
- The servers should enterprise-class Rack-Mount Server from the same vendor with advanced performance and energy efficiency of the Intel Xeon processor

2.4 SYSTEM FEATURES

A. The IP-based Telephony Communications System shall provide the following features. The contractor shall specify any features that the system does not support and/or any additional features supported by his system:

1. Abbreviated ring.
2. Answer / answer release.
3. Application sharing.
4. Attendant console.
5. Audio volume adjustment.
6. Authorization codes.
7. Auto echo cancellation.
8. Automated call-by-call bandwidth selection.
9. Automated phone installation configuration.
10. Automatic line selection.
11. Automatic phone moves.
12. Busy / direct line selection.
13. Busy indicator.
14. Call back / ring again.
15. Call block.
16. Call coverage.
17. Call detail records.
18. Call forwarding (busy).
19. Call forwarding (off premise).
20. Call forwarding (ring and/or no answer).
21. Call forwarding (self directed / programmable).
22. Call hold / release.
23. Call park / pickup.

24. Call Privacy.
25. Call routing.
26. Call transfer.
27. Call waiting.
28. Calling line ID (line and name).
29. Camp-on.
30. Chat.
31. Conference (uni-cast).
32. Conference (multi-cast).
33. Console queuing.
34. Date & time.
35. Directory.
36. Direct inward dialing (DID).
37. Direct outward dialing (DOD).
38. Distinctive ringing (internal vs external call).
39. Distinctive station ringing pitch.
40. Do not disturb.
41. Drop.
42. DTMF delivery.
43. Event logging and reports.
44. Event viewer interface.
45. External SMDI interface.
46. Feature access.
47. File transfer.
48. Headset options.
49. Hunt groups.
50. H.323 RAS support.
51. Idle line preference.
52. Inspect.
53. Intercom.

- 54. IP phones set / IP precedence bit.
- 55. IP routable.
- 56. IP-based integration messaging.
- 57. JTAPI.
- 58. Last number redial.
- 59. License management.
- 60. Line pools.
- 61. Line status monitor.
- 62. Microphone disable.
- 63. Multiple calls per line appearance.
- 64. Multiple line appearance.
- 65. Music on hold.
- 66. Night service.
- 67. Number portability.
- 68. Paging interface.
- 69. Performance monitor interface.
- 70. Personal extension.
- 71. PRI protocol support (NI-2 and
- 72. Privacy (prevent barge in on
- 73. Recall / timed flash.
- 74. Redundant call processors.
- 75. Remote process control.
- 76. Ringer-pitch Adjustment.
- 77. Ringer volume adjustment.
- 78. Ringing option by line / station.
- 79. Shared extensions on multiple phones.
- 80. Simultaneous ring.
- 81. Single button collaboration computing / virtual meetings.
- 82. Speakerphone mute.

- 83. Speed-dial (auto-dial).
 - 84. System events on Windows NT event viewer.
 - 85. TAPI2.1.
 - 86. Three way calling.
 - 87. Toll and nuisance number (900, 976, 970, 550, 540, exchanges) restriction.
 - 88. Tone on hold.
 - 89. Video.
 - 90. Visual message displays (all digital telephones) (name, extension, etc.).
 - 91. Voice announces to busy.
 - 92. Web administration.
 - 93. Web documentation.
 - 94. Web-based dial (auto-dial) directory.
 - 95. Whiteboard.
- B. The system shall provide methods for disposition of blocked calls such as announcements, reorder, queuing, etc.

2.5 CALL PROCESSING SYSTEM

- A. The IP-based Telephony Communications System shall be scalable and able to provide service for users ranging from 100 users to over 20,000 users using a single system.
- B. The system shall be non-blocking and shall be able to process, as a minimum Typically 10-15% of the total subscribers number, simultaneous conversations.
- C. The system shall support as a minimum 100,000 busy hour call attempt.
- D. The system shall have the most recent software release at the time of delivery. The Contractor shall provide a timetable of all scheduled software releases and upgrades.
- E. All system changes and software upgrades shall be able to be performed on-line with minimal interruption and/or disturbance of the running system.
- F. The system shall have a back-up procedure for the operating software, which includes up-to-date moves and changes.
- G. The system shall support Computer Telephony Integration (CTI), Telephony Application Programming Interface (TAPI) and Java Telephony Application Programming Interface (JTAPI) applications.
- H. The Contractor shall list all partner programs for third-party applications development.
- I. The call processing system shall be based on open standards (H.323, H.248 and SIP) and has an open architecture operating system.

- J. The system shall be scalable and modular and be able to support a variety of distributed configurations.
- K. The system shall provide an industry leading solution for remote offices that need to be effectively networked to a main location, or any other site.

2.6 PUBLIC MEDIA GATEWAYS

- A. The system shall be able to provide transparent connectivity to legacy TDM equipment and the Public Switched Telephone Network (PSTN). This shall include all options available for analog station and trunk and digital trunk connectivity.
- B. The media gateways shall, as a minimum, support the following types of PSTN trunk interfaces:
- C. Media gateways shall use standardized codecs to provide voice compression and packetize voice traffic so it can be carried over an IP network such as G.711, G723.1, G.729a, etc.
- D. The system shall support all the PRI services and features and signaling options including, but not limited to, the following: ANI (caller ID), Call-by-Call, Dialed-Number Identification String (DNIS), DID, DOD, Advice of Charge, Non-Facility-Associated Signaling (NFAS), Calling Number Identification (CNI) and all other supplementary services (forward, transfer, conference, hold).
- E. The media gateways shall be able to provide set of reports to manage and change the parameters of the PSTN interface as required such as a detailed view of traffic on PSTN interfaces, a view of the status of these interfaces (enabled/disabled), etc.
- F. The Contractor shall provide a list of PBXs and Central Office switches to which his PRI trunk has been successfully connected, tested and operated.

G. Redundant Voice Gateway Capacity

Each voice gateway

- Should support h.323 integration to the call control
- Should support MGCP and SIP protocols
- Should be able to communicate with the new Telephony systems to get its dial plan remotely from the new Call control via MGCP protocol
- High-performance analog/digital gateway, allowing VoIP over less expensive Session Initiation Protocol (SIP) trunks.
- Should support at least 300 Session Initiation Protocol (SIP) sessions
- Should support at least 200 Digital voice support
- The VG should support these analog voice interfaces: FXS (Foreign exchange Subscriber), FXO (Foreign exchange Office) and E1 PRI. In

Each Voice gateway should include:-

- 4 E1/T1 Lines.
- Upgrading for DSP for voice processing to handle the external calls at least 256 channels

2.7 IP TERMINALS AND CLIENT DEVICES

A. STATION HARDWARE AND IP SOFTPHONE

1. The Contractor shall provide detailed description of each IP telephone available with the system listing features, capabilities, limitations, and purpose of use.
2. The IP phones, industry standard devices, shall be able to work over LAN equipment other than the original Manufacturer LAN equipment.

3. The system shall support in-line power for IP phones.
4. IP phones shall be able to share existing Ethernet ports with data devices. It shall not be required by the Employer to add additional Ethernet ports to support voice.
5. The phones shall have a built-in switch to support automatic VLAN.
6. The system shall include IP soft-phone operable without additional physical IP phone. The Contractor shall provide detailed description of the IP soft-phone and its features and capabilities.
7. The soft-phone shall be operable on normal PC operating system environment such as Microsoft Windows. The end user shall require no special arrangements.
8. The IP soft-phone shall support all related open industry standards such as Telephony Application Programming Interface (TAPI), T1.20, NetMeeting, H.323, SIP, G.711, G. 723.1, and G.729a codec.
9. The IP soft-phone shall be equipped with user friendly Graphical User Interface (GUI) with easy manipulation features such as setting up conference calls by just dragging and dropping the participants from a list on the display or from a directory or placing a call by just dragging and dropping the party to be called from a directory.
10. The Graphical User Interface (GUI) shall be provided with programming capabilities to allow the users to configure and customize certain features on the IP soft-phone.
11. The IP phone shall support various QoS techniques such that it prioritizes the voice traffic directly.
12. The IP soft-phone shall include an integrated help function.
13. The IP phones shall maintain a call history log (separate from the system CDR).
14. The IP phones shall support shared extensions.
15. The IP phones shall support pushing of URL content.
16. The IP phones shall be able to be configured, as a minimum, to point to a primary and backup server for redundancy. The fail-over in case of main server failure shall be automatic, immediate and unattended.
17. The IP phones shall have a "log-in" feature to allow users to use another person's phone and have his calls directed to that phone.
18. The station equipment shall provide, as a minimum, the following features:

Telephony features:

- a. Hotel directory speed dial
- b. Alphanumeric dialing
- c. Automatic wakeup
- d. Daily wakeup alarm set
- e. Do not disturb
- f. Recall
- g. Audible message waiting.
- h. Voice mail retrieval.
- i. Conference call.
- j. Conference / transfer display prompt
- k. Conference transfer toggle / swap
- l. Hold / un-hold conference

- m. Direct inward dialing
- n. Direct outward dialing

Attendant telephony features:

- a. Call waiting
- b. Priority queue
- c. Override of diversion features
- d. Recall
- e. Dial access to attendant
- f. Individual attendant access
- g. Attendant backup
- h. Multi attendants / zoned attendants
- i. Attendant room status
- j. Attendant control of trunk group access
- k. Direct trunk group selection
- l. Attendant intrusion
- m. Attendant lockout – privacy
- n. Attendant vectoring
- o. Automated attendant
- p. Calling inward restricted stations
- q. Conference
- r. Listed directory numbers
- s. Release loop operation
- t. Selective conference mute
- u. Serial calling
- v. Timed reminder and attendant timers
- w. Centralized attendant service
- x. Display
- y. Auto start do not split
- z. Auto manual splitting
- aa. Attendant control of trunk group access
- bb. Attendant direct extension selection
- cc. Attendant direct trunk group selection
- dd. Crisis alerts to an attendant console
- ee. Trunk group busy / warning indicators
- ff. Trunk identification by attendant

Call centre features (option):

- a. Computer telephony integration
- b. Automatic call distribution
- c. Call management system
- d. Call prompting
- e. Call vectoring
- f. Call work codes
- g. Caller information forwarding
- h. Circular station hunt group
- i. CMS measurement of ATM
- j. Dialed number identification services
- k. Direct agent calling
- l. Duplicate agent login administration
- m. Expert agent selection
- n. Leased occupied agent
- o. Multiple call handling
- p. Multiple music / audio sources
- q. Multiple split queuing
- r. Network call redirection
- s. Priority queuing

- t. Reason codes on closing call
- u. Redirection on no answer
- v. Remote logout agent
- w. Service observing

Call accounting features:

- a. CDR backup
- b. CDR archiving
- c. CDR purging
- d. CDR reload from archive
- e. CDR collection
- f. CDR mediation
- g. CDR rating / billing / charge calculation
- h. CDR re-rating / re-billing
- i. Multiple and flexible charging scheme
- j. Support of complex rate structure based on multiple criteria's
- k. Alarm when no or too few CDR (not collected) (SYMP / SYSLOG)
- l. Exception support / default rate
- m. Special days support
- n. Special discount plans by user / groups triggered by PMS
- o. Carrier based tariff configuration
- p. Destination based charging
- q. Multiple carrier support
- r. Time and day based tariffs
- s. Surcharge rate or percentage by destination
- t. Data / voice services billing (bearer recognition)
- u. Automatic reporting at selected interval by extension, department, guest
- v. Automatic reporting for call answering performance
- w. Service provider(s) rated CDRs upload / settlement report

Voice mail features

- a. Full integration with PMS
- b. Multi language / selected by PMS
- c. Automatic clear on checkout
- d. Automatic transfer if room-allocation
- e. Backup
- f. User recorded greeting
- g. Local or remote access to voice mail (PIN code facility)
- h. New message notification to PMS and to telephone message waiting light

2.8 APPLICATIONS

A. VOICE MAIL AND UNIFIED MESSAGING SYSTEM : (Option)

1. DESCRIPTION AND SUPPORT OPTIONS: The Contractor shall give a detailed description of his voice mail/unified messaging product offering. Include an overview of the hardware, software, architecture, and components of the equipment to meet client requirements.
2. SPECIFICATIONS
 - a. The voice messages shall be stored in an industry standard format.
 - b. Voicemail up to 24 concurrent connections
 - c. Multi-level Auto-attendant
 - d. Night service with alternate greetings
 - e. (dial zero to reach administrator)
 - f. Voicemail to email (notification)
 - g. Voicemail to email (attachment)

- h. Web Dialer
- i. Call Queuing
- c. The voice mail / unified messaging system shall be PC-based.
- c. The voice mail / unified messaging system shall support AMIS and/or VPDVI for networking.
- d. Once a voice mail is left, the user shall be able to forward it to another user. The user shall also be able to append comments before forwarding the message to another user.
- e. The voice mail / unified messaging system shall be remotely accessible for both subscribers and administrators, e.g. from a standard touch-tone phone or any other types of clients and points of access.
- f. The system shall support analog and/or digital interface ports. If analog, the Contractor shall include the specific interface card required for the IP communication system. If ports are digital, the Contractor shall provide all specifications that the telephone system must meet for proper operation.

3. SYSTEM FEATURES

- a. The system shall have a voice digitization technique. The voice digitization rate used for recording users' speech shall be as a minimum 64kb/s for G.711 and 8kb/s for G.729a.
- b. The system shall provide a notification message that these limits have almost been reached.
- c. The system shall provide an "end of recording" warning and user adjustable playback speed control (with full pitch preservation).
- d. The unified messaging system shall provide text to speech capabilities to support email-by-phone features.
- e. The unified messaging system shall provide Automatic Speech Recognition (ASR) and speech recognition features.
- f. If a caller does not know a particular subscriber's extension number, the system shall provide him the ability to "look up" the subscriber by "spelling" the name via touch-tone input.
- g. The voice mail system shall support multiple greeting.
- h. The voice mail system shall support a "zero out" to the attendant feature. This feature shall be configurable by class of service. The "zero out" destination could be a station rather than the attendant. The call shall be re-directed if the "zero out" destination is busy, or rings unanswered.
- i. Users should be required to enter a password to access their voice mailbox.
- j. The system shall track failed password entries in a single session. The system shall also automatically disconnect the caller after a configurable number of failed attempts.
- k. The system shall track failed password entries across multiple sessions. The system shall also automatically lock out the user after a configurable number of failed attempts.
- l. The system shall log information about failed password attempts.
- m. The system shall require a system administrator password.

4. USER FEATURES

The system subscribers shall be able to conduct as a minimum the following actions:

- a. Pause and replay messages.
- b. Record messages; send and mark "urgent", "private", etc.
- c. Transfer messages to other users and append them with their own comments.
- d. Create their own distribution lists.
- e. Edit/Modify their own distribution lists.
- f. Dial internally by name / company directory.
- g. Obtain user instruction through system prompts.
- h. Record personal greetings.
- i. Modify own passwords.

- j. Set business days and hours for alternate greetings.

5. SYSTEM ADMINISTRATION

The system administration shall be done through a standard web-enabled GUI which can perform the following actions:

- a. Add or modify a class of service. State what user permissions or characteristics within a class of service can be created or modified.
- b. Set the minimum and maximum password length for a user.
- c. Set the maximum length of voice messages.
- d. Set the maximum failed login attempts before a user lockout from the mailbox.
- e. Assign default passwords for users, and reset passwords for users that have been locked out of their mailboxes.
- f. Set the "disk space remaining" warning level.
- g. Add, delete, or modify a user.
- h. Provide reports concerning storage and call information.

2. SYSTEM SOFTWARE

- a. The system shall have the most recent software release at the time of delivery. The Contractor shall provide a timetable of all scheduled software releases and upgrades.
- b. All system changes and software upgrades shall be able to be performed on line with minimal interruption and/or disturbance of the running system.
- c. The system shall have a back-up procedure for the operating software, which includes up-to-date moves and changes.
- d. The system shall support Computer Telephony (CTI), Telephony Application Programming Interface (TAPI) and Java Telephony Application Programming Interface (JTAPI) applications.
- e. The Contractor shall list all partner programs for third-party applications development.

3. AGENT STATION HARDWARE AND SOFTWARE

- a. The IP agent phones work shall operate using a standard Ethernet port.
- b. The IP phone shall use a single directory that is common for the data network and allow display of name, extension browsing and dialing by press of a button.
- c. No "hard phone" shall be required for the agent desktop to be VoIP enabled.
- d. The agent IP phones shall support as a minimum the following features:
 - 1. Audio volume adjustment.
 - 2. Auto echo cancellation.
 - 3. Call forward busy.
 - 4. Call forward no answer.
 - 5. Call forward all calls.
 - 6. Call hold / release.
 - 7. Call park / pickup.
 - 8. Call transfer.
 - 9. Call waiting.
 - 10. Calling line ID (line and name).
 - 11. Chat.
 - 12. Conference (uni-cast).
 - 13. Last number re-dial.
 - 14. Ringer pitch adjustment.
 - 14. Ringer volume adjustment.
 - 15. Speakerphone mute.
 - 16. Speed dial (auto-dial).
- e. The callers shall have the ability to be presented with the option of leaving a

message. This message shall be able to be routed accordingly.

- f. The agent shall have a tool available for pre-defined responses.
- g. The solution shall be able to support remote agents or satellite offices.

C. CONFERENCING : (Option)

- 1. The system shall support conferencing features. A minimum of <#> parties in conference and a minimum of <#> simultaneous conferences shall be supported.
- 2. The system shall support password protection and entry and exit tones with conference connections.
- 3. The system shall have a scheduling package for managing defined capacities with conference connections. The system shall be able to schedule a minimum of <#> simultaneous conference calls with a minimum of <#> participants per conference.
- 4. The system shall provide VPN connection facilities to enable project employees from non-company telecommuting locations (a) to gain authorized access to the IP-based Telephony Communications System to make calls to (b) local or (c) long distance calls.

D. WEB COLLABORATION FUNCTIONALITY : (Option)

- 1. Project is considering adding web collaboration functionality at some future time. Please describe your current web collaboration capabilities.

2.9 CALL ROUTING AND REPORTING SOFTWARE FUNCTIONALITY

- A. The system shall manage call routing from a single application.
- B. The system shall provide as a minimum the following routing strategies:
 - 1. Application based routing and reporting.
 - 2. Automatic call distribution.
 - 3. Call-by-call routing.
 - 4. Call re-routing based on wait time.
 - 5. Call re-routing based on non-answer.
 - 6. Conditional routing based on time of day, day of week and holidays.
 - 7. Conditional routing based on calls in queue.
 - 8. Conditional routing based on caller origin.
 - 9. Conditional routing based on dialed number.
 - 10. Conditional routing based on caller-entered digits (CED).
 - 10. Directed agent routing (single agent selection).
 - 11. Database call handling.
 - 12. Look ahead queuing.
 - 13. Look back queuing.

14. Overflow (retains queue position).
 15. Priorities.
 16. Skill-based routing.
 17. Build your own strategy routing.
- C. The system shall provide agent proficiency setup.
 - D. All contacts shall be "queued" in the same fashion regardless of media type.
 - E. The system shall provide routing priorities.
 - F. The software shall provide reports for all agents across all locations.
 - G. The software shall collect information through the entire life of the complete Employer interaction and provide not only real time, but also historical reporting.
 - H. The application shall support a web-view monitoring tool for read-only access to real time contact center performance reports and call routing scripts.
 - I. The system shall offer the ability for an agent to record a conversation with a customer (for instance if a customer was being abusive).

2.10 DIAL PLAN AND ADVANCED ROUTING FEATURES

- A. The Contractor shall be responsible of the system Dial Plan design and configuration and the advanced routing features including, but not limited to, the following:
 1. Amount and type of routing plans.
 2. Type of trunks supported in routing scheme.
 3. Queuing and overflow capabilities.
 4. Use of authorization codes on individual routes.
 5. Handling digit deletion and insertion regarding the North American Dialing Plan.
 6. Route filtering method.
- B. The Contractor shall submit the system Dial Plan structure for approval.
- C. The system shall be compliant with the North American Numbering Plan (NANP).

2.11 EMERGENCY SERVICES

- A. The system shall support emergency services, . The system shall also be able to redirect callers who dial "emergency calls " to a predetermined location, i.e. security desk, operator's console, etc. The Contractor shall coordinate with project different disciplines during the design stage to make sure that the designed system will integrate this service.
- B. The system shall be capable to provide location information of the IP phone and makes an emergency call.
- C. The system shall provide Voice Recording functions associated with emergency and hot line

services.

2.12 COMPUTER TELEPHONY INTEGRATION (CTI)

- A. The system shall be able to provide screen-pop integration capability.
- B. The system shall be able to access database information for call routing decisions or screen pop data.
- C. The system shall be able to deliver third party call control from a CTI-enabled desktop.

2.13 E-MAIL RESPONSE MANAGEMENT

- A. Please describe your current e-mail management capabilities. Include specific details on how your system interfaces with email and with which systems it can interface.

2.14 FAX MANAGEMENT

- A. Please describe your current fax management capabilities. Include specific details on how your system interfaces with fax contacts and with which systems it can interface.

2.15 SYSTEM ADMINISTRATION REQUIREMENTS

- A. A system administration tool(s) shall be available to meet the following requirements:
 - 1. The system administration application shall be accessible from any workstation on the LAN/WAN.
 - 2. The system administration application shall be accessed through a standard web browser.
 - 3. The system administration tool shall be capable to make block copy changes to a number of subscribers or class of service simultaneously.
 - 4. The administration of multiple remote sites shall be able to be done through a centralized workstation.
 - 5. The administration tool(s) shall have security features to prevent unauthorized access to the administration application. A minimum of four security levels shall be defined. Permission levels shall be customizable and cannot be set to a certain limit.
 - 6. The administrative application system shall have an alternate form of access if the primary access is unavailable.
 - 7. The administrative application shall have on-line help.
 - 8. A database shall be used to administer the IP call-processing unit and populate telephone tables. This database shall be capable to be integrated with project e-mail, NT, and HR databases.

2.16 SYSTEM MONITORING AND DIAGNOSTICS

- A. The system shall have diagnostic tools that support the Windows 2000 Event Log. These diagnostic tools shall be able to produce diagnostic reports to aid in isolating faults. The diagnostic tools shall be remotely accessed and SNMP compliant.
- B. Remote diagnostics should be supported. The administrators shall be able to see and access

any alarms or alerts on the system from remote terminals.

- C. The system shall be capable to produce monitoring report(s) including but not limited to the following:
 - 1. Performance monitoring.
 - 2. Quality monitoring.
 - 3. Events monitoring.
- D. The system shall support the system monitoring items listed below:
 - 1. Trunking status.
 - 2. Real time traffic.
 - 3. Status of all routing components.
 - 4. Status of all remote components.
 - 5. Status of individual stations.
 - 6. Status of gateway ports.
 - 7. Provide call trace capability.
 - 8. Monitor for Toll Fraud.
 - 9. Telephone system analysis.
- E. The system shall provide system alarms and alarm notifications from the IP call-processing unit.

2.17 SYSTEM REPORTING AND CALL DETAIL REPORTING

- A. The IP-based Telephony Communications System shall have a fully features CDR reporting applications.
- B. The system shall have the capability to report by location and on a consolidated enterprise level. The following minimum standard reporting capabilities shall be available:
 - 1. Directory Number Allocation.
 - 2. Trace Log Files.
 - 3. Real Time Monitoring.
- C. The system shall have the capability to generate customized reports.

2.18 NETWORK MANAGEMENT SYSTEM

- A. The Network Management System shall be a PC based system configured and installed to monitor and manage the IP-based Telephony Communications System.
- B. IP-based Telephony Communications System components shall use SNMP, SNMPII or RMON to communicate to the network management station.

- C. The Network Management System shall provide the following monitoring capabilities:
1. Configuration Management - The installation, initialization, modification and tracking of the system configuration parameters (hardware and software) to enable the continuous operation of services.
 2. Performance Management: The generation of reports and displays to collect performance data based on performance parameter values. This module shall generate visual and audio alarms to alert operators when the performance falls below defined thresholds.
 3. Security Management - The protection of the system components and addressing those aspects of security essential to the operation of the network.
 4. Accounting Management - The establishment and implementation of a mechanism allowing charges to be made for the use of IP telephony system components.
 5. Fault Management - The detection, isolation and correction of abnormal network conditions.
- D. Network Management System Software
1. Levels
 - a. Software shall provide different access right levels and passwords:
 1. Level 0: no password is required: access to supervision,
 2. Level 1: a password allows to modify a set of parameters,
 3. Level 2: a password allows to enter criteria and parameters.
 - b. To reach a level, the operator uses a password to be allowed to enter the system.
 2. Features
 - a. Software shall provide reporting:
 1. Alarm/event history consisting of alarm/event lists,
 2. Operator history consisting of database changes and log-ins by operator.
 - b. A query function shall allow selected data to be sorted on not less than 3 selection criteria.
 - c. Software shall allow a backup function.
 - d. All servers and workstations shall be fitted with the latest virus protecting software.
2. For more detailed specifications, refer to Section 16746 "Network Management System" of this Specification.

PART 3 - EXECUTION

3.1 DESIGN

- A. The design of the IP-based Telephony Communications System shall consist of the following tasks:
1. Needs Analysis - The Contractor shall work with the Employer's Representatives, departments, tenants and any other company or organization and determine their exact

requirements for IP-based Telephony Communications Services.

2. Engineering and Design - With the information gathered the Contractor should determine hardware and software requirements for project's IP-based Telephony Communications System. This shall include the quantities and configuration of the system components and the configuration of the Network Management System. The configuration shall include IP telephony addressing plan, etc.
3. The Contractor shall determine the exact requirements for external communications and interfacing if it is determined that such services will be required for the support of the new systems.
4. The Contractor shall coordinate with the other disciplines to ensure that environmental requirements for the IP-based Telephony Communications System are met, and to ensure that cabling is installed at the locations specified during the needs analysis.

3.2 PROJECT MANAGEMENT

- A. The Contractor is required to supply a complete description (Project Plan) of the key activities required for the installation of the system.
- B. In the project plan, the Contractor shall include a project organization chart with the reporting relationships of project team members and other key personnel. An escalation matrix should also be included.
- C. It is essential that the installation of the new system be as transparent as possible to the users. There should be no telephone service interruptions, no interim changes in dialing procedures, and no perceived degradation in the quality of service.
- D. A master project schedule must be included, along with a work responsibility matrix,

3.3 FACILITY REQUIREMENTS

- A. The Contractor shall furnish all space, power, and environmental requirements for the system.
 1. Space - Provide the physical dimensions of the equipment.
 2. Power - All power requirements, including any special conditioning or grounding requirements.
 3. Heat - The Contractor must provide heat dissipation calculations for the communication room(s) and the recommended safe temperature operating range for the system.
 4. Floor Loading - The Contractor must provide complete floor loading requirements.

3.4 INSTALLATION

- A. The Contractor is solely responsible for the complete turn-key engineering of the new IP-based Telephony Communications System and all interconnecting facilities.
- B. Acceptance of works will be restricted to the equipment and installations complying with the approved submittals, approved shop drawings, and the Employer's Representative's agreement.
- C. The Contractor shall perform station reviews, data base preparation, and original program initializations.
- D. The Contractor shall install, configure and test the components of the IP-based Telephony

Communications System including the Network Management System.

- E. The Contractor has to carry out any site works under direct supervision of qualified technicians who are to be well trained with qualified Manufacturer experience.
- F. The Contractor shall complete the required data circuits from the system to the end user station.
- G. The Contractor shall coordinate the ordering of all long-distance and local communications facilities and services as deemed necessary by project Ensure that WAN circuits are in place as required. After services have been provided, the Contractor shall test the services to ensure functionality.
- H. Cabling made by the Contractor shall account for redundancy, disaster recovery, and protection against single points of failure.
- I. The system shall comply as a minimum with standard Ethernet distance limitations.
- J. Site workmanship of any network component has to be limited to the layout and fixation, and inter-wiring of various items of the ready made equipment.
- K. In addition to the above, the Contractor is also expected to supply the following:
 - 1. Coordination meetings with the Project authorities, project departments, existing contractors, etc.
 - 2. Progress reports and Progress reviews,
 - 3. Insurance for the Transport of the equipment,
 - 4. Quality Assurance setup and management,
 - 5. Document Management,
 - 6. Configuration Management for the duration of the Project,
 - 7. Off-the-shelf Software updates for the duration of the warranty,
 - 8. User documentation and training including textbooks,
 - 9. Worksite expenses (Setup and removal of temporary offices, Worksite vehicles, Site Offices, Computers, Printers, Desks, etc.),
 - 10. Archival.

3.5 FIELD QUALITY CONTROL

- A. The Contractor shall submit to the Employer the manufacturing and shipment schedules for all equipment and/or materials at least one month prior to the time of packing for shipment as long as the lead time available is sufficient or such shorter period as may fit the actual circumstances. Should the Employer's representatives fail to attend on the specified date for inspection; the Contractor shall proceed with shipment and carry out the relevant tests itself. The Contractor shall provide the Employer a copy of the recorded factory results made under its cognizance before shipment. If the test results show that the equipment and/or materials do not comply with the Specifications, such non-complying equipment and/or materials shall be rejected and shall not be shipped until repaired or replaced and tested again. In such case, the Contractor shall be held liable for any resulting delay. In all cases, the Contractor shall be responsible for the compliance of his equipment and materials with the Contract's

specifications.

- B. Testing: On installation of system components, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
- C. Correct malfunctioning units at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.6 COMPLETION SERVICES

- A. The Contractor shall initiate system operation. The Contractor shall provide competent start up personnel on each consecutive working day until the system is fully functional and ready to start the acceptance test phase.
- B. Preparation for acceptance (prior to final inspection):
 - 1. Temporary and old systems, facilities and utilities shall be properly disconnected, removed and disposed of off-site.
 - 2. All systems, equipment and devices shall be in full and proper adjustment and operation, and properly labeled and identified.
 - 3. All materials shall be neat, clean and unmarred and parts securely attached.
 - 4. Test reports of each system component shall be complete and available for inspection and delivery as directed by the Employer's Representative.
- C. System acceptance requirements: Before final acceptance of work, the Contractor shall deliver six (6) composite "Systems Operation and Maintenance" manuals in three-ring binders, sized to hold the material below, plus 50% excess. Each manual shall contain, but not be limited to:
 - 1. A Statement of Guarantee including date of termination and the name and phone number of the person to be called in the event of equipment failure.
 - 2. A set of operational procedures for the overall system that includes all required activities and that allows for Employer's operation of all system capabilities. This procedure shall fully address all Employer's established system operating objectives.
 - 3. Individual factory-issued manuals, containing all technical information on each piece of equipment installed. In the event such manuals cannot be obtained from a manufacturer, it shall be the responsibility of the Contractor to compile and include them. Advertising brochures shall not be used in lieu of the required technical manuals and information. All manuals shall be printed to ensure their permanence. No "blue-line" type of reproduction is acceptable.

3.7 FACTORY TESTS

- A. Factory Acceptance Tests
 - 1. The Factory Acceptance Tests shall be carried out in a hardware and software environment, which simulates the final configuration of the system.
 - 2. The Contractor shall carry out any Factory Acceptances Tests, in Manufacturer's factory itself, before any site delivery, in order to show to the Employer's Representative that the system of both hardware and software and the system after integration of various sub-systems is able to satisfy site technical requirements of the equipment specifications.

3. Some of the functional or performance tests, which cannot be conducted in a simulated environment, due to their nature and complications, may subject to the Employer's Representative's approval be combined with the On Site Tests.
4. All travels and trips costs shall be provided by the Contractor for five (5) representatives to be nominated by the Employer.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.
2. The tests are to cover every aspect related to the specification of the system and its operation; including, but not limited to, visual inspections, measurements, and operation.
3. All Factory Acceptance Tests need to be carried out in the presence of the Employer's Representative unless otherwise agreed by the Employer's Representative. The Employer's Representative will sign off the testing document on satisfactory completion of the tests.
4. All Factory Acceptance Test Specifications, at every level, shall be subject to configuration management and change control by the Contractor.
5. The results of the Factory Acceptance Tests, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representative.

C. Equipment Tests

1. Equipment is to be tested for quality and operation at the factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Employer's Representative before dispatch of equipment to site.

3.8 ON SITE TESTS AND INSPECTION

A. On Site Assembly Verification

1. The purpose of this phase is to check the assembly and the connection of the equipment without any power supply.
2. Any verification can give raise to a punch list item either because of an anomaly or a none-conformity with the tender documents.
3. The punch lists are collated for each module and the phase report is only released when all the stipulations on the punch lists are cleared.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.
2. The tests are to cover every aspect related to the specification of the system and its operation including, but not limited to, visual inspections, measurements, and operation.

C. On Site Cable Tests

1. Cables are to be tested to ensure that no damage have occurred to them during transportation to site and/or during the course of pulling in and laying.

D. Inspection

1. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

E. Pre-Testing

1. Align and adjust system and perform pre-testing of all components, wiring, and functions to verify compliance with specified requirements.
2. Correct all deficiencies by replacing malfunctioning or damaged items with new items.

F. Manufacturer's Field Services

1. Engage a factory authorized service representative to inspect field assembled components and equipment installations and perform system pre-testing, testing, adjustment and programming.
2. Report results in writing.

G. Procedure

1. Notify the Employer's Representative not less than 30 days in advance, of proposed schedule, procedures and tests to be used in operational testing.
2. Conduct operational tests only with the Employer's Representative present.

H. Report

1. Prepare a written report of observations, inspections, tests, and results, including:
 - a. A complete listing of every device and circuit,
 - b. Date of each test and retest, and by whom,
 - c. Results of each test and, if failure occurred, corrective action taken prior to retest.

I. Certification

1. The Contract shall certify that all devices, circuits, and total system are finally tested successfully.

J. Operational Tests

1. Schedule tests after pre-testing has been successfully completed.
2. Perform operational system tests to verify compliance with Specifications.
3. Test all modes of system operation including:
 - a. Functional operation of each field mounted device,
 - b. Functional operation of each control circuit,
 - c. Supervision function of each initiating, indicating, monitoring, and control circuit,
 - d. Perform tests that include originating program and counting material at final outlets, controller inputs, and other inputs,
 - e. Signal Ground Test: Measure and report ground resistance at each global equipment pin.
 - f. Re-testing: Correct deficiencies, and re-test. Prepare written record tests.
 - g. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

4. Schedule tests with at least seven days advance notice of test performance.
- K. Integrated Tests with Other Contractors
 1. The Contractor shall make equipment available for testing and demonstrating various features specified.
 2. The test procedures shall reflect the sequence of tests to be performed.
 3. Retesting: Correct deficiencies and retest until total system meets requirements of the Specifications and complies with applicable standards. Prepare written records of tests.
 4. Schedule testing with at least seven days advance notice.

3.9 TRAINING

- A. The Contractor is required to conduct end-user training on project premises, tailored specifically to < project's particular requirements (e.g., console operator, message center operator, secretary, and professional) in the use, configuration and maintenance of the IP telephony equipment.
- B. Training shall be provided for Technical Staff of the Employer in the Testing, Maintenance and Fault Location of the IP-based Telephony Communications System.
- C. For each product and/or application, the Contractor shall provide a detailed description of the training the Manufacturer will provide.
- D. Trainers
 1. All training shall be certified training by Manufacturer and trainers shall be approved by client before starting.
 2. Engage a factory authorized service representative to explain programming and operation of system and to train Employer's personnel on procedures and schedules for maintaining, programming, operating, adjusting, troubleshooting, and servicing the system.
- E. Trainees
 1. Training for engineers on IP Telephony operation and maintenance shall be for a minimum of six (6) engineers.
 2. Training for engineers on IP Telephony administration shall be for a minimum of four (4) engineers.
- F. Training Program
 1. Scope
 - a. Training shall be in sufficient scope to ensure that all trainees who complete the program will be certified as capable to operate and/or maintain the equipment, systems, and facilities provided and installed under this Contract, and to ensure a smooth transition between construction and operations activities.
 2. Language
 - a. Training shall be conducted in English and Arabic.

3. Training Aids

a. Training aids shall include:

1. Approved Operation and Maintenance (O & M) manual(s) prepared by the Contractor as part of this Contract,
2. Training manuals, including course outline, basic text of instructions modules, and trainee workbook,
3. Films, slides, video tape(s),
4. Charts, models, hand-outs, catalogues,
5. Samples and other visual,
6. Written aids to complement instruction.

b. In addition, spare parts and other special hardware shall be provided to support "hands-on" familiarization with the equipment or systems.

4. Training Manuals

- a. Training manuals shall be provided for each training course covering both the classroom and on-the-job phases.
- b. The organization of the manuals shall follow the same sequence as the course's scheduled presentation of material, providing such additional background and supplementary information, as a trainee may need to understand the O & M manuals.
- c. There shall be as many Training Manual types as Trainees categories.

5. Training Execution

a. Scope

1. Training shall be performed in accordance with an approved training program. All training aids shall be available and approved prior to start of training.

b. Contents

1. Training course can be broken down into modules either classroom lecture or 'On-the-job' training.
2. In case of lecture, it is the Employer responsibility to provide the classroom for the duration of the course.
3. No lecture module should exceed 2 hours time.
4. "On-the-job" training can be scheduled for entire 8 hour shift.
5. Handouts must support each module; the collation of the Handouts forms the Training Manual.
6. Laboratory equipment, spare parts, and mock-up models may be used for theoretical orientation.
7. However, practical "hands-on" familiarization shall be provided on equipment that is either installed and operable or ready to be installed and capable of being operated. System spares of special hardware items may be used to support "hands-on" familiarization as long as said spares are returned to inventory in satisfactory condition in accordance with approved procedures

c. Proficiency

1. At designated intervals each trainee's proficiency levels shall be determined by written, oral and practical performance tests.

d. Operations Training

1. Operators shall be provided with a thorough training in all aspects of system/sub-system operation under both normal and abnormal conditions. This training shall include, but not be limited to:
 - a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
 - b) Terminology,
 - c) Operations theory and interface,
 - d) Equipment appearance, functions, concepts and operations,
 - e) Operating mode, practices, and procedures under normal and emergency conditions,
 - f) Safety precautions,
 - g) On-the-job operating experience covering all system/sub-system operating functions, activities, and tasks including those associated with degraded operating modes, failure recognition, and recovery processes,
 - h) Familiarity with content and use of O & M manuals and related reference publications.
- e. Maintenance Training
 1. Maintenance training shall cover all on-site routine, preventive, and remedial maintenance of the system/sub-system.
 2. This training shall include, but not be limited to:
 - a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
 - b) Terminology,
 - c) Operations theory and interfaces,
 - d) Equipment appearance, layout, functions, concepts and operations,
 - e) Operating modes, practice, and procedures under normal and emergency conditions,
 - f) Safety precautions,
 - g) Use of tools and test equipment,
 - h) Use of system utilities, diagnostic software and various software tools associated with the system maintenance,
 - i) Preventive maintenance,
 - j) Troubleshooting, diagnostics, and testing,
 - k) Backup and restoration of software/configuration,
 - l) Assembly and disassembly,
 - m) Repair and parts replacement,
 - n) Parts ordering practices and storage,
 - o) Failure and recovery procedures,
 - p) System/sub-system cabling,
 - q) Familiarization with and use of O & M manuals and other reference materials.
- f. Administrator Training
 1. Administrator course shall be provided so the system administration staff will be able to:
 - a) Configure the IP-based Telephony Communications System equipment and the access of all the users,
 - b) Identify and remedy software faults,
 - c) Upgrade and implement data and software changes,
 - d) Production of revised or new displays.
 2. This training shall include, but not be limited to:

- a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
- b) Terminology,
- c) Operations theory and interfaces,
- d) Software design and organization,
- e) Database structure, generation, and modification,
- f) Assembly, compilation, linking, editing, debugging, distributing, testing and integration of program modules,
- g) Interface software design,
- h) Configuration management and control of software,
 - i) Backup and restoration of software,
- j) Use of system utilities, diagnostic software and various software tools associated with the design, development, and maintenance of the System,
- k) Familiarization with and use of O & M manuals and other reference materials.

3.10 MAINTENANCE AND WARRANTY

- A. The IP telephony system and all associated equipment in the Contractor's solution shall be warranted by the Contractor and by the Manufacturer to be free of defects in equipment, software, and workmanship for a period of at least two years from the date of Substantial Completion.
- B. During the warranty period and any subsequent maintenance agreement, any defective components shall be repaired or replaced at no cost to project
- C. All system maintenance during the warranty period and under any subsequent maintenance agreements shall be performed by the Contractor organization using personnel employed full time by the Contractor and at no additional cost to project other than those charges stipulated to maintain the warranty.

3.11 LOGISTICAL SUPPORT

- A. The Contractor shall identify the address of the Manufacturer's local service centers and the number of service personnel trained on the system.

3.12 REPAIR RESPONSE

- A. The Contractor shall provide routine system monitoring to assure the continued operation of all system components.
- B. During the warranty period, the Contractor must supply no more than a 1-hour response to major problems, 24 hours a day, 7 days a week.

3.13 GUIDELINES FOR DOCUMENTATION TRANSMITTAL

- A. Content of the Transmittals
 - 1. Contractor to prepare detail drawings, design calculations, technical data sheets and samples and submit the same for review by the Employer's Representative. The Contractor shall submit the following key elements to the Employer's Representative for review:
 - a. Detailed layout showing the marking and/or the equipment as required,
 - b. Manufacturers' Catalogues,

- c. Provide all relevant Testing Certificates,
 - d. Inventory label for each item supplied under this Contract. Labels shall be submitted for review by the Employer's Representative and shall be attached to each individual item for easy reference.
 2. The following documents are to be submitted to the owner prior to handing over:
 - a. As-built drawings for the relevant areas,
 - b. Complete inventory list,
 - c. Three sets of the Maintenance Manuals are to be provided. Such manuals shall include a full technical description with block and schematic diagrams to allow the Employer staff to maintain the system equipment and components,
 - d. Three sets of the Operation Manuals are to be provided.
- B. Drawings
 1. The Contractor will have to establish plans to scale and diagrams as per the following presentation:
 - a. IP-based Telephony Communications System schematic diagrams, detailed design, connection diagrams, etc.
 - b. Floor layout of each building and raceways will have to be on scale 1/100.
 - c. Equipment room layout will have to be on scale 1/50.
 - d. Racks and cabinet configuration, front and back view, as well as the plans of detail and service shafts, will have to be on scale 1/10.
 2. All Design Development drawings, Construction Drawings, and As-Built Drawings shall be submitted in hard copy format as well as in electronic format in the quantities specified below.
 3. Quantity of Submittals:
 - a. Electronic Files: 1 set.
 - b. Reproducible hardcopies: 1 set.
 - c. Prints: 3 sets.

End of Section 27 30 00

SECTION 27 41 00: IP TELEVISION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Related sections include the following:

1. Division 26 Section "Basic Electrical Materials and Methods".
2. Division 26 Section "Raceways and Boxes".
3. Division 26 Section "Cable trays for electrical systems".
4. Division 26 Section "Grounding and Bonding".

1.2 SUMMARY

- A. Work comprises complete IPTV system includes, but not limited to, the following:-
1. Digital Head end equipment composed of a rack mounted basic units including satellite receiver/modulators, terrestrial TV modulators.
 2. Antennas including, antennae, FM antenna, satellite dishes, their amplifier and combiner.
 4. Ancillary equipment and accessories.

1.3 SUBMITTALS

- A. Product Data: include detailed manufacturer's specifications for each component specified. Include data on features, ratings and performance.
- B. Shop Drawings: include plans, elevations, sections, details and attachments to other Work.
1. Design Calculations: Calculate requirements and perform structural analysis for installed products including selection of seismic restraints, signed and sealed by the qualified professional engineer responsible for their preparation design calculation shall indicate the level of signal of each channel at any TV outlet RJ45.
 2. Include dimensioned plan and elevation views of components and enclosures, and details of control panels. Show access and workspace requirements.
 3. Wiring Diagrams: Power, signal, and control wiring
 4. Installation details for the satellite Dishes and antennae
- C. Samples: full size, for each outlet and finish plate, for colors and textures.
- D. Product Certificates: signed by manufacturers of television equipment and components certifying that products furnished comply with requirements.
- E. Installer Certificates: signed by manufacturer certifying that installers comply with requirements.
- F. Field Test Reports: indicate and interpret test results for compliance with performance requirements of installed systems.
- G. Maintenance Data: for television equipment and components to include in maintenance manuals specified in the general and special conditions of contract. In addition to requirements specified in the general and special conditions of contract Section "Contract Closeout," include the following:

1. Detailed operating instructions covering operation under both normal and abnormal conditions.
2. Routine maintenance requirements for system components.
3. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: an experienced installer who is an authorized representative of the television equipment manufacturer, for both installation and maintenance of units required for this Project, to supervise installation of the system.
- B. Systems installations are to comply with the respective local regulations for radio and TV transmission and reception. Systems materials, outlets and equipment are to be the standard products of manufacturers and compatible with CCIR standards for RF devices, and IEC standards for electronic circuitry and components, and/or Local Standards.

1.5 PROJECT CONDITIONS

- A. Environmental Limitations system components are equipped and to be rated for the environments where installed.
 1. Service Conditions for Outdoor Equipment: rate equipment for continuous operation under the following environmental conditions, unless otherwise indicated:
 - a. Temperature: -1.5 deg C to plus 36 deg
 - b. Relative Humidity: 50percent.
 - c. Weather: wet and corrosive.
 2. Service Conditions for Indoor Equipment: rate equipment for continuous operation under the following environmental conditions, unless otherwise indicated:
 - a. Temperature: 1.5 deg C to 36 deg C.
 - b. Relative Humidity: 50 percent.

1.6 COORDINATION

- A. Coordinate layout and installation of IPTV equipment and suspension system components with other construction that penetrates ceilings or is supported by them.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 related Sections.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 related Sections.
- B. Work shall include supplying 2 years spare parts for the system as per manufacture recommendations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Manufacturers offering products that may provide the products in compliance with the requirements of the specifications and to be incorporated with the Work are listed below and not limited to :

1. Hirschmann (Germany)
2. Philips (Netherlands)
3. Wisi (Germany)
4. TELEVES (Europe)
5. FTE (Germany)
6. BKTEL (Germany)

2.2 SYSTEM DESCRIPTION

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation IPTV and Satellite Reception systems in the building in accordance with Drawings and Specifications.
- B. The IPTV system shall be modular to allow future expansion without major changes.
- C. The IPTV system shall support the following function requirements
1. Overall system latency shall be less than 200ms
 2. Overall system jitter shall be less than 50ms
 3. System acceptable zap time shall be less than 500ms.
 4. Individual alphanumeric number codes shall be assigned to each IPTV set top box.
 5. Language selection shall be flagged at default, and shall be user selectable. A choice of English and Arabic shall be available.
 6. All transactions shall be logged in a secured database
 7. All defaults are reset and user related data are erased upon user subscription deletion.
 8. All alarm conditions are reported to the server.
 9. Interactive Middleware shall be capable of operating continuously in standalone mode whereby all transactions will be logged.
- D. The Contractor shall design, provide, install, test, and commission all IPTV Systems described herein.

2.3 The IPTV system is comprised of the following elements:

- A. Satellite dish
- a. Mounted in an open area with clear line of sight to the specific television service provider's satellite, the satellite antenna receives the original signal from the satellite to be processed within the system. At least three fixed parabolic dishes to receive the required channel.
 - b. The dishes shall be of the symmetrical parabolic type and 1.8 m diameter.
The components specification shall be as follow:
Frequency range: 10.95 - 12.75 GHz
Material: Aluminum.
- B. Integrated Receiver Decoder(s)

- a. Demodulates the satellite signal, descrambles multiple channels (via a Common Interface CA module), and provides an MPTS output over IP.
- b. Transport stream input with ASI connection C. Transport stream output with ASI connection D. DVB Common Interface CA support
- c. Director single service decryption
- d. Front panel and web browser control, with alarm relay

C. Video Multimedia Server

- a. The video server takes stored MPEG-4 content and makes it available demand over the converged network.

D. HD and SD Processor/Streamer(s)

- a. Transcodes signals from MPEG-2 to MPEG-4 streams via IP.
- b. System shall be compatible with and utilize the Multicast feature of the TCP/IP protocol. Thus, every TV program will be available on the network at all times, no matter how many users are viewing it.
Self managed, hot-standby redundancy configuration. B. 2 built-in Gigabit Ethernet interfaces for traffic I/O
- c. 2 built-in Fast Ethernet interfaces and Serial port for management
- d. Up to 8 sub-modules for video processing and additional input and output interfacing
- e. Up to 4 MPEG-4 AVC Ultra Compression encoders
- f. Up to 4 MPEG-4 AVC Ultra Compression transcoders

E. Middleware server

- a. The middleware content server manages content and provides the software graphical user interface between IPTV content and endpoint set top boxes to enable the end user to select from a number of features offered by the IPTV system. Examples of some of the common features offered are as follows:
 - 1. Welcome message
 - 2. Channel guide and selection for live television
 - 3. Pay TV
 - 4. View Bill
 - 5. Customer service menus
- b. System shall be based on standard Network Computer Architecture, TCP/IP, and Multicast ready Ethernet network.

F. Decoder

- a. MPEG-2, SD, 4:2:0 decoding B. MPEG-2, SD, 4:2:2 decoding C. MPEG-2, HD, 4:2:0 decoding
- b. 3 x HD-SDI, SD-SDI, or ASI Outputs E. 1 x RGB or YPrPb analog video output F. 1 x ASI input
- c. 2 x balanced analog audio outputs
- d. 2 x balanced digital audio outputs
- e. 4 x unbalanced digital audio outputs.

G. VHF/UHF Antenna

- a. For reception of local off-air channels.

H. System controller

- a. Provides control and monitoring of the entire IPTV location.
- b. System shall provide remote monitoring of system performance, fault analysis, software downloading, etc. Any faults or alarm signals shall be communicated instantly.
- c. System shall have full control to every IPTV set top box connected to the system. All required updates, access right requests, addition or removal of services, or restarting any set top box shall be possible to do remotely.

K. IPTV set top boxes

- a. The IPTV set top box resides at the IPTV endpoints where television or information viewing is desired. It provides the interface between the MPEG-4 streamed signal and the audiovisual equipment that require digital or analog audio and video signals in order to be viewed.
- b. By using a handheld infrared controller or an integrated control system, the end user can view and navigate on-screen menus and control video and audio content that is to be displayed on the local audiovisual system or associated television.

N. IPTV system shall be designed with the greatest level of resiliency and redundancy based on state functional and technical design requirement. Further, the system shall be modular to allow future expansion without major changes.

O. The Contractor shall design, provide, install, test, and commission all IPTV systems described herein.

P. The system shall utilize the campus network with QoS for audio and video input and output, system control and maintenance and monitoring functions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cable. Check raceways, cables trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for antenna to verify actual locations of cable connections before antenna installation.
- C. Examine walls, floors, roofs, equipment bases, and roof supports for suitable conditions where television equipment is to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 IPTV SYSTEM INSTALLATION

- A. Install The Building IPTV & satellite system equipments, including associated control devices as indicated, in accordance with manufacturer's writ instructions, requirements of applicable standards, and in accordance with recognized code of practices

to ensure that installation complies with requirements and services intended function.

B. Coordinate with other work as necessary to interface installation of The Building IPTV & satellite systems work with other works.

C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment. Where manufacturer's torque requirements are not indicated,

D. Anchor mounting hardware firmly to walls, floors, or ceilings, to ensure enclosures are permanently and mechanically secured. Provide all hardware and accessories for proper mounting.

E. Provide equipment earthing connections for The Building IPTV & satellite system units as required.

3.3 FIELD QUALITY CONTROL

A. Inspection: verify that units and controls are properly installed, connected, and labeled and that interconnecting wires and terminals are identified.

B. Pretesting: align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Replace malfunctioning or damaged items. Retest until satisfactory performance and conditions are achieved. Prepare television equipment for acceptance and operational testing as follows:

1. Off-Air, Mast-Mounted Antenna Sources: connect the receiver to the down lead of a 10- element, single-channel antenna, tuned and oriented to optimize reception for the channel and placed at the system antenna's location. Alternatively, connect the receiver to a single- channel video amplifier connected to the down lead of the above single-channel antenna.

C. Test Schedule: schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.

D. Operational Tests: perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

E. System Acceptance Tests: include the following:

1. Instrumentation: use a field-strength meter rated for minus 40-dB mV measuring sensitivity and a frequency range of 54 to 812 MHz, minimum. Provide documentation of recent calibration against recognized standards.

2. Signal Level: use a field-strength meter to measure signal levels at system outlets. Readings on each of the channels designated to be received must be within specified limits.

3. Signal-to-Noise-Ratio Test: use a field-strength meter to make a sequence of measurements at the output of the last distribution amplifier or of another agreed-upon location in system. With system operating at normal levels, tune meter to the picture carrier frequency of each of the designated channels in turn and record the level. With signal removed and input to corresponding head-end amplifier terminated at 75 ohms, measure the level of noise at the same tuning settings. With meter correction factor added to last readings, differences from first set must not be less than 45 dB.

3.4 CLEANING

- A. Clean installed items using methods and materials recommended by manufacturer.
- B. Clean system components, including antennas and supports, head-end equipment, distribution components, and outlets.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain television equipment.
 - 1. Train Owner's maintenance personnel on procedures and schedules for troubleshooting, servicing, and maintaining equipment.
 - 2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.
 - 3. Demonstrate programming and tuning of satellite receivers.
 - 4. Review data in maintenance manuals. Refer to the general and special conditions of contract Section "Operation and Maintenance Data."
 - 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 - 6. Conduct a minimum of eight hours' training as specified in instructions to Owner's employees in the general and special conditions of contract Section "Contract Closeout."

3.6 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: when requested by Owner within one year of date of Substantial Completion, provide on-site assistance in tuning and adjusting the system to suit actual occupied conditions and to optimize performance. Provide up to two adjustments at Project site for this purpose, without additional cost.

END OF SECTION 16850

SECTION 275116 - PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes equipment for amplifying, distributing, and reproducing sound signals including the following:

1. Paging microphone.
2. Server
3. Audio mixer
4. Network Power amplifiers CD player
5. Loudspeakers and distribution network.
6. Volume control
7. Power supply

- B. Related Sections include the following:

1. Division 28 Section "Fire Alarm".
2. Division 25 Section "Building Management System".
3. Division 26 Section "Basic Electrical Materials and Methods".

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: A separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.4 SUBMITTALS

- A. Product Data: For each type of equipment, submit data for approval including catalogues and literature, sufficiently detailed for engineering purposes, and with full description of components and operating parameters.
- B. Shop Drawings: Submit drawings for approval including, but not limited to, the following:

1. Detailed system schematic diagram
 2. Layout of paging microphone and audio mixer
 3. Amplifier racks and cabinets layouts, dimensions, front, side and rear views, construction, access panels, dimensions, weight etc.
 4. Complete electrical and physical characteristics of amplifiers, switching panels, loudspeakers, CD player, microphones etc.
 5. Complete system wiring diagrams, size and type of cables, enclosures, terminal and splice boxes etc. and routing plans of wiring system.
- C. Product Certificates: Signed by manufacturers of equipment certifying that products furnished comply with specified requirements.
- D. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.
- E. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.
- F. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Include record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.
- G. Maintenance Data: For equipment to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of type of equipment required for the public address system whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards: System is to be in accordance with IEC 268, EIA, DIN or other equal and approved standards.

1.6 The contractor / Supplier should comply with this specifications and Mistakable City specifications together, and any conflict the priority to Mistakable City specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- a. Altec Lansing/University Sound. (USA).
 - b. Bosch. (Holland).
 - c. Rauland-Borg Corp. (USA).
 - d. SIEMENS (Germany).
 - e. RCA (USA).

2.2 OPERATION, DESIGN AND COMPONENTS

- A. Operation: System is to be used for public address or paging. Under normal conditions, an external audio source may be introduced as desired by the operator. Pre-recorded messages are to be programmable switched in, and are to have automatic priority over the external source. By using the microphone, operator is to have priority over audio message within the system. Sound distribution to zones is to be controlled by zone selector controls. Each separate system provided for restaurants are to be a completely independent system, suitable for background music and local paging / announcements. Under emergency conditions, the voice alarm system is to automatically turn off the public address system.
- B. Design Parameters: System is to be designed for public address and pre-recorded message distribution, with uniform and acceptable level of speech intelligibility. Design shown on the Drawings is based on selected manufacturers' models, which are to be checked for performance before implementation. Alternative system design is to be submitted to Engineer for approval, with specification, characteristics, aiming and mounting positions of loudspeakers and full particulars of calculations and equipment selections. System design is to be based on the following criteria:
1. Average Sound Pressure Level: 85 dB with respective amplifiers set at 50% of maximum volume.
 2. Intelligibility: Alcons : 10 or better.
 3. Signal – to – Noise Ratio: 6 to 10 dB (A) – provided that the overall SPL doesn't become too high.
 4. Total harmonic distortion.
 - a. Electronic: Less than 1% at specified output level.
 - b. Acoustic: Less than 3% at specified output level.
 5. Sound Pressure Level: 80 to 90 dB A
 6. Frequency Response : +/-3 dB over 300 Hz to 10 kHz
 7. Uniformity of Coverage : +/- 3 dB (0.5, 1, 2 and 4 kHz)
 8. Signal Head Room: 6 dB margin

2.2 PAGING MICROPHONE

- A. Paging Microphone: Dynamic cardioid, gooseneck and desktop type, having double audio in signal chime unit. Microphone is to be fully dust and moisture protected, designed specifically for speech reproduction and with at least the following performance:
1. Frequency Response : 60 Hz – 15 kHz (+/- 3 dB)
 2. Nominal Impedance : 250 ohm
 3. Output Level (1 kHz): - 54 dB (odB = 1 mw/ μ bars)
 4. Ambient Temperature Range: 0 to 45°C

2.3 CENTRAL RACKS AND CABINETS

- A. CENTRAL RACKS are to contain audio mixer, CD player, power supply module, monitor unit, power amplifier and output terminal module. Racks are to be 483 mm standard frame racks, withdrawable and hinged. Equipment is to be mounted and

designed for 483 mm rack mounting.

- B. CABINETS are to be 483 mm frame, totally enclosed, with side and rear panels removable, and cable entrance at rear, top or bottom. Surface finish is to be textured and of approved color. Frames are to be anodized aluminum sections. Each frame is to be provided with ventilation rack, including automatically operated fan with thermostatic

control. Suitable ventilation openings are to be provided. Enclosure is to be IP 42 to IEC 144 for indoor installation.

- C. Storage: Rack cabinets are to have storage drawers for cables and accessories.
- D. Mains Wiring: Equipment is to operate from 220 V, 50 Hz mains and is to be capable of continuous operation under any load conditions with variations of +/- 10% of nominal voltage. Mains wiring inside console are to be totally segregated from low-level signal wiring.
- E. Electric connections, other than those for low-level signals, are to be by push-on spade clips or multi-connector blocks.
- F. Low Level Signal Wiring: Heavily braided, PE insulated, screened cable, PVC sheathed with standard DIN plug connections. Amplifier output lines are to be twisted pairs heavily screened with tinned copper braid. Hum-producing earth return loops are to be avoided.
- G. Power Supply: Complete power supply unit is to be provided, independently fused on the live conductor, with mains front indicator light, on/off switch, cartridge-type fuse and fuse-holder with blown fuse indicator lamp. Standby power is to be available from source shown on the Drawings.
- H. Monitor unit is to monitor sound signals at loudspeaker level. Unit is to contain position input-selector switch, volume control with on/off switch and pilot lamp. Amplifier section is to have isolation transformer, power amplifier with solid-state integrated circuits, and regulated power supply. Amplifier is to be capable of operation from 220 VAC, 60 Hz a.c. line. Monitor speaker is to be compact type, mountable on monitor unit panel, with 10-watt power rating, uniform frequency response (60 - 15,000 Hz) and is to provide, with 1-watt input, an 80 dB SPL at 1 m.

2.4 MIXER AMPLIFIER / CHANNELS POWER AMPLIFIER

- A. General: At least one power amplifier is to be provided per zone, for mounting in standard 483 mm racks, located in central control room. Amplifiers are to be driven by audio mixer such that malfunctions of any single amplifier results only in one zone failure.
- B. Input Level: Adjustable with a preset potentiometer on front panel. Illuminated VU meter is to be mounted on front panel.
- C. Output: Fully protected against failure due to mismatch, short circuits, thermal and electrical overloads, overdrive or eventual transients.
- D. Performance: Each power amplifier is to have at least the following performance:
 1. Output Power: As shown on the Drawings.
 2. Effective Frequency Range: 50 Hz to 18000 Hz.
 3. Input: 0 dBm line level (0.775 V).

4. Input Impedance: 50 Kilo-Ohm.
5. Output Voltage (load impedance): 100 V (100 ohm), 70 V (50 ohm) and 50 V (25 ohm).
6. Signal/noise Ratio (all controls closed): ≥ 85 dB (un – weighted).
7. Total Harmonic Distortion at 1000 Hz: Less than 0.5%.
8. Ambient Temperature: 40 deg. C.
9. Power Supply: 220 Volts, 60 Hz.

2.5 COMPACT DISK (CD) PLAYER

- A. Type: rack mounted, high quality, compact disk playback type with 6-disk cartridge standard, single beam laser assembly and auto playback programme facilities. CD player is to have pre-amplifier if necessary with the following performance:

1. Playback system	:	compact disk
2. Frequency range	:	2 Hz - 20 kHz
3. Signal-to-noise ratio	:	not less than 97 dB
4. T.H.D.	:	not greater than 0.008% (1
5. Out-band rejection	:	not less than 56 dB
6. Max. audio line out	:	2 V (rms)
7. Min. load impedance	:	10 kohm
8. Power supply	:	220 V, 60 Hz.

2.6 LOUDSPEAKERS

- A. Ceiling Loudspeaker: Cone-ceiling loudspeaker, flush mounting type. The loudspeaker is to have an off white circular metal grille and includes integral spring – loaded ceiling locking clamps and 100 V, 70 V, 50 V matching transformer. Loudspeaker shall have the following performance

1. Rated Power: 6 Watts.
2. Sound Pressure Level: 92 dB 1 w/1m.
3. Frequency Response: 1000 Hz to 12000 Hz.
4. Opening Angle (at 1kHz - -6dB): 160 degrees.

- B. Loudspeaker: Wall mounting containing number of cone speakers and including 100 V, 70 V, 50 V matching transformer. Loudspeaker shall have the following performance:

1. Rated Power: 30 Watts.
2. Sound Pressure Level: 97 dB 1 w/1m.
3. Frequency Response: 2000 Hz to 12000 Hz.
4. Opening Angle (at 1kHz - -6dB) Horizontal / Vertical: 170 degrees / 40 degrees.

2.7 VOLUME CONTROL

- A. Volume Control: Flush mounting type legend black indicating OFF/ MAX positions with stops fitted to the switch and auto transformer type for more than 5 watt.

100 watt rated unless the total wattage of the supported zone is more than this, suitable rating shall provide. Volume control shall be at least five volume steps plus OFF and MAX.

2.11 PUBLIC ADDRESS SYSTEM CABLING

- A. Conduits and Raceways: Comply with Division 26 Section "Raceways and Boxes" of the Specification.
- B. Cables for Sound Distribution: Rated for 200 V (maximum) operating voltage, finely stranded tinned copper, 1.5 mm diameter (minimum), polyethylene insulated, twisted pair and aluminized polyester shield, stranded tinned drain wire, PVC over-sheathed.
- C. Microphone Cable: PE insulated, finely stranded tinned copper conductor, with copper braid screen and PVC over-sheaths.

PART 3 – EXECUTION

3.1 INSTALLATIONS

- A. General: Equipment installation on site is to be limited to the layout and fixation, and inter-wiring of various items of the ready-made equipment. Acceptance of works is to be restricted to the equipment and installations complying with the approved submittal, approved shop drawings, and the agreement of Engineer.
- B. Co-ordination with other Works: Undertake the proper co-ordination between the works and installations of all other associated systems. The layout shop-drawings is to also reveal the measures taken therein, and every fixation principle, and is to be subject to the approval of Engineer.
- C. Layout of Equipment: The central switching is to be laid out properly in a communication - equipment room so as to reserve relevant space for maintenance activities as is to as any future expansion of the system. All other equipment is to be laid out as per the approved shop drawings. After the proper layout of all equipment is accomplished, all components are to be labeled, and marked according to an approved labeling designations and materials.
- D. Install equipment to comply with manufacturer's written instructions.
- E. Wiring Method: Install wiring in raceway except within consoles, desks, and counters. Conceal cable and raceway except in unfinished spaces.
- F. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- G. Match input and output impedance and signal levels at signal interfaces. Provide matching networks where required.
- H. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.
- I. Wall-Mounting Outlets: Flush mounted.
- J. Floor-Mounting Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.
- K. Weatherproof Equipment: Install units that are mounted outdoors, in damp locations, or where

exposed to weather consistent with requirements of weatherproof rating.

- L. Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

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.

3.3 TESTING

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installations, including connections. Report results in writing.
- B. Operational Test: Perform tests that include originating program and page material at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and freedom from noise and distortion.
- C. Signal-to-Noise Ratio Test: Measure the ratio of signal to noise of complete system at normal gain settings, using the following procedure:
 - 1. Disconnect a microphone at the 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 the ratio of signal to noise.
 - 2. Repeat test for each separately controlled zone of loudspeakers.
 - 3. Minimum acceptance ratio is 50 dB.
- D. 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 the distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
- E. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use a 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.
- F. Power Output Test: Measure electrical power output of each power amplifier at normal gain setting at 60, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
- G. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding."
- H. Re-testing: Correct deficiencies, revising tap settings of speaker-line matching transformers where necessary to optimize volume and uniformity of sound levels, and retest. Prepare written record tests.

- I. 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.
- J. Schedule tests with at least seven days' advance notice of test performance.

3.4 WARRANTY

- A. Provide the services of a system engineer to assist the personnel provided by the employer during the installation and commissioning period.
- B. Five (5) sets of instruction manuals shall be provided for the sound system. All manuals shall be in the English language.
- C. Obtain from the manufacturer of the equipment a warranty that all equipment supplied will be free of defects in labor, materials and workmanship and will perform satisfactorily in compliance with all pertinent specification for a period of one (1) year after commissioning.
- D. During the warranty period, the services of a factory representative qualified to advise on the operation and maintenance of the equipment specified shall be provided by the manufacturer.

3.5 OCCUPANCY ADJUSTMENTS

- 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. Provide up to three on-site assistance visits within one year of Substantial Completion.

END OF SECTION 27 51 16

SECTION 28 13 00 - IP ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Security management Servers.
 - 2. Security Management Workstations.
 - 3. Access Control Workstations.
 - 4. Access Control Panels.
 - 5. ID Badging and Card Printer.
 - 6. Proximity Card Readers.
 - 7. Request to Exit Devices.
 - 8. Electromagnetic Door Locks.
 - 9. Magnetic Door Contact.
 - 10. Alarm relays.
 - 11. Miscellaneous cable, wire, associated connectors, and hardware
 - 12. Power supplies.
 - 13. Complete Integrated Security Management System (SMS).

All labor, equipment and material necessary to provide and install a complete and fully operational card access system, as indicated.

- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods."
 - 2. Division 26 Section "Grounding and Bonding."
 - 3. Division 26 Section "Raceways and Boxes."

1.3 SYSTEM DESCRIPTION

- A. General: Fully integrated system with all low current systems like , security, fire alarm, BMS, parking control and communication systems... etc
- B. The system shall require number of access control programming panels and able to many number of access control doors -, all access control panels shall be connected together through LAN network software and hardware. The access control panels shall operate in both a programmed and a manual mode.
- C. The system shall be a modular and networkable access control system capable of access control of selected doors, alarm monitoring, video imaging, and CCTV camera call-up that allows for easy expansion or modification of inputs, outputs, and remote control stations. The system control at the host work station 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 on-line through system programming, without hardware changes.
- D. The system shall be interfaced with the fire alarm system through the use of fire alarm system control modules.
- E. 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, activation of remote devices, door control, and card or personal identification number (PIN) validation.
- F. Access control functions shall include, validation based on time of day and day of week, holiday scheduling, site code verification with card validation override, video image storage and retrieval of cardholder photographs, and access validation based on positive verification of card, PIN, and card and video.
- G. Utilizing assigned passwords, it shall be possible to define the levels of system operation for each individual operator. Operator action's range from basic monitoring to full control of the system including programming.
- H. The system programming shall be user friendly, and capable of being accomplished by personnel with no prior computer experience. The programming shall be MENU driven and include on-line "Help" or "Tutorial" information, as well as on-line data entry examples. The system shall provide both supervised and non-supervised alarm point monitoring. Upon recognition of an alarm, the system shall be capable of switching CCTV cameras that are 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 day of week.
- I. The method of communication from remote locations to the central server components shall be transparent to the user.
- J. The Access Control and Security Management Systems shall be an IP based system utilizing the project Local Area Network (LAN). The IP Access Control and Security Management Systems shall be capable of monitoring, and controlling all access field devices located at different areas. Installation shall comply with local code requirements as applicable.

- K. IP Access Control and Security Management Systems shall be designed to provide a centralized location with the ability to monitor and control from secure location(s) within a facility.
- L. The system shall be user friendly, providing a monitoring station that allows for training of non-technical personnel to effectively operate and administrate the system.
- M. Any cables distance restriction is the contractor responsibility.
- N. The contractor has full responsibility for performing complete site survey before bidding in order to confirm system compatibility with actual site conditions.
- O. After installation, the Employer shall be able to perform hardware configuration changes as desired without the services of the Contractor or manufacturer.
- P. Equipment repair shall be able to be accomplished on site by module replacement.
- Q. All control components shall utilize "Distributed-Processing" concepts. The distributed processing shall include the ability to down-load operating parameters to any access control panel, thus allowing the panel to provide full operating functions independent of any other system component.
- R. The system shall be interfaced with the IP CCTV, BMS and car parking system.

1.4 SUBMITTALS

- A. Product Data: Include detailed manufacturer's specifications and data cut sheets for each system component. Include data on features, ratings, and performance.

Retain below if desired. Submittal of sample warranties provides opportunity to verify that coverage complies with requirements .Sample Warranty: Copy of manufacturer's proposed

exclusions.

- C. Shop Drawings: Indicate layout, wiring diagrams, and dimensions. Locate devices as shown on Drawings.
- D. Manufacturer's Installation Instructions: Provide installation instructions.
- E. System Operation Description: Include method of operation and supervision of each component and each type of circuit, and sequence of operations for manually and automatically initiated system inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are not acceptable.
- F. Product Certificates: Signed by manufacturers of components certifying that products furnished comply with requirements.
- G. 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.
- H. Tests and Certificates: Submit complete certified manufacturer's type and routine test records, in accordance with the Standards specified in "Quality Assurance" Article.

- I. Field Test Reports: As specified in "Field Quality Control" Article of this Section. Indicate and interpret test results for compliance with system description and performance requirements.
- J. Record (As-Built) Drawings: Include:
 - 1. Complete wiring diagrams, including complete terminal strip layout and identification, and wire termination and tagging for all conductors.
 - 2. Locations for all components installed and/or connected to under this specification.
- K. Warranties: Warranties specified in this Section.
- L. Maintenance Data: For products and system to include in maintenance manuals specified in Division 1. Include data for each type of product, including all features and operating sequences, both automatic and manual. Include user's software data and recommendations for spare parts and components to be stocked at Project site.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm specializing in providing access control systems similar to that indicated for this Project and with a record of successful in-service performance.
 - 1. Manufacturer's system shall be a standard "off-the-shelf" package utilizing the latest hardware and software technology. Any major system development efforts necessary to meet specified requirements are unacceptable.
 - 2. Manufacturer or factory-authorized agency shall maintain a service center capable of providing training, parts, and emergency maintenance and repairs for overall system at Project site with eight hours' maximum response time.
- B. Edit paragraph below for specified features, as per applicable Project requirements.
- C. Installer Qualifications: An experienced Installer who is an authorized representative of the equipment manufacturer for both installation and maintenance of manufacturer's equipment, and who has completed system installations similar in design and extent to that indicated for this Project, with a record of successful in-service performance.
- D. Materials and workmanship shall conform to the latest issue of all industry standards, publications, or regulations referenced in this Section, including the following, as applicable:
 - 1. Regulations and Standards: System components, parts and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC)
 - 2. Compliance with Local Requirements: Comply with applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Engineer, in writing.
 - 3. Conform to requirements of referenced industry standards, applicable sections.
 - 1. BS EN 50131 Alarm and Intrusion systems.
 - 2. BS EN 50132 CCTV surveillance systems for use in security applications
 - 3. BS EN 50133 Access control systems for use in security applications
 - 4. BS EN 1711 Building Hardware.
 - 5. BS 4737 Intruder Alarm Systems in Buildings.
 - 6. BS 6360 – Specification for conductors in insulated cables and conductors.

7. BS 7671 - The 16th Edition of the Institute of Electrical Engineers (IEE) Regulations.
 8. ISO/IEC 7816.
 9. ISO/IEC 14443.
 10. ISO 15693.
 11. National Electrical Safety Code, current edition.
 12. National Fire Protection Association National Fire Codes, current edition.
 13. NACOSS/NCP 30 - The National Approved Council for Security System.
 14. EIA/TIA-568 Commercial Building Telecommunications Wiring Standard.
 15. EIA/TIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces.
 16. EIA/TIA-606 Administrative Standards for the Telecommunications Infrastructure of Commercial Buildings.
 17. IEEE, 802.3 digital data network standard.
- E. Source Limitations: Obtain system components from one manufacturer who shall assume responsibility for system components and for their compatibility.
- F. Warranty :One-year warranty is industry standard; some manufacturers commonly provide two-year warranties if requested. When warranties are required, coordinate with Division 1 Section "Product Requirements.

1.6 "WARRANTY

- A. Manufacturer's Warranty :Provide written warranty, signed by manufacturer and Installer agreeing to replace access control system devices and equipment that fail in materials or workmanship within specified warranty period.

Below is an example only. Revise warranty to period required and verify availability

.Warranty Period: Two years from date of Substantial Completion.

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.

.Access Control Devices: Furnish quantity equal to 5 percent of the number of units of each type installed, but not less than one of each type.

- B. Test Equipment: Provide, together with an itemized list, all test equipment and tools required for routine maintenance, safety checks and equipment repair. Deliver test equipment and tools at the same time as the system equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Kantech - CANADA
2. Honeywell - USA
3. Johnson Control-USA
4. BOSCH – Holland
5. SCHNIDER –France
6. HID –USA
7. GALAXY

2.2 ACCESS CONTROL SERVERS

2.3 HARDWARE

The Access Control System PRIMARY AND SECONDARY Servers should be rack-mounted and to be installed in centralized security room; The Server Hardware shall be as per the system manufacturer recommendations for proper system operation, however, the contractor to ensure the following minimum hardware requirements,

Processor	Intel® Xeon
Memory	4GB UDIMM, 1333MHz, LV, Dual Bank x 8
Storage	As per latest technology
Video Card	As per latest technology
Optical Drive	DVD +/- RW
Network	As per latest technology

2.4 SOFTWARE

- A. System software shall be designed specifically for security applications and shall provide for: polling and demand requests to monitor status, processing alarms according to priority, controlling and processing communications with client work stations, and synchronizing all system activity. System software shall permit point additions and deletions, activation and deactivation, and system reprogramming by authorized personnel. Application software shall provide the following operating features:

1. On a door-by-door basis, lock or unlock doors according to a day and time schedule or an event-initiated program. The software shall allow automatic control of selected inputs, outputs and groups of outputs. Access control shall include pulse and energize/de-energize options for output points and shunt/unshunt options for input points.
2. On a door-by-door and individual cardholder basis, permit access to a limited group of cardholders according to a day and time schedule, operator command, or an event-initiated program.
3. Provide for the creation of up to 8 time zones, 50 time and day schedules, with up to 30 holidays assignable to each schedule.
4. Provide for individually-adjustable alarm shunt time delays for entry and exit for each door.
5. Modify access control privileges of individual cards.
6. The software shall provide multi-level password protection, with user-defined operator name/password combinations. Name/password log-on shall restrict operators to selected

- areas of the program. Provide the capability to lockout all users for a user-definable number of minutes after a user definable number of invalid log on attempts.
7. Provide anti-pass back: This feature prevents the reuse of a card at a designated reader for a user programmable time period.
 8. Provide the following reporting:
 - a. Alarm history consisting of acknowledged alarms.
 - b. Badge history including access attempts by valid, invalid, lost and suspended badges.
 - c. Operator history consisting of database changes and log-ins by operator.
 - d. A query function to allow selected data to be sorted on not less than 3 selection criteria.
 - e. Provide facility to export (as a whole or individually) the following data to be used in common database software package:
 - Floors.
 - Doors.
 - Transactions.
 - Messages.
 - Passwords.
 - Individuals.
 - Groups.
 - Field Names.
 - Alarms (sorted by priority).
 - f. Prepared Historical Report: Provide an on-line, historical, database sort report utility, with the following features:
 - g. Prompts to select database sort by time, by date, by point (or range of points) with system supplied default values of 24 hours.
 - h. APPLICATION PACKAGE
 - i. The primary operator interface to the system shall be through a graphical, "object oriented", interactive presentation using a mouse and cursor for object selection and commands. Features;
 - j. Microsoft Windows OR Linux.
 - k. Input commands through keyboard or mouse.
 - l. Extensive context sensitive help facilities.
 - m. Incorporate password access to various levels of the system.
 - n. Time schedules including holidays.
 - o. Maintenance of a daily log.
 - p. Control programming using English/Arabic language.
 - q. Database management, Data Exporter/Reporter using 3rd party packages.
 - r. Alarm management.
 - s. Graphics.
 - t. Historical data file for all points.
 - u. User initiated logging and reports.
 - v. Support of multiple operator workstations.

- w. Ability to integrate with CCTV, Public Address System or any other system available within the facility.
- 9. The software shall support the use of card readers and/or keypads.
- 10. Provide color graphics editor which allows the generation of custom dynamic graphics for graphical representation of the card access system. The editing menu shall provide help menus for selecting graphics, choosing colors, copying previous graphics, and deleting data points. Information on the color graphic display shall be dynamic and automatically updated. The software shall provide the capability of linking high level maps with lower level (more detailed) maps and vice-versa.
- 11. The system software shall support "pop-up" windows for point commands. On selecting an object with the cursor, a window shall open up to present the operator with choices corresponding to the operator's password authorizations. These point commands shall include state changes, manual override of application software and test mode activation. This window shall include, for reference, the point's descriptor (name), the point's hardware address, and alarm status.
- 12. The system software shall support "pop-up" windows for point editing. On selecting an object with the cursor, a window shall open up to present the operator with a list of active point database editors, if permitted by the operator's password level. Selecting one of these editors shall allow the operator to modify the basic parameters associated with a point, as well as access any programs assigned to the point (such as time schedules, events, etc.).
- 13. The system software shall be based upon interactive prompts and choices using "dialog boxes," as opposed to memorization of commands, "syntax", exact spellings, etc. This interactive prompt and choices approach shall be used in monitoring, issuing commands, and editing. Command choices shall be as simple as "clicking" the cursor over the correct word choice prompts (i.e., SECURE, UNLOCK), without having to type in the letters.
- 14. The system software shall support a "zoom" function. It shall be possible for an operator to locate any system point to monitor status, issue commands, or edit associated database without knowledge of the point's name, address, or associated controller, and without having to refer to a "tree" directory; e.g. the operator shall be able to zoom in on a building in a campus graphic, zoom in on a floor in a building graphic, zoom in on a door in a floor plan graphic, etc.
- 15. The system software shall be compiled for a faster execution speed and shall offer all of the following features and capabilities;
- 16. Input / Output Capabilities: From any local PC workstation or any remotely connected PC workstation, the system operator shall have the capabilities through the keyboard/mouse to request dynamic displays of current values or status using a tabular or graphic format. A global database sort utility shall allow an expanded tabular display of only the points on the current graphic display. This expanded tabular display shall list point name, hardware address, alarm status, override status, and test mode status.
- 17. Obtain a summary of all access control doors with status (under access control, access control disabled, or access control ignored) and allow issuing commands to the access control doors to manually force the door to one of the above states, or provide a momentary release (act as a valid key/card access), or return to automatic control (remove manual state).
- 18. Add, delete, or change points within each Controller or application routine while on-line.
- 19. Change point I/O descriptors, status, and alarm descriptors while the system is on-line.
- 20. Add new Controllers to the system while the system is on-line.
- 21. Develop, modify, delete or display full range of color graphic displays providing dynamic, animated displays. All development, editing and display work shall be capable

of being performed with the system fully on-line and in full communication with the Controllers.

2.3.3 DATABASE CREATION AND SUPPORT

The intent of this specification is to provide an ACS system that will allow the operator to independently perform his own modifications to the system from any operator workstation. All changes shall be carried out while utilizing standard procedures, and must be capable of being done while the system is on-line and operational. The Access Control Panel on the LAN shall automatically check a PC workstation's database files upon connection to verify a current database match. A utility shall inform the operator if the Access Control Panel's database files do not match the backup files stored on the PC workstation, along with the date of the last Access Control Panel modification and date of the last backup. The operator must have, as a minimum, the on-line capability to;

1. Add and delete points.
2. Modify any point parameter.
3. Determine which PC workstation(s) will receive alarms, messages & transactions on a point by point / door by door basis.
4. Add, modify, or delete alarm limits.
5. Obtain an "audit trail" of which application programs are controlling an individual point, on a point by point basis.
6. Create and/or modify override parameters.
7. Add, modify, and delete any applications program.
The database shall be an open format or provide a means to export data for use in other third party programs.

2.5 COMMUNICATION NETWORK

- A. All communication shall be via copper cables, UTP cat 6A type as described in section 271000.

2.6 ACCESS DOOR CONTROLLER

- A. The door controller is a micro-processor based device which supports the operation of card access and security monitoring hardware.
All points in the system shall be monitored and/or controlled through "intelligent" Access Control Panels. Each control panel in the system shall contain a minimum 10 hours battery backup. Each control unit shall completely independent with its own hardware clock calendar and all firmware and software to maintain complete control on an independent basis. Access Control Panels shall connected together through the LAN network TCP/IP. Access control generally shall;

Acquire, process, and transfer information to the PC operator workstations or other control units on the network.

Allow access to both database and control functions by multiple workstations at the same time.

- B. Record, evaluate, and report the changes of state and/or value that occur among points associated with the control panel. If any operator workstation or transmission network fails, but the power to the control unit does not, the control unit shall continue to perform all control functions associated with the points connected to that control unit.
- C. The system controllers must provide an integral time clock and have the capability to synchronize time with operator workstation or other ACS panels at least weekly.
- D. Control panel Upload/Download Capability: Each control panel shall be able to download from or upload to any PC operator's workstation. All point data shall be modifiable from any authorized PC operator's workstation and downloaded to the control panel over the Control Panel LAN. This upload/download shall be readily performed on a regular basis without interrupting the control functions in the control panel. All upload/downloads shall be performed without the operator workstation being taken "off-line. Additionally, all Control Panel upgrading shall be performed via a download from any workstation on the system; i.e. it shall not be necessary to replace e-proms to perform a system revision upgrade.
- E. Door controller shall support the operation of access control card readers, electric door locks, door and other digital alarm devices, and door exit devices. The door controller shall be capable of supporting a minimum of: 8 sub terminals with not less than 4,000 badges, 12 monitored and supervised digital input points and 18 digital output points. Each card reader, input point and output point shall be identified with a user-assigned name of up to 16 characters. Panel shall be capable of storing a minimum of 5000 alarm transactions and 10,000 access transactions.
- F. Required software shall be resident in the door controller. This shall include approved card access codes for each reader and the door unlock times for each door connected to the DOOR CONTROLLER. Approved card codes and door unlock times may be updated through the work stations. The door controller software shall allow direct control of the output relays and input status ports through the work stations.
- G. Door controller shall be capable of proper operation in an ambient environment of from 2 deg. C to 49 deg. C, 20% to 90% RH, non-condensing.
- H. Detection circuits supported by the DOOR CONTROLLER's shall be supervised.
- I. Modules: Removable without having to disconnect field cabling.
- J. Zoning of different doors located in the campus and connected to different Access Control Panels.
- K. The panel shall be configured with IP address and gateway address in order to be reachable through the LAN and WAN.

2.7 PROXIMITY CARD READERS

Each card reader shall be intelligent and of the "Proximity" technology. Card reader shall read 125 kHz proximity card.

- L. Read range shall be nominally 8 - 12 cm and for, from the rear surface when used with a card. The reader may be mounted directly on any material including metal without the use of standoffs, or concealed behind any building material except metal.
- M. The card shall be read when presented in any orientation or at any angle to the front surface of the reader. An LED on the front surface of the reader shall indicate to the user that the card presented to the reader has been read. An audio beep tone to indicate that the card has been read shall be available.
- N. Each reader shall communicate directly back to the door controller. The reader must operate over shielded cable up to 100 meters from the door controller without any additional power supplies.
- O. The card reader shall communicate to the door controller in a supervised mode of communications. In the event of a reader malfunction, it shall be capable of being detected by the door controller and an alarm must be generated at the work stations. A built in tamper switch within the reader is required. Full error checking shall be provided within each reader prior to sending the information to the door controller.
- P. Where required on Drawings, provide with integrated keypad for personal identification number (PIN) entry.
- Q. All readers are to be weather resistant, suitable for indoor or outdoor use and use tamper proof screws for installation. Readers are to be rated for operation at a temperature range of minus 30 deg. C to 65 deg. C and a humidity range of 0% to 95% RH, non-condensing.
- R. The card reader shall have a hold line that will buffer a card read until the panel has asserted that the information can be sent up line.

2.8 ACCESS Badges / CARDS

- S. The contactless card shall be compatible with;
 - ISO/IEC 7816.
 - ISO/IEC 14443.
 - ISO 15693.
- T. Card read/write card 125 kHz proximity technology on a single card with the ability to add magnetic stripe, barcode, and other features such as photo identification.
- U. An ISO Standard PVC credit card size having a punched slot for a strap or clip.
- V. The presence of small metal objects such as keys or coins near the card shall not alter the code read by the reader or prevent the code from being read by the reader.
- W. Cards are to be passive type technology (no battery). They must be capable of being printed with a custom logo which is to be coordinated with the Engineer. The cards must be thin and light weight. Maximum card thickness is 1.8 mm. Provide slot punch on each card. An initial quantity of 2,500 badges, each with a self-adhesive photo pouch, is to be included in the tender proposal. A lifetime warranty against defects in materials and workmanship shall be provided for all badges.

2.9 DOOR LOCK

- a. ELECTROMAGNETIC / ELECTRIC LOCK as per the door type.
- b. Lock to operate on 24 VDC and be provided with concealed door position switch.
- c. Approved by the authority having jurisdiction, including local fire authorities.
- d. UL listed.
- e. Field adaptable for internal-swinging/external-swinging doors.
- f. Provide a minimum holding force of 1200-1600 lb.
- g. Provide with an integral door status switch and magnetic bond sensor.

2.10 PUCH BUTTON

For Door release to operate on 24 VDC.

- a. UL Listed.

2.11 EMERGENCY BREAK TO EXIT

- b. Bush button to release emergency doors magnetic lock.
- c. Operation: Momentary N.O. and N.C. DPDT Circuits.
- d. MAGNETIC DOOR CONTACT
- e. UL Listed.
- f. ¾" diameter recessed magnetic contacts with factory installed wire leads, minimum 1 ft. long – 22AWG.
- g. Self-lock mounting.
- h. Installation shall include the application of mounting compound for added adhesive strength.
- i. Where field conditions prohibit the use of a recessed magnetic contact, surface mounted switch shall be used.
- j. Operation: N.O. and N.C. Magnetic contacts.

2.12 POWER SUPPLY

- a) Power supply shall use input power of 220 VAC, 50 Hz and output 12 VDC or 24 VDC. Output voltage shall be filtered and regulated. Provide multiple output circuits on individual breakers.
- b) Power supply shall be housed in a key locked NEMA 1 enclosure. Provide matching enclosure for battery back-up batteries. An integral battery charging circuit shall be standard. Provide batteries for minimum standby time of 1.0 hour. Battery type shall be sealed lead acid or gel cell.

ACCESS CONTROL WORKSTATION

WORKSTATION HARDWARE

Workstation shall be graphical user interface .The Workstation Hardware shall be as per the system manufacturer requirements for proper system operation, however, the contractor to ensure the following minimum hardware requirements

- a. Screen size as shown on drawings
- b. Processor: latest standard and size at the time of commissioning.
- c. Monitor Card: latest standard and size at the time of commissioning.
- d. Network Card: latest standard and size at the time of commissioning.
- e. Keyboard: full size.
- f. Operating systems: Windows, UNIX, Linux,
- g. Anti-virus software included
- i. Protocols: TCP/IP.
- j. Operating temperature: +10° C to +55° C.
- k. Operating Voltage: 220V AC $\pm 10\%$, 50 Hz.
- l. Processor: latest standard and size at the time of commissioning.
- m. Monitor supports HDMI, DVI, BNC and VGA input
- n. Supports up to 1920 x 1080 (HD) resolution
- o. Aspect ratio: 16:9
- p. Brightness: 350 cd/m²
- q. Contrast ratio: 3000:1
- r. Video format: NTSC/PAL auto detect

2.12.1 WORKSTATION SOFTWARE

- 2.13 Provide an on-site operator workstation to provide user friendly, operator interface with the complete system.
- 2.14 If required, provide an off-site operator workstation to provide user friendly, operator interface with the complete system. Provide all operator interface software and commissioning.

2.15 GENERAL

The ACS shall allow all connected workstations to function in a true multi-user, multi-tasking environment such that;

- 2.15.1 All terminals can access the same network at the same time.
- 2.15.2 All terminals can access and/or control the same control unit at the same time.
- 2.15.3 All terminals can access and/or modify the same control unit database at the same time.
- 2.15.4 All terminals shall be able to archive data, alarms, access transactions, and network actions to hard disk regardless of what application programs are being currently executed (i.e., LAN operating system, spreadsheets, word processing, etc.). All archiving disk traffic shall be accomplished on-line without affecting the operation of the current programs.
- 5. Latest revisions of all programs at time of practical completion.
- 6. Licensing of software at time of practical completion.
- 7. The software shall include support for fully integrated Security/Access Control.

D. APPLICATION PACKAGE

The primary operator interface to the system shall be through a graphical, "object oriented", interactive presentation using a mouse and cursor for object selection and commands. Features;

- 1. Microsoft Windows OR Linux.
- 2. Input commands through keyboard or mouse.
- 3. Extensive context sensitive help facilities.
- 4. Incorporate password access to various levels of the system.
- 5. Time schedules including holidays.

6. Maintenance of a daily log.
7. Control programming using English/Arabic language.
8. Database management, Data Exporter/Reporter using 3rd party packages.
9. Alarm management.
10. Graphics.
11. Historical data file for all points.
12. User initiated logging and reports.
13. Support of multiple operator workstations.
14. Ability to integrate with CCTV, Public Address System or any other system available within the facility.
Remote workstation: Provide facility so that data stored on an on-site workstation may be downloaded to a remote workstation.

E. GRAPHICS

1. The system shall support an operator definable “default” system page. The default system page shall be displayed upon system start-up, operator activity time-outs, and when the system is not in use. This default system page may be any one of the standard dynamic graphic pages, or may be a custom display developed for this purpose. The operator shall be able to display their corporate logo, emergency information, an index of all graphic pages, etc. as the default system page.
2. Dynamic graphic programming
 - a. Shall be part of the ACS system, which is not to be considered as an add-on feature.
 - b. The operator shall have the ability to construct "dynamic" graphics pages for monitoring and system control. This graphics utility shall be usable both for on-line control such as override and alarm acknowledgment, and for display of system status and alarm activity.

2.14 ID BADGING AND CARD PRINTER

- A.** The ID Badging and Card Printer System shall be installed at Security Control Center. The system shall be user friendly system for card production. The software will feature a utility wizard to assist in data base creation or integration where multiple levels / location of data, access and photographs reside. The system will be designed for the building environment with enhanced security features to allow controlling several levels of access. System Server is to store all card holder's information and design elements.

B. The Card Printer / Encoder shall have the following specifications:

Dual Sided Printing	Provided
Encoding	Magnetic Stripe encoding
Connections	Smart Card encoding
Rewrite Technology	USB & Ethernet
Print Speed	Included
Color Capability	24 Seconds/Card – 150 Cards / hours
	Full Color & Monochrome

2.15 System shall include Digital, 10MP Camera, Design Software and PVC Card Printer.

2.15.1 INTERFACES

System shall interface with the following systems

- 1- CCTV system to monitor any un-authorized transactions
- 2- Fire Alarm System to override door locks in case of fire
- 3- Building Management System

3 EXECUTION

A. INSTALLATION

- a. Installation shall be supervised and tested by a representative of the manufacturer of the system equipment. The work shall be performed by skilled technicians under the direction of experienced engineers, all of whom shall be properly factory trained and qualified for this work.
- b. Wire and Cable:
 - i. All wiring and cable shall be installed in metal raceways or within equipment. Conductors within equipment enclosures shall be carefully cabled and laced. Individual conductors shall be tagged with markers indicating the function, source, and destination of all cabling, wiring and terminals. All cables and wires shall be identified, utilizing heat-shrink, pre-printed, wire markers.
 - ii. Number of Conductors: As recommended by system manufacturer for functions indicated.
 - iii. After installation, and before termination, all wiring and cabling shall be checked and tested to ensure there are no grounds, opens, or shorts on any conductors or shields. A V.O.M. shall be utilized to accomplish these tests and a reading of greater than 20 megohms shall be required to successfully complete the test.
 - iv. Visually inspect wire and cable for faulty insulation prior to installation. Protect cable ends at all times with acceptable end caps except during actual termination. At no time shall any coaxial cable be subjected to a bend less than a 150 mm radius.

- v. Protect wire and cable from kinks.
 - vi. Provide grommets and strain relief material where necessary, to avoid abrasion of wire and excess tension on wire and cable.
 - vii. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- c. Identify components, conductors, and cables according to Division 16 Section "Basic Electrical Materials and Methods." Color-code conductors, and apply wire and cable marking tape to designate wires and cables so media are identified and in coordination with system wiring diagrams.
- d. Raceway: All raceway shall be installed in accordance with Division 16 Section "Raceways and Boxes". Use communications cable tray wherever possible for low voltage cabling. Exposed raceway below 2.4 meters and in dry locations shall be rigid steel conduit.
- a. Install card access equipment in security console as shown on sheet design drawing.
- b. Provide 19 mm, minimum, thick plywood backboard to support the ACPs (controllers) and associated equipment mounted to the wall in each room. Coordinate location and size of backboard with Engineer prior to installation.

C. GROUNDING

- a. Properly ground each piece of electronic equipment prior to applying power. Properly ground all shielded wire shields to the appropriate earth ground at the hub end only, not at the remote or device end.
- b. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. FIELD QUALITY CONTROL

- a. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- b. Pretesting: Align and adjust system and perform pretesting of all components, wiring, and functions to verify compliance with specified requirements. Correct deficiencies by replacing malfunctioning or damaged items with new items.
- a. Testing: Perform the following field quality-control testing:
 - b. Manufacturer's Field Services: Engage a factory-authorized service representative to inspect field-assembled components and perform system pretesting, testing, adjustment, and programming.
 - i. Notify Engineer not less than 30 days in advance, of proposed schedule, procedures and tests to be used in operational testing. Conduct operational tests only with Engineer present.

- ii. Operational Tests: Schedule tests after pretesting has been successfully completed. Perform operational system tests to verify compliance with Specifications. Test all modes of system operation; including:
 - 1. Functional operation of each field mounted device.
 - 2. Functional operation of each control circuit.
 - 3. Supervision function of each initiating, indicating, monitoring, and control circuit.
- iii. Report: Prepare a written report of observations, inspections, tests and results, including:
 - 1. A complete listing of every device and circuit.
 - 2. Date of each test and retest, and by whom.
 - 3. Results of each test and, if failure occurred, corrective action taken prior to retest.
 - 4. Certification that all devices, circuits and total system finally tested successfully.
- c. Retesting: Correct deficiencies and retest until total system meets requirements of the Specifications and complies with applicable standards.
- d. Schedule testing with at least seven days' advance notice.

F. ADJUSTING

- a. Occupancy Adjustment: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting and reprogramming to suit actual occupied conditions. Provide up to two visits to Project for this purpose without additional cost.

G. DEMONSTRATION

- a. Engage a factory-authorized service representative to explain programming and operation of system and to train Employer's maintenance personnel on procedures and schedules for maintaining, programming, operating, and adjusting, troubleshooting, and servicing system. Refer to Division 1 Section "[**Demonstration and Training**] [**Closeout Procedures**]."
 - i. Train personnel on procedures to follow if operation fails or malfunctions.
 - ii. Provide a minimum of six (6) four (4) hour periods of training in operation and maintenance.

END OF SECTION 28 13 00

SECTION: 28 13 55 DISABLE TOILET ALARM SYSTEM

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions of Contract, apply to this Section.
 - A. Related sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Raceways and Boxes".
 - 3. Division 26 Section "Cable trays for electrical systems".
 - 4. Division 26 Section "Grounding and Bonding".

1.2 SUMMARY

- B. Work comprises complete disable toilet alarm system, the system outlined here is to include all necessary devices that provide the functions listed in this specification.

1.3 SUBMITTALS

- A. Product Data: include detailed manufacturer's specifications for each component specified. Include data on features, ratings and performance.
- B. Shop Drawings: include plans, elevations, sections, details and attachments to other Work.
- C. Samples: full size, for each outlet and finish plate, for colors and textures.
- D. Product Certificates: signed by manufacturers of disable toilet alarm system and components certifying that products furnished comply with requirements
- E. Any supplying contractor proposing equipment which is not the base standard for this specification must provide full submittals at the time of bid. This option shall be exercised at the discretion of the OWNER/specifying authority.
- F. Prior to submission of bid, the supplying contractor shall submit six (3) complete submittal sets. Each set shall consist of the following:
- G. Shop Drawings: Detail the system including the following:
 - a) Cabling Diagrams: Single-line block diagrams showing cabling interconnection of all components for this specific equipment. Include cable type for each interconnection.
 - b) Wiring Diagrams: Power, signal, and control wiring.
 - c) Station Installation Details: For built-in equipment; dimensioned and to scale.
 - d) Equipment Cabinet Drawings: Dimensioned and to scale

- II. Coordination Drawings: Detail system components that fit, match, and line up with provisions made for equipment specified in other Sections
- III. Manufacturer Certificates: Signed by manufacturers certifying that disable toilet alarm system equipment complies with requirements.
 - 1. Manufacturer's Warranty Statement.
 - 2. Field Tests Reports and Observations: Include record of final adjustments certified by Installer.
 - 3. Operation and Maintenance Data: For disable toilet alarm system equipment to include installation, operation, and maintenance manuals , include the following:
 - a. Operating instructions.
 - b. Troubleshooting guide.
 - c. Wiring diagrams and terminal identification.
 - d. Equipment parts list.
 - e. Product data for types and sizes of wires and cables used.

1.4 COORDINATION

Coordinate wiring paths and maintenance access at locations listed below. Coordinate trim features and finishes at these locations to present a unified design appearance.

- 1. Pull cord
- 2. Reset button
- 3. Zone light

1.5 WARRANTY

The installing manufacturer's representative shall guarantee all labor, parts, and installation for a period of 1 year from substantial completion or first beneficial use of the system. Provide manufacturer two (2) year warranty for accessories

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: an experienced installer who is an authorized representative of the equipment manufacturer, for both installation and maintenance of units required for this Project, to supervise installation of the system.
- B. Systems installations are to comply with the respective local regulations system. System materials, outlets and equipment are to be the standard products of manufacturers and compatible with UL-1069 listed and IEC standards for electronic circuitry and components, and/or Local Standards.

C. REFERENCES

- NEC – National Electrical Code - NFPA 70 and 99 ADA – Americans with Disabilities Act
- NEMA – National Electrical Manufacturers Association – Installation Standards

1.6 PROJECT CONDITIONS

- Environmental Limitation: system components are equipped and to be rated for the environments where installed.
 - 1. Service Conditions for Indoor Equipment: rate equipment for continuous operation under the following environmental conditions, unless otherwise indicated:
 - a. Temperature: 1.5 deg C to 45 deg C.
 - b. Relative Humidity: 50 percent.

1.7 COORDINATION

- A. Coordinate layout and installation of equipment and suspension system components with other construction that penetrates ceilings or is supported by them.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 related Sections.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 related Sections.
- B. Work shall include supplying 2 years spare parts for the system as per manufacture recommendations.

PART 2 - PRODUCTS

MANUFACTURERS

- A. Available Manufacturers: Manufacturers shall provide the products in compliance with the requirements of the specifications and to be incorporated with the Work are listed below or approved equal:
 - 1- Zeta
 - 2- Honeywell
 - 3- Cooper

2. SYSTEM DESCRIPTION

Provide a complete turn-key disable toilet alarm system operating as an integrated solution.

2.1 Pull-Cord Unit.

- a. Six (6) foot, cut-to-length, PVC pull-cord for call placement with plastic cord guide and large easy to pull plastic "bell" attached.
- b. Call from station may be configured to be canceled remotely from panel.

- c. Unit shall mount in a standard UL recognized

2.2 Zone Light unit.

- a) Programmable to indicate the highest level call within zone light areas using maintenance free LED indicators of the following colors: white and red. Depending on the call priority the indicators can light solid or flash.
- b) Dome Light housing and lens resist damage.
- c) Unit shall mount in a standard UL recognized.

2.3 Reset button unit

- a. A cancel button,
- b. Cancel button shall cancel any call.
- c. Call from station may be configured to be canceled remotely from panel ,
- d. LED to illuminate the station in low ambient light conditions.
- e. Unit shall mount in a standard UL recognized.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cable. Check raceways, cables trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- C. Examine walls, floors, equipment bases, supports for suitable conditions where equipment is to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Wiring Method:

- A. Install wiring in raceway except within consoles, desks, and counters; and except in accessible ceiling spaces and in gypsum board partitions, where cable wiring method may be used. Use UL-listed plenum cable in environmental air spaces including plenum ceilings.
- B. Install cables without damaging conductors or jacket.
- C. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.
- D. Pull cables without exceeding cable manufacturer's recommended pulling

tensions.

- E. Pull cables simultaneously if more than one is being installed in same raceway.
- F. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
- G. Use pulling means, including fish tape, cable, and basket-weave wire or cable grips that will not damage media or raceway.
- H. Identification of Conductors and Cables: Retain color-coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams. Label stations, controls, and indications using approved consistent nomenclature.
- I. Grounding Provisions: Comply with requirements in Division 16 Section "Grounding and Bonding for Electrical System"

3.3 FIELD QUALITY CONTROL

- A. Inspection: verify that units and controls are properly installed, connected, and labeled and that interconnecting wires and terminals are identified.
- C. Test Schedule: schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
- D. Operational Tests: perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
- E. Electrical Components, Devices, and Accessories: Listed and labeled according defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with NEC as applicable to construction and installation of system components and wiring.
- G. Conform to NFPA 70.

3.4 CLEANING

- A. Clean installed items using methods and materials recommended by manufacturer.
- B. Clean system components, including antennas and supports, head-end equipment, distribution components, and outlets.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain television equipment.
 - 1. Train Owner's maintenance personnel on procedures and schedules for troubleshooting, servicing, and maintaining equipment.
 - 2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.
 - 3. Demonstrate programming and tuning of satellite receivers.
 - 4. Review data in maintenance manuals. Refer to the general and special conditions of contract Section "Operation and Maintenance Data."
 - 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 - 6. Conduct a minimum of eight hours' training as specified in instructions to Owner's employees in the general and special conditions of contract Section "Contract Closeout."

3.6 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: when requested by Owner within one year of date of Substantial Completion, provide on-site assistance in tuning and adjusting the system to suit actual occupied conditions and to optimize performance. Provide up to two adjustments at Project site for this purpose, without additional cost.

END OF SECTION 281355

SECTION 28 23 00 – IP SURVEILLANCE CCTV

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Contract

1. General provisions of the Contract, including Conditions of Contract, apply to this Section.
2. In particular, refer to these documents for all elements related to costs and responsibility related to delivery, storage, and roll-out phase.

B. Related Sections

1. Requirements of the following applies to this Section:
 - a. Division 26 Section “General Requirements”.
 - b. Division 26 Section “Basic Materials and Methods”.
 - c. Division 26 Section “Structured Cabling”.
 - d. Division 28 Section “IP Access Control System”.

1.2 DEFINITIONS

- a. CCTV: Closed Circuit Television.
- b. EMI: Electromagnetic Interference.
- c. EN: European Standard.
- d. FTP: File Transfer Protocol
- e. GUI: Graphical User Interface.
- f. HMI: Human Machine Interface.
- g. IEC: International Electro-technical Commission.
- h. IP: Internet Protocol.
- i. ISO: International Standard Organization.
- j. LAN: Local Area Network.
- k. MTTR: Mean Time To Repair.
- l. iSCSI: Internet Small Computer Systems Interface
- m. NVR Network Video Recorder
- n. PTZ Pan - Tilt - Zoom
- o. RAID Redundant Array of Independent Disks
- p. FIBRE Fiber Optic Interface
- q. FoV Field of View
- r. FPS Frames Per Second
- s. MJPEG :Video Codec “Motion JPEG”

- t. MPEG4: Video Codec defining audio and visual digital data compression
- u. RAID-0 ;Block Level Striping without Parity or Mirroring (Min. 2 Drives)
- v. RAID-1: Mirroring without Parity or Striping (Min. 2 Drives)
- w. RAID-5 :Block Level Striping with Distributed Parity (Min. 3 Drives)
- x. RAID-6 : Block Level Striping with Double Distributed Parity (Min. 4 Drives)
- y. RAID-10 (1+0) :for Mirroring without Parity and Block Level Stripping (Min. 4 Drive)
- z. TB:Terra Bytes
- aa. VMS Video Management System
- bb. SLA: Service Level Agreement.
- cc. UL: Underwriters Laboratories.
- dd. UPS: Uninterrupted Power System.
- ee. UTP: Unshielded Twisted Pair.
- ff. VLAN: Virtual LAN.
- gg. VPN: Virtual Private Network.
- hh. WAN: Wide Area Network.
- ii. WWW: World Wide Web.

1.3 SUMMARY

- A. This Section includes the specifications for a fully integrated IP Surveillance System including but not limited to
 - 1. IP Cameras
 - 2. Server with Monitoring / Management Software Applications
 - 3. Integrations to External Systems (e.g., Access Control, BMS etc)
 - 4. Workstations
- B. Objectives
 - 1. The IP Surveillance System is mainly used for:
 - a. Operation purposes,
 - a) Effectively monitor critical areas such and restricted areas
 - b) Prevent break-ins and dishonest insurance claims
 - c) Quickly evaluate incidents and take appropriate actions
 - d) Remote monitoring with access to live and recorded video from any authorized computer
 - e) Automatic alarms in case of camera tampering and trespassing
 - f) a cost-efficient and scalable system that facilitates all handling and investigations of their recorded video.

g) real-time monitoring of the environment, people, and assets, and provides a recorded archive for investigative purposes.

2. The functions of the IP Surveillance System consist of:

- a. Facilitating the coordination of the operations,
- b. Supplying staff with video information improving their conception of the project premises,
- c. Monitoring the flow of people in, out, and within the project premises, entrances, corridors... etc
- e. Monitoring of zones for the Fire Alarm System,
System shall integrate with the following systems:
 - 1- Access control system.
 - 2- Security system.
 - 3- Fire alarm system
 - 4-BMS system....
- f. Recording and storage of images Provides access to video at any time from any network location within the constraints of available bandwidth, allowing remote monitoring, investigation, and incident response through remote physical security staff or law enforcement personnel.
- g. Network-wide Management—IP cameras and servers are monitored and managed over a single network for fault, configuration, and centralized logging
- h. The operator can record scenes from project cameras for periods up to 24 hours per day for 30 days

1.4 SYSTEM DESCRIPTION

A. Overview of Current Environment

B. Requirements of The project for IP Surveillance

C. Purposes

1. The present document is to describe the IP Surveillance active infrastructure to be installed as part of the project IT systems.
2. 25% spare capacity is required at all levels of the system.
3. The software licensing shall be for the entire network with no limitation on the number of workstations or standard end-users.

D. Scope of Works

1. The Scope of Works shall include, but not limited to, detailed engineering, coordination, manufacture, supply, transportation, delivery, installation, testing, commissioning, setting to work, training and maintenance services during the 24-month Warranty Period, Operation and Main tenance services for the IP Surveillance active infrastructure of The project IT systems. This shall include at least the following tasks:
 - a. Coordination with contractors, and providers of interfaced systems,
 - b. Project management,
 - c. Planning management,
 - d. Detailed functional analysis until approval by the client,
 - e. Finalization of system to the approval of the client,
 - f. Detailed software specification to the approval of the client,
 - g. Delivery of the interface control document to the approval of the client,
 - h. Software development, complying with the detailed software specification,
 - i. Supply of needed IP Surveillance equipment and components,
 - j. Transport, unloading, and storage on the site of the required equipment and components,
 - k. Equipment installation,

- l. Software installation and configuration,
 - n. System integration with interfaced and existing systems,
 - o. Complete testing of the system (unit tests, integration tests, final acceptance tests, users tests, etc.),
 - p. Training,
 - q. System implementation in the project premises,
 - r. System roll-out,
 - s. System maintenance after successful initial proving period during Warranty,
 - t. Supply of spare parts for 2 years,
 - u. System maintenance tools delivery,
 - v. Writing and delivering of documentation (user's manual, maintenance manual, test reports, etc.),
 - w. Operation and Maintenance as an option to the client.
2. Technical specifications and architecture principles are generic and can be used to future extensions.
 3. Specific Requirements:
 - a. Manufacturer technical validation and endorsement of the design documentation and implementation shall be provided.
 - b. Risk analysis on the design with advantages and drawbacks will have to come from the Manufacturer.
 - c. Post deployment auditing by Manufacturers shall be specified in the documents,
 - d. Submission of credential of the trainers shall be approved by the Manufacturer and by the client.
 4. The Contractor shall be responsible for the provision of the licenses for all software, programs and modules provided for the works including those developed and modified by the Contractor. The appropriate licenses supplied by the Contractor shall enable the Employer to use, modify, and develop the software, programs and modules for the works supplied under this Contract. The software licensing shall be for the entire project with no limitation on the number of workstations or standard end-users.

E. Coordination

1. Coordinate Works of this Section with the Employer's:
 - a. Departments, contractors, organization, etc.
 - b. Construction and implementation works.
 - c. Structured cabling network, both for technical room configurations and for connectors' type (electrical and optical).
 - d. Active communication and data processing equipment.
 - e. Fiber optic cabling infrastructure.
 - f. Workstations and servers suppliers.
 - g. IT systems providers using the data network active infrastructure.
 - h. Others (list given above not exhaustive).
2. Meet jointly with representatives of above concerned organizations, contractors, and Employer's Representative to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.
3. Record agreements reached in meetings and distribute record to other participants.
4. Adjust arrangements and locations of equipment and way of wiring closets to accommodate and optimize arrangement and space requirements.

F. Variant and Options

1. The Contractor should propose no variant.
2. Options consisting in additional provisions to the basic system may be submitted to the Employer for approval, with specifications, characteristics, aiming and full particulars of calculations and equipment selections. All options shall be priced separately.

G. Operational Constraints

1. The system will run 24 hours per day, all the days of the year.

1.5 SUBMITTALS

A. Design Submission: Shall include, but not limited to:

1. Equipment Datasheets must include (at least) the following information:
 - a. Product performance and existing features,
 - b. Environment requirements (Power, temperature, humidity temperature ... etc.),
 - c. Features, software application / license and hardware releases roadmap on the next 5 years,
 - d. Standardized tests passed and results and available product certificates,
 - e. Product compatibility matrix with other manufacturers/vendors (specify level of testing in operation, lab test, declarative or theoretical),
 - f. MTBF.
2. System Requirement and Design Specification
 - a. System Architecture and justification.
 - b. Justification of performance requirements.
3. Management software datasheets must include (at least) the following information:
 - a. Product performance and existing features,
 - b. Known limitations (number of network elements managed, number of administrators, number of clients, size of the database, etc.),
 - c. Hardware requirements (storage, computation, processor needs, operating system, display, etc.),
 - d. Features and software releases for the next 5 years,
 - e. Standardized tests passed and results and available product certificates,
 - f. Product compatibility matrix with other manufacturers/vendors (specify level of testing in operation, lab test, declarative or theoretical).
4. Installation, configuration, integration and support offers must detail:
 - a. Level of qualification of the personnel involved. Detail if some parts shall be subcontracted.
 - b. Training program provided by the Manufacturer to the Contractor teams and related certificates.
 - c. Project structure and localization during operations (distinguish local and remote teams).
 - d. Detailed responsibility matrix for a task by task responsibility assignment.
5. Technical documentation and troubleshooting guides shall be provided in English, both paper and electronic version, for each type of equipment in the offer.
6. Product Certificates: signed by Manufacturers certifying that products furnished comply with requirements.
7. Human Machine Interface (HMI) Design:
 - a. For dedicated Workstation users.
 - b. For standard end users.
8. Software Requirement and Design Specification:
 - a. Software Architecture and justification (e.g.: off-the-shelf and specific software, etc.).
 - b. Justification of performance requirements.
9. Test Plan:
 - a. The Contractor shall provide Test Plan on the testing methodologies used for various tests involved throughout different stages of the Works. This shall also include the plan for integrated tests for interface with other systems. The Contractor shall submit the Test Plan for approval by the Employer's Representative.

- b. Test program shall be part of the test plan.
- c. In establishing the test program, the Contractor and the Employer's Representative shall agree which activities shall be attended by the Employer's Representative.
- d. After approval, the Test Plan shall be amended as required during the life of the Project to reflect changes in system design and the identification of additional testing requirements.

10. Maintenance and Warranty offers must detail:

- a. Comprehensive cost structure according to committed GTI, GTR and MTBF.
- b. Maintenance stock dimensioning.
- c. Distinguish maintenance during warranty period and after.
- d. Teams' organizations (distinguish local and remote teams, give associated manpower).
- e. Hardware repairs and software patch support procedures.

B. Project Schedule

1. Provide a detailed Build Plan that includes, but is not limited to:

- a. All activities required to deliver a production ready network to the project.
 - 1) The duration of each activity in days,
 - 2) The resources required to complete each activity,
 - 3) Any dependencies amongst activities,

C. Product Data

- 1. Include detailed Manufacturer's specifications and data sheets for each system component.
- 2. Include data on features, ratings, and performance for each component specified.
- 3. For each type of equipment, submit data for approval including part numbers, technical data sheet, and literature, sufficiently detailed for engineering purposes, and with full description of components and operating parameters.

D. Shop Drawings

- 1. Indicate layout, wiring diagrams, and dimensions.
- 2. Locate devices and components on drawings.
- 3. Submit drawings for approval including, but not limited to, the following:
 - a. Detailed system schematic diagram,
 - b. Layout of network components, network management system, etc.
 - c. System labeling schedules, including electronic copy of labeling schedules in software and format selected by the Employer's Representative.
- 4. Complete electrical and physical characteristics of network components, network management system, etc.
- 5. Complete system wiring diagrams, size and type of cables, enclosures, and terminal, splice boxes etc., and routing plans of wiring system.
- 6. Include dimensioned plan and elevation views of components. Show access and workspace requirements.

E. System Operation Description

- 1. Include method of operation and supervision of each component and each type of circuit, and sequence of operations for manually and automatically initiated system inputs.
- 2. Description must cover this specific Project; Manufacturer's standard descriptions for generic systems are not acceptable.

F. Manufacturer's Installation Instructions

1. Provide Manufacturer's installation instructions.
2. Certificates signed by Manufacturers of equipment certifying that the provided products comply with contract specified requirements.

H. Licensing

Licenses shall be required for IP surveillance equipment such as (IP cameras, Major software releases for the NVR, Servers, workstations, encoders/decoders). The licensing shall include an automated online registration which shall be available from the manufacturer to support updating licenses upon demand and delivering electronically via email. CCTV license shall be available up to 3 years without any update.

G. Product Certificates

1. The Contractor shall provide certificates signed by Manufacturers of components certifying that the provided products comply with requirements.

H. Tests and Certificates

1. Test specifications as defined in the Test Plan shall be submitted for Approval.
2. Submit complete certified Manufacturer's type and routine test records, in accordance with the Standards specified in "Quality Assurance" Article.
3. It shall specify test results for compliance with performance contract requirements.
4. Include record of signal ground resistance measurement certified by the Contractor.

I. Field Test Reports

1. As specified in "On-Site Tests and Inspections" Article of this Section, the Contractor shall indicate and interpret test results for compliance with system description and performance requirements.

J. Qualification Data

2. For firms and persons specified in "Quality Assurance" an article shall be written to explain and demonstrate their capabilities and experience.
3. To 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 the Employer's Representative.
4. An experienced Contractor, which is an authorized representative of the Manufacturer, for both installation and maintenance purpose, is formally required for this Section.

K. Record (As-Built) Drawings

1. Complete wiring diagrams, including complete terminal strip layout and identification, and wire termination and tagging for all conductors.
2. Locations for all components installed and/or connected to under this specification.

L. Sample Warranty

1. Copy of Manufacturer's proposed warranty, stating obligations, remedies, limitations, and exclusions.
2. Provide copy of sub-contractor's warranty certificates.
3. Provide Contractor's warranty certificates.

M. Maintenance Data

1. For products and systems, the Contractor shall include maintenance manuals.

The Contractor shall include data for each type of product, including all features and operating sequences, both automatic and manual.

2. The Contractor shall include user's software data and recommendations for spare parts and components to be stocked at project site.

1.6 REGULATIONS AND STANDARDS

A. Rules

1. The Works shall be conformed to requirements of referenced industry standards, applicable Sections.
2. The Works shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Employer's Representative, in writing.
3. Conflict: Should an instance occur in this Specification and referenced Sections in which equipment, components, material or construction methods called for is less than minimum requirement of the referenced industry standards, rules, local regulation, etc., the Employer's Representative shall be immediately informed in writing. Consequent to the Employer's Representative's approval, supply the equipment, components, material and perform the work as through called for to minimum code standards.

B. Standards

1. Standards to be used is the IEC or other equal and approved codes, taking into account that network cables with fitted accessories and connector and wiring have to be of fire rated type in accordance with all NFPA requirements codes (NFPA72 and extensions).
2. System components, parts, and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).

C. Precautions

1. The above list is a partial list issued from standard organizations. Additional consideration may be required to provide protection of equipment and protection of data from intrusion, induced noise or other events that can disrupt vital operation.
2. System equipment and material shall be as per any of the following or any other similar codes:

UL- Underwriter's Laboratories Inc

UL983 UL 1410 Surveillance Cameras Television Receivers and Video Products

ANSI- American National Standards Institute ANSI 208

Other References shall include: 1. Electronic Industries Association – EIA

International Electro-technical Commission – IEC

Institute of Electrical & Electronic Engineers - IEEE

International Organization for Standardization- ISO

International Telecommunication Union- ITU

All equipment shall be manufactured by ISO 9000 certified companies.

1.7 QUALITY ASSURANCE

A. Requirements

1. All Works shall be executed and controlled by a quality management system in accordance with the requirements of ISO 9001.
2. This system shall comprise all the participants to the Contract within the Contractor's teams and its sub-contractors.
3. The Quality Assurance Plan is based on quality manuals of the Contractor and subcontractors.

The Contractor nominates from the beginning of the Project, the person in charge of quality assurance of the whole project, who is directly linked to the Project Director. The Contractor should establish from the beginning of the Project, the Quality Assurance Plan based on Contractor's quality system that should define:

- a. Scope of Quality Assurance Plan, with conditions of validity and revision,
- b. Approach and structure of the Contractor's quality management system to fulfill the requirements of the Contract and ISO 9001,
- c. Organization retained for the Project with sub-contractors list,
- d. Details of how the Contractor proposes to manage sub-contractors and to ensure that the relevant quality system requirements of ISO 9001/2 are observed and implemented by the sub-contractors in the execution of the works sub-contracted,
- e. The quality plans of the Contractor.

B. Manufacturer Qualifications

1. A firm specializing in providing IP Surveillance Systems, similar to that indicated for this Project and with a record of successful in-service performance for at least 10 years.
2. Manufacturer's systems shall be, as often as possible, a standard "off-the-shelf" package utilizing the latest hardware and software technology. Any major system development effort necessary to meet specified requirements is unacceptable. Even if this system is a new concept, it should not require huge development and shall be based on existing and proven technologies.
3. Manufacturer or factory-authorized agency shall maintain a service center capable of providing training, parts, and emergency maintenance and repairs for overall system at Project site with eight hours of maximum response time.

C. Installer Qualifications

1. An experienced Installer who is an authorized representative of the equipment Manufacturer for both installation and maintenance of Manufacturer's equipment, and who has completed system installations similar in design and extent to that indicated for this Project, with a record of successful in-service performance for at least 10 years.

D. Materials and Workmanship

1. They shall conform to the latest issue of all industry standards, publications, or regulations referenced in this Section, including the following, as applicable:
 - a. Regulations and Standards: System components, parts, and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).
 - b. Compliance with Local Requirements: Comply with applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Employer's Representative, in writing.
 - c. Conform to requirements of referenced industry standards, applicable Sections.

E. Source Limitations

1. For each category of technology used for the IP Surveillance infrastructure, obtain system components from one Manufacturer who shall assume responsibility for the system components and for their compatibility.

1.8 COORDINATION

- A. Coordinate Work of this Section with Employer's existing:
 - 1. Routers/Switches/Servers/Workstations/Gateways.
 - 2. WAN/LAN passive network suppliers.
 - 3. Infrastructure and cabling contractors.
 - 4. Etc.
- B. Coordinate with The project to confirm location of equipment, devices and system components.
- C. Meet jointly with representatives of concerned organizations, contractors, and Employer's representative to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.
- D. Record agreements reached in meetings and distribute record to other participants.

1.9 TESTING AND REPORTS

- A. The Contractor shall test all components and cabling of the IP Surveillance system after installation to ensure functionality and performance within industry approved guidelines.
- B. A written report shall be submitted describing testing procedure and detailing test results.
- C. The Contractor shall provide and supply all necessary technical and skilled manpower, tools, test equipment, materials and transportation required for performing system and components testing.

1.10 RECORD DOCUMENTATION

- A. Operation and Maintenance Manuals
 - 1. The Contractor shall submit full system documentation for the installed system and all ancillary equipment.
 - 2. System documentation shall consist of:
 - a. A complete set of product data sheets for all component and parts.
 - b. A complete set of operations manuals for all components of the system.
 - c. Maintenance manuals for all components of the system and for the system as a whole.
- B. Test procedure, data and results from acceptance testing.

1.11 WARRANTY

- A. Special Warranty
 - 1. Manufacturer's Warranty: Provide written warranty, signed by the Manufacturer and the Installer agreeing to replace system devices and equipment that fail in materials or workmanship within specified warranty period.
- B. Experimental Period
 - 1. There shall be an experimental period of 90 days after successful testing and commissioning of the system, but before issuance of substantial completion certificate. During this period, the Contractor shall undertake supervision and responsibility for operation of the system under actual site conditions. If any malfunctioning or anomaly noted on the system during this period,

it shall be attended immediately. The experimental period will restart automatically from the date of clearing such troubles and start normal operation.

2. During this period, the Contractor shall fully demonstrate the system performance under actual operation conditions. This demonstration is to confirm, to the satisfaction of the Employer's Representative, that the system is free of remarks and is ready for provisional taking over.
3. After the satisfactory completion of this period, the system is to be taken over by the Employer, as per Contract Conditions, whereby the Warranty Period is to commence.

C. Warranty Period

1. Two years from the satisfactory completion of the Experimental Period.
2. During the Warranty Period, the Contractor shall undertake Maintenance actions as defined in the Maintenance and Warranty Article.
3. During the Warranty Period, the Contractor shall provide, at its own cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.

1.12 COMMISSIONING

A. Purpose

1. In-System Commissioning
 - a. The Contractor is responsible for the equipment installation in the system, so that the system stays globally functional. Therefore, equipment commissioning must be done through demonstration of product capability and compliance with requirements when wired and configured in the system.
 - b. Test system and power supply redundancies by unplugging redundant links.
 - c. Check recovery times.
2. The Contractor shall be required to perform a range of Site Acceptance Tests on site for each individual sub-system to demonstrate that all items have been correctly installed and adjusted on a location by location basis and that the sub-system operates in every respect in accordance with the Specifications.
3. During this phase the equipment are powered and the automation and networking are gradually integrated layer by layer.
4. The tests shall be performed by the Contractor and witnessed by the Employer's Representative.
5. Any defects, which may become apparent during the course of these tests, shall be immediately rectified by the Contractor at his expense.
6. The Site Acceptance Test Specifications shall be prepared by the Contractor and submitted for Approval.
7. All Site Acceptance Tests shall be carried out in the presence of the Employer's representative who shall sign off the testing documentation on satisfactory completion of the tests.
8. The Site Acceptance Test Specifications, at every level, shall be subjected to configuration management and change control by the Contractor.
9. If modification or reprogramming is required as a result of the tests, all affected parts of the Site Acceptance Tests, as determined by the Employer's Representative, shall be re-tested.
10. The results of the Site Acceptance Tests, version of software and hardware tested, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representative.

B. Tests

1. Those tests are divided into 2 sub-phases.

2. Preliminary Testing:
 - a. Mechanical:
 - 1) Mechanical tests,
 - 2) Calibration of the components.
 - b. Automatism / Electrical:
 - 1) Powering Tests with electricity,
 - 2) Control of Input/Output,
 - 3) Control of the safety measure either personal or material,
 - 4) Test of local mode operation.
 - c. Network / Software Tests:
 - 1) Test of the Network,
 - 2) Test of the Supervision Workstation user interface,
 - 3) Test of the portable Terminal user interface.
3. Test of the System:
 - a. The tests performed during this phase are performed with and without loading conditions.
 - 1) Testing the crippled mode (Safe shut down consecutive to loss of energy, etc.),

1.13 MAINTENANCE

A. Support

1. The Contractor must offer a comprehensive explanation of its Service Level Agreement (SLA) policy. The SLA should cover at least the following performance terms:
 - a. 99.999% availability.
 - b. Emergency level 24/24, 7/7 phone support shall be available. Distant intervention on system must be offered.
 - c. High-level problem investigation support must be offered 5/7 during working hours.
 - d. Maintenance stocks must be properly sized by the Contractor in order to match operational quantities replacement needs given Manufacturers MTBFs for each equipment and components within the network.
2. Maintenance service must include:
 - a. Contract lifetime software patching for revealed problems during operations.
 - b. Contract lifetime hardware replacements on established malfunctions or weaknesses generating repetitive loss of service quality
 - c. Repairs in reasonable time for factory returned equipment.

B. Maintenance Service

1. During the Warranty Period, Manufacturer or factory-authorized agency shall maintain a service center capable of providing spare parts and emergency maintenance and repairs for the overall system at Project site 7 days a week and 24 hours a day. Competent personnel shall be dispatched to rectify stoppages at any time during the day or night when being called on by the Employer.
2. The Contractor shall submit a Service-Call Report to be sent to the Employer immediately following every call out, indicating the time of call out visit, cause, remedial action taken and the time that the service was restored.
3. A Maintenance Manpower Plan shall demonstrate the Contractor's committed resource level available for all types of activities to be carried out within the Warranty Period. Such plan shall be submitted for Approval six months before commencement of the Warranty Period.

4. The Contractor's response time, during the Warranty Period, shall not exceed 1 hour. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.
5. During the Warranty Period, the MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on site, but shall exclude the response time.
6. During the Warranty Period, the monthly average of the Repair Time shall be lower or equal to six minutes for each device. This performance will be checked.
7. The Contractor shall liaise with the Employer's Representative and carry out safety and performance inspections for the installation on site. Any necessary adjustments to the installation shall be made within 14 days of completion of such checks. A Safety and Quality Report shall be submitted, no later than 14 Days after such safety and performance checks, for the Employer's Representative's approval.
8. The Contractor shall provide at least four inspection visits at six-month interval during the Warranty Period.
9. The Contractor shall be responsible to clear away from the Site all surplus materials, rubbish, temporary works of every kind and leave the whole of the Site and installation clean and in a workmanlike condition to the satisfaction of the Employer's Representative, upon completion of each item of the repair, and maintenance works.

C. Maintenance Performance Data

1. Updates
 - a. The system will have to be conceived to facilitate the updates that will take place throughout its life. The replacement in exploitation of a version of software by the following one must be an easy operation, without risk, rapid and reversible.
 - b. This update shall be transparent for the user and shall be done without interruption of the service.
2. Corrections
 - a. In the event of error, the system shall have, as soon as possible, to store in a file a certain number of information allowing the correction of this error, e.g. entries in the transactions, faulty operations of the statistics, etc.

1.14 GLOBAL SYSTEM REQUIREMENTS

A. General

1. Coordinate the features of material and equipment so they form an integrated system. Match components and interconnections for optimum future performance.

B. Expansion Capability

1. Unless otherwise indicated, provide equipment extensions capabilities for five years after each equipment delivery. The Contractor shall inform the Employer when extension limit is to be reached. Extension limit means:
 - a. Equipment in a given area unable to accommodate 20% further increase in network elements to connect. Limitation shall be made specific.
 - b. System management tools are unable to accommodate 20% further increase in number of ports or network elements. Limitation shall be made specific.

1.15 SPARE PARTS AND EXTRA MATERIAL

- A. Contractor shall provide Manufacturer recommended spare parts for all major components in the system for two years fault free operation.
- B. However, a minimum of 2% peripherals of each type installed, but not less than one from each type shall be included in the deliverable irrespective of Manufacturer recommendation.

- C. During the Warranty Period, the Contractor shall provide, at his cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.
- D. The Contractor shall guarantee the flow and availability of the spare parts without a major design change for at least ten years period.

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:

- Honeywell- USA
- AXIS- Swedish
- American dynamics-USA
- Pelco- USA
- Bosch -Holland

2.2 SYSTEM REQUIREMENTS

- A. General: Fully integrated system with all low current systems like, another security, fire alarm, BMS, parking control and communication systems... etc

Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance. Cameras, Servers, Storage units, VMS software, workstations, printers, and shall be from one of the most reputed Manufacturers and the Manufacturer's choice shall be coordinated under the full responsibility of Contractor.

2.3 IP CAMERAS REQUIREMENTS

2.3.1- A network camera is a device including the followings:

A - IP Fixed Dome /BOX Camera:

- Specifications:-
 - a. 1/3" CMOS, 5MP resolution, Full HD resolution, High quality image.
 - b. True Day/Night (TDN)
 - c. IR – infra red
 - d. FOV : 50 m
 - e. True wide dynamic range
 - f. Minimum Illumination (Lux) : 0 lux @ F 1.2 Color; 0 lux B/W
 - g. Motion detection: Yes
 - h. Multiple video stream not less than dual streams.
 - i. Support ONVIF Open standard
 - j. H.264 and MJPEG-4 video compression provides excellent image clarity
 - k. Max Frame Rate: 25 fps
 - l. Resolutions: 5MP (2560x1920), 1080p (1920x1080), SXGA (1280x960), 720p (1280x720), SVGA (800x600).
 - m. Lens Focal Length: auto iris, varifocal lens,
 - n. White Balance. ATW
 - o. Alarms: Motion detection
 - p. Alarm Input: 1
 - q. Network Ethernet: RJ-45 connector, POE or POE+
 - r. Support protocols: unicast and multicast
 - s. Operating Humidity. 0% to 75%
 - t. Storage Temperature. -20°C to 60°C
 - u. Vandal-resistant, tamper proof,

B. Cameras types:

- a. Type 1: Indoor/Outdoor, fixed, (vandal resistant, tamperproof) and true day night mini dome/Box camera.
- b. Type 2: Indoor/Outdoor, high speed, -(vandal resistant, tamperproof)
- c. All outdoor cameras should be IP65

C. Camera Housings and Mounts: the housing is to provide long term protection of cameras, lenses, control electronics and accessories. It shall be designed to withstand direct solar heat and ambient condition (dust-tight and waterproof).

- a. Wiring to all cameras shall pass from the back box through the mount and into the housing. Exposed wiring of any kind shall not be acceptable.
- b. Provide sun shields for camera housings in outdoor locations exposed directly to sunlight.
- c. Provide lightning protection for all exterior cameras.
- d. 10/100 base T. M.
- e. Software: The IP camera shall be equipped with built-in software for:
 - f. Web server.
 - g. FTP server.
 - h. FTP client.
 - i. E-mail client.

2.3.2. IP Movable PTZ camera:-

- a. 35x PTZ, 2MP resolution for full HD resolution for high quality image
- b. True Day/Night (TDN)
- c. Minimum Illumination: 0.01 lux @ F1.2 color; 0.01 lux b/w
- d. Motion detection : yes
- e. Multiple video stream not less than dual streams
- f. Support ONVIF open standard
- g. H.264 and MJPEG-4, video compression provides excellent image clarity
- h. Max Frame Rate: 25 fps
- i. Resolutions : 1080p (1920x1080), SXGA (1280x960), 720p (1280x720), SVGA (800x600), D1 (720x480), 4CIF (704x480), VGA (640x480),
- j. Lens Focal Length : Varifocal, Auto iris,
- k. White Balance, ATW
- l. Alarms : Motion detection
 - a. Alarm Input : 1
- m. Wide Dynamic Range: True WDR
- n. Support protocols : unicast and multicast
- o. Network
 - a. Ethernet: . RJ-45 connector, POE+ or UPOE
- p. Operating Humidity : 0% to 70%
- q. Storage Temperature.: -20°C to 60°C
- r. Pan Travel 360° continuous

2.4 NVR (Network Video Recorder)

- The Network Video Recorder shall run on a 64-bit Linux to enable support a secure operating system, ability to run on a wide range of hardware platforms, and operate efficiently as a network appliance.
- The NVR is able to constantly record video from a maximum of 64 High-Definition cameras, each capable for max frame-rate and max resolution.
- The operator can record scenes from project cameras for periods up to 24 hours per day for 30 days.
- Maximum aggregate throughput of 400/480 Mbit/s on recorded video streams
- The NVR shall support dual streaming settings for each camera
- The NVR shall support IP cameras and encoders capable of supporting dual video streams.
- NVR is a software-based, open platform solution that functions as an appliance server and operates on hardened and embedded Linux® operating system.
- The system shall include built-in video loss detection and system diagnostic features. Video loss detection alerts operators of a camera failure. Diagnostic monitoring assists in set-up, programming, and troubleshooting.
- The Network Video Recorder shall synchronize audio and video streams and maintain synchronization within a seconds.
- The Network Video Recorder shall support the completion of a motion search over 2 weeks of available recorded video of a scene containing an average level of motion throughout, regardless of codec or resolution of the recorded video, within seconds.
- Provides ease of installation and a simple wizard mode of operation.
- The NVR shall support the following video compression technologies as native operation:
 - M-JPEG
 - MPEG-4
 - H.264
- The NVR shall have a preinstalled, preconfigured appliance server solution:
- All storage internal and external provides RAID capability.
- NVR shall support HTTPS and SSL security hardening protect against cyber-attacks and other threats
- NVR shall include at minimum: dynamic bandwidth management, video content analysis (analytics), and operation from a single user interface.
- The NVR shall support ONVIF open platform standard,
- The NVR shall support N+1 failover redundancy
- The NVR shall be Rackmount type
- The NVR shall support redundant power supply and RAID controllers in all configurations.
- The NVR shall support the ability to set the maximum recording period per camera
- The NVR shall support camera-by-camera configuration of the following recording modes:
 - Not Recording
 - Continuous Recording
 - Alert-Based Recording only
 - Continuous recording with Alert-based tagging
- The NVR shall support motion detection with up to a maximum of 5 configurable motion alarm rules. Up to a maximum of 64 simultaneous channels set to low sensitivity is supported to generate the motion detection meta-data.
- The NVR shall provide required functionality in the following areas:
- System Performance

- Initial Installation / Configuration wizard
- Video Recording, Live Viewing & Playback
- Audio Recording, Live & Playback
- Event or Alarm Generation / Management
- External Storage
- Supported IP Cameras & Peripheral Devices
- Local Client on supported hardware systems
- Web Client
- Maintenance / Software Upgrades
- SDK for integrations with other systems
- NVR shall provide the ability to transcode high quality high frame rate H.264 video for the purpose of transmitting over narrow bandwidth communication channels and for the purpose of streaming to thick clients or smart phone apps.
- NVR software auto-detects whether a connected client is on a Local-Area or Wide Area Network and automatically, seamlessly switches streaming protocols
- Video intelligence supports at a minimum the following 6 types of configurable alarm rules:
 - Object Detection
 - Object Abandoned/ Removed
 - Direction
 - Linger
 - Enter an area
- NVR shall support fast post recording motion-based video searches over days, weeks or months of video, the NVR shall support generation and storage of motion metadata information from one of the camera's MJPEG or MPEG4 video streams connected to the NVR

2.5 NETWORK MANAGEMENT SYSTEM AND SYSTEM SOFTWARE SERVER /CLIENT REQUIREMENTS

- A. The network management system shall be fully-integrated software server / client allowing users to real time viewing, control, playback, each camera in the system from different nodes within the network.
- VMS solution shall enable ability to install or upgrade a video management system, access control and event management system, Or any security system that supports Video, access control, BMS interfacing and associated security devices.
 - The system shall allow for recording of up to 25 frames per seconds when connected to PAL cameras.
 - VMS shall support ability to institute a password protection that would require unique validated sets of credentials before the feature's operations can be carried out (video search and retrieve, instant playback, clip export) to support privacy rights.
 - VMS shall support dynamically display menu items and controls which are applicable to the system configuration for improved user experience.
 - VMS shall support the simultaneous display and monitoring in the same surveillance window NVR
 - VMS shall install on a hardware platform meeting the recommended specification shall support the simultaneous display of up to 64 video streams across all connected monitors.
 - VMS shall provide the ability to view live and recorded video on the same camera within a single application layout.
 - VMS shall provide a completely user-customizable 'Site View': enabling the organization of cameras, recorders, into user-defined, multi-level folders, similar to Windows Explorer-style file organization. On a large or distributed system, a Site will automatically be created in the Site List.

- VMS shall support the completion of a motion search over days, weeks of available recorded IP video of a scene containing an average level of motion throughout, regardless of codec or resolution of the recorded video, within seconds
- VMS shall allow the user to add additional, related cameras to the View from any motion search result, and shall automatically synchronize the date/time of the added cameras to the original search result (“Investigate mode”).
- VMS shall support access to live video during a NVR fail-over event without any changes on software. After a fail-over event has been resolved, recorded video stored on the temporary NVR fail-over recorder shall be available for search/playback without any changes.
- VMS shall support virtual Pan-Tilt-Zoom control during playback to enhance the usage of megapixel video.
- VMS shall support the ability to provide Client-to-Client “Push” enabling a workstation the ability to “push” any layout (e.g. video, alerts, web site, etc.) to another workstation’s monitor based on roles, security and license settings.
- VMS shall support a Bi-Directional interface to enable ability to easily integrate with other 3rd party systems over a serial or TCP/IP connection.
- VMS shall support database management tools which enable ability to setup rules to regulate the archival to provide enhanced support when using a Microsoft SQL Express database.
- VMS shall support On-Screen Display text within the video panes in the Surveillance windows.
- VMS shall support managing recorded video using the storage video vault to protect any tagged video and/or audio from being data culled.
- VMS shall support advanced integrated mapping that supports standard raster and Auto Cad files. It shall allow creation of one or more layers to organize the objects, custom map icons, video pop-up when hovering over a camera icon or during an event, nest maps, and dynamically show animated state changes of any object with field-of-view cones to identify expected coverage.
- VMS shall support maps to allow visual management of a unified security system. The maps shall be created by importing AutoCAD files (e.g. DWG, DXF) and standard raster image files (e.g. JPG, PNG).
- The VMS shall support the following motion search on a particular camera based on the following criteria:
 - Start date & time
 - End date & time
 - Motion search region
 - Amount of Motion
 - Duration of Motion
 - Motion Search Sensitivity

The VMS shall support the following video intelligence analytic search functions

VMS shall support exporting “tamper-protected” video clips using dual-authentication mechanism.

- VMS shall support unlimited operator configurable events, including the action-based trigger of events.
- The system shall provide 10 event priority levels with pre-defined colors and labels.
- The system shall allow an event to be configured to:
 - Be sortable by event name, date/time, priority, state, and any other displayable information.
 - Require or not require operator acknowledgment.
 - Display an operator-defined text message upon event activation.
 - Allow the operator to associate an audio wave file with the event.
 - Run imports and exports.
 - Run reports and remove report results.
- VMS Event Viewer tab shall be capable of displaying the following features:
 - System clock.

- Date/time when the event was received by the server
- Count of the active events.
- Clear event.
- Clear all events
- Event action message (automatically display selected message for event).
- VMS Event Viewer tab shall provide the ability to view video associated with an event within the same GUI.
- VMS shall allow the user to configure the system as a Virtual Matrix – controlling which cameras, tours are displayed in each pane of each monitor connected to the Client.
- VMS shall support using motion meta-data or embedded video intelligence to provide a bounding box that indicates what caused the alarm to be fired for easy visual identification within the Event Viewer.
- VMS shall support ability to allow any device within the security system (e.g. camera, door, etc.) to be linked to as many as other objects.

The VMS shall support the following database backup and restore functions.

- VMS GUI shall provide easy access to the program information.
- VMS shall support report printing. The report printer(s) may be connected directly to the client PC, or shared over a network.
- VMS shall support as report printer(s) any printer for which a printer driver exists within the host operating system.
- A user-friendly operator interface for monitoring and controlling the system through a Windows environment through the use of a computer mouse.
- Multiple, linked graphical maps including site and building floor plans. Icons placed on graphical backgrounds shall be used to select, control, and monitor each camera in the IP Surveillance System.
- Simple and logical navigation between graphical maps.
- A master graphic to direct operators to more detailed graphics. The GUI shall allow the operator to select the master graphic from any other graphic. Each map shall include camera and monitor icons located within the graphic area, and shall include icons to allow the operator to navigate between other areas near the current map.

2.6 SERVERS REQUIREMENTS

A. The PCs or system workstations are used for surveillance and alarm viewing as well as for data storage
The PCs shall be installed in a console in the control room.

B. The PC or system workstation shall have the following minimum features and requirements:

- a. Screen size as shown on drawings
- b. Processor: latest standard and size at the time of commissioning.
- c. VGA Card: latest standard and size at the time of commissioning.
- d. Network Card: latest standard and size at the time of commissioning.
- e. Keyboard: full size.
- f. Operating systems: Windows, Unix ,Linux.
- g. Operating temperature: +10° C to +55° C.
- h. Operating Voltage: 100/120/220V/240 V AC ±10%, 50 Hz.
- i. C. The system shall support a wide range of automated storage options ranging from as little as a few hours of online storage capacity to keep long-term storage using hard drives, digital tape or other cost-effective long-term storage media. The system shall be capable of supporting unlimited video storage capacity by enabling system operators to periodically remove and replace hard drives, tape cartridge, or other removable storage media.

D. The system shall allow flexible storage architecture for enabling best storage utilization.

E. The storage system shall be equipped with a database mirroring and distributed video storage features, which shall allow the system to sequentially distribute recorded video among the installed hard disks. And therefore, in case of a hard disk failure, the user shall be able to receive a relatively reduced

frame rate, but shall not lose the complete video sequences.

- F. Record and storage capacity shall ensure at least the recording for all the cameras during 30 days continuously. The Contractor shall submit design calculations to justify the selection of the hard disk or other storage media and the capacity and type of the storage library.
- G. Recorded and stored images shall be accessible from any workstation PCs connected directly to the LAN or via dial-up modem connections.
- H. Scheduled Recording Administration:
 - 1. The system shall be able to establish a recording schedule based on hours of the day and days of the week.
 - 2. The system shall be able to specify the times during which each camera will be recorded along with the recording settings to be used during each period including the frame rate, resolution, and quality settings.
- I. The storage system shall be designed to work with the Network Management System in order to send recorded pictures to all monitors or remote workstations on request.
 - 1. Full Automation: The system shall use automated tape libraries or other fully automated solutions for long-term storage so that no operator intervention is required to manage storage media.
 - 2. Specialized Storage Servers: For maximum system configuration flexibility and expandability, long-term storage shall be implemented using separate storage servers. Separate storage servers provide increased system configuration flexibility by allowing multiple storage units to share a single long-term storage device.
 - 3. Shared Long-Term Storage Devices: the system shall enable multiple storage servers to share a single long-term storage device such as a tape library.
 - 4. Immediate Transfer to Long-Term Storage: The system shall be able to copy video selected for long-term storage to long-term storage media as soon as possible after the initial recording.
 - 5. Ability to Catch Up after Storage Server Downtime: If a storage server must be taken out of service temporarily for maintenance, the system shall be able to retain video designated for long-term storage online.
 - 6. Variable Retention Times: The system shall support segmentation of cameras into groups based on video retention requirements so that video is retained for some cameras longer than other cameras. When using digital tapes for long-term storage, the system shall store video files with similar retention requirements together on the same tape so that all video on the tape expires and can be overwritten at approximately the same time.

2.7 ALARMS AND EVENTS

- A. Overview: For the purpose of these Specifications, an “alarm” is any event that can be received or detected by an external equipment (access control for example) or internal (failure for example) and responded to in real time. Many types of events are not “alarms” in the traditional sense of an immediate problem such as a fire or intruder. An event can be any type of activity that may be the subject of future investigation and video review. The two basic requirements for an event are time and location:
 - 1. Time: A signal or data that can be detected or received in real time.
 - 2. Location: A physical location associated with the signal or data that can be related to cameras and camera presets.

All the pictures shall be recorded and stored, continuously or on event. The operation cameras output shall be recorded all the time. The security cameras output shall be recorded on event with pre and post alarm.

- C. Alarm Recording: The system shall be equipped with Alarm Recording function that:
 - 1. Enables the system administrator to define alarm responses including instructions to trigger recording of specified cameras at specified frame rates and quality settings.

2. Enables system administrator to determine the pre-alarm duration.
 3. Record cost-effective low frame rate video during non-alarm periods, and then start recording at high frame rate (real-time) in response to alarm events.
 4. Enables system administrator to determine whether video will be retained on long-term storage media for each continuous or scheduled recording instruction and automatically retain video on long-term storage media when video is recorded as part of a defined response to an alarm event.
- D. Tasks Related to Alarms: The system shall be able to perform the following tasks:
1. Execute video image analysis algorithms (video sensor), including activity detection and video loss detection and generate alarm messages.
 2. Receive signals from alarm inputs and generate alarm messages.
 3. Send alarm messages to the server or program that manages alarm responses.
 4. Process alarm response instructions, change recording modes and control alarm relay outputs.
 5. Forward alarms from a remote node to a central alarm monitoring site, including modem or LAN/WAN communication.
 6. Motion detection feature shall be provided for fixed cameras looking at sensitive areas, in order to initiate alarm when unauthorized movement is detected. The Contractor shall coordinate and check precise location.
- E. Event recording mode shall be used in relation with the Security System for access controlled doors.
- F. The system shall perform the following tasks in response to requests from one or more workstations:
1. Supply one or more live video streams.
 2. Enable one or more users to play back previously recorded video, including “instant replay” of video recorded within the last few seconds.

2.8 INTERFACES

- A. The IP Surveillance System shall be integrated and interfaced to the following systems:
1. Fire Alarm System: The interface with the Fire Alarm System shall allow the control and the local surveillance of each fire alarm zone. The system shall be able to display images as pop up window from the zone in alarm on the screen of the Fire Alarm System operator. The interface shall be compliant with NFPA requirements. The PTZ cameras shall automatically switch to the location of a fire alarm initiation. The alarm initiation shall be either the activation of any manual pull station, monitor module detection for flow switch activation, sensor, etc.
 2. Building Management System: The interface with the Building Management System shall provide the following information:
 - a. Main System ON,
 - b. Main System OFF,
 - c. Main System in Default.
 3. Structured Cabling Network: The system shall be interfaced with the Structured Cabling Network to allow the communication between the Security and Access Control System, work stations, recording and storage servers, Network Management System, and all other interfaced systems through the network backbone.
 4. Access Control system: The system shall be interfaced with the Access control system work to allow the communication between the Security and Access Control System, work stations, recording and storage servers, Network Management System, and all other interfaced systems through the network backbone.

2.9 VIDEO WORKSTATION:

- a. Workstation hardware should be comply with the specification as following but not limited to
- b. Processor: latest standard and size at the time of commissioning.
- c. Monitor Card: dual monitor card, latest standard and size at the time of commissioning.
- d. Network Card: latest standard and size at the time of commissioning.
- e. Windows operating system included
- f. Anti virus software included
- g. Protocols: TCP/IP.
- h. Hardware Redundancy.
- i. Power: Power over Ethernet

2.10 LED MONITOR

- a. LED backlighting
- b. HDMI, DVI, BNC and VGA input
- c. Supports up to 1920 x 1080 (HD) resolution
- d. aspect ratio : 16:9
- e. Brightness :350 cd/m2
- f. Contrast ratio: 3000:1
- g. Video format : NTSC/PAL auto detect

2.11 CCTV CONSOLE:

- a. Console: Contractor shall submit console specifications as per engineer /client requirements, as per the number of monitors/ workstations /persons and follow the below minimum requirements but not limit to

Console is to be of modular design and contemporary styling, solid welded steel construction with concealed mounting screws, having laminated desk top and monitor turret housing, and containing the following:

Monitors

Auxiliary equipment.

- b. Console is to have louvered side panels and interface styling throughout. Sections are to include face mounted 40 mm drop edge wiring surfaces with radius corners. Surface is to include one pair (per section) of support arms 550 mm deep. Supervisor cabinets are to include locking sliding drawer. Surface top and three sides are to be finished in gray linen 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.

- c. Finishes: steel cabinet and console are to be phosphates 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.

2.12 IP MONITOR DECODER DEVICE:

- a. Provides high quality analog video and audio
- b. Sequence mode for multiple video sources
- c. Supports secure management and encrypted video streams
- d. Video decoding Motion JPEG and MPEG-4 (auto detection)
- e. Unicast and multicast connection
- f. Frame rates up to 30/25 (NTSC/PAL) Bit rates
- g. Audio decoding Stereo and mono G.711, G.721, G723
- h. Video sequencing Up to 100 video sources may be preconfigured Manual cycling (video select button)
Automatic cycling (configurable time interval)
- i. Auto-connection on alarm from video source

- j. Supported protocols IPv4, HTTP, HTTPS, SSL/TLS*, TCP, ICMP, RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, ARP, DNS
- k. Operating conditions 0-60 °C
- l. Humidity: 20 - 90% RH

2.13 VIDEO WALL CONTROLLER SOFTWARE :

- A. The Video Wall Software (VWS) shall allow users to display High Definition inputs and displaying
- B. The software shall support multiple clients for dynamic collaboration.
- C. High Definition outputs on a video wall of up to 40 monitors.
- D. The software shall be networkable configuration.
- E. A. The software shall give individual operators the ability to manage multiple display walls from their computers.
- F. Multiple operators shall be able to work simultaneously on any of the display walls in the control room using their mouse as a remote pointer directly on the display wall.
- G. The software shall provide for ease of saving and retrieval of layout configurations.
- H. The software shall allow individual remote operators, running CWS, to send a clone of any client' s desktop to the display wall in a picture in picture manner.
- I. The size and position of this window can be easily modified.
- J. The software shall extend their desktop surface to the entire display wall area or to a portion of it. This allows them to run an application from their own computer, but using the large number of pixels available on the display wall.
- K. Software Protection - The VWS shall ship complete with the hardware and shall be protected with a USB dongle. The VWS software shall run automatically as soon as you start your computer. The VWS will display a unique icon to the right end of the Windows Taskbar when loaded properly.
- L. The (VWS) shall consist of the following primary components:
- M. Upon opening the software the VWS software shall display the Control Workspace Overview
- N. Consisting of the following:
 - O. There shall be a Menu bar at the top of the interface.
 - P. The menu bar shall contain (as a minimum)
 - Q. There shall be a Toolbar just underneath the menu bar.
 - R. There shall be a Resource Explorer section on the left part of the interface.
 - S. There shall be an Operations section on the right side of the interface.
 - T. There shall be a Display Wall Active area in the middle of the interface, between the
 - U. Resource explorer and the operation section.
 - V. The VWS shall automatically display the IP address of the Display Wall Controller.
- W. Display Wall Active Area - as long as the mouse is within the Display Wall Active Area of the interface, the VMW software shall render and keyboard commands active on the Display wall server.
- X. This shall allow the user to open files, type text, and move and resize windows around on the desktop of the Display wall server from VWS client computer.
- D. Virtual Resolution - the VWS software shall activate a Virtual Resolution mode when the F12 key is pressed. This shall give the user a much finer control of the mouse across the whole surface of the display wall.

PART 3 - EXECUTION

3.1 DESIGN

- A. The design of the IP Surveillance System will consist of the following tasks:
 - 1. Needs Analysis - The Contractor shall work with the Employer's Representative, departments, tenants and any other company or organization and determine their exact requirements.

2. Engineering and Design - With the information gathered, the Contractor should determine hardware and software requirements for The fully integrated IP Surveillance System. This shall include the quantities and configuration of the system components and the configuration of the Network Management System.
3. The Contractor shall determine the exact requirements for external communications and interfacing if it is determined that such services will be required for the support of the new system.
4. The Contractor shall coordinate with the other disciplines to ensure that environmental requirements for the IP Surveillance System are met, and to ensure that cabling is installed at the locations specified during the needs analysis.

3.2 PROJECT MANAGEMENT

- A. The Contractor is required to supply a complete description (Project Plan) of the key activities required for the installation of the system.
- B. In the project plan, the Contractor shall include a project organization chart with the reporting relationships of project team members and other key personnel. An escalation matrix should also be included.
- C. It is essential that the installation of the new system be as transparent as possible to the users. There should be no service interruptions and no perceived degradation in the quality of service.
- D. A master project schedule must be included, along with a work responsibility matrix, identifying the tasks the Contractor will perform and the tasks The projects expected to perform to successfully implement the new system.

3.3 FACILITY REQUIREMENTS

- A. The Contractor must furnish all space, power, and environmental requirements for the system.
 1. Space - Provide the physical dimensions of the equipment.
 2. Power - All power requirements, including any special conditioning or grounding requirements.
 3. Heat - The Contractor shall provide heat dissipation calculations for the communication room(s) and the recommended safe temperature operating range for the system.
 4. Floor Loading - The Contractor must provide complete floor loading requirements.

3.4 INSTALLATION

- A. General
 1. Acceptance of works will be restricted to the equipment and installations complying with the approved submittals, approved shop drawings, and the Employer site Engineer agreement.
 2. The Contractor has to carry out any site works under direct supervision of qualified technicians who are to be well trained with qualified Manufacturer experience.
 3. Site workmanship of any network component has to be limited to the layout and fixation, and inter-wiring of various items of the readymade equipment.
 4. In addition to the above, the Contractor is also expected to supply the following:
 - a. Coordination meetings with the Project authorities, the project departments, existing - contractors, etc.
 - b. Progress reports and Progress reviews,
 - c. Insurance for the Transport of the equipment,
 - d. Quality Assurance setup and management,
 - e. Document Management,
 - f. Configuration Management for the duration of the Project,

- g. Off-the-shelf Software updates for the duration of the warranty,
- h. User documentation and training including textbooks,
- i. Worksite expenses (Setup and removal of temporary offices, Worksite vehicles, Site Offices, Computers, Printers, Desks, etc.),
- j. Archival.

B. Site Survey

- 1. Examine all the technical rooms and where equipment are to be deployed:
 - a. Identify equipment location,
 - b. Identify links on patch panels,
 - c. Identify and check general power supply and grounding,
 - d. Procure premises environment characteristics (kW/m², air conditioning characteristics, etc.),
 - e. Make heat dissipation calculation and adjust surface to be used according to rooms environment data,
 - f. Confirm feasibility for each technical room and location before starting to deploy.
- 2. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Examination

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

D. Equipment Data

1. Submit complete technical data including Manufacturer's catalogues and specifications, system description including operational aspects, system features, and components.

E. Shop and Construction Drawings

1. Submit drawings for approval.
2. Constraints to be studied by the Contractor as part of its necessary Shop-Drawing development:
 - a. The integration of the hardware (Equipment, Cables, etc.) shall be studied in such a way to deliver on site a package ready for installation.
 - b. The Contractor shall ensure the full coordination between the IP Surveillance System constraints and other systems or any other interfaced systems.
 - c. The Contractor remains responsible of the proper coordination as to avoid any technical mismatches.
 - d. All the system shall be studied, installed, and tested in order to offer an easy maintenance and access.
 - e. All coordination due by the Contractor shall always cover both Hardware's and Software's. It also covers all aspects of Shop Drawing elaboration, manufacturing, construction, testing, and commissioning, to achieve comprehensive systems in proper and efficient working order.
 - f. The final coordination on site with Civil Works, Facades, Architecture, HVAC, Fire fighting, Electrical and any other construction aspect, remains the duty of the Contractor.

F. Detailed System Schematic Diagrams

1. Exact routing of cables, giving type and size,
2. Exact location of cameras, equipment, components, cabinets, and racks as well as patch panels, etc. in communication rooms.

G. Typical Installation Details of the System Components

1. After installation, the Employer shall be able to perform hardware configuration changes, to redefine any new mapping and modifications as desired without the services of the Installer or Manufacturer.

H. Coordination with Other Works

1. It is under the Contractor responsibility to carry out any coordination between its own installations and other Project entities and systems.
2. The layout shop drawings have to be used as a guideline and need to be improved before any site workmanship.
3. The layout shop drawings are to also reveal the measures taken therein, and every fixation principle, and are to be approved by the Employer's Representative.
4. For this purpose any starting of work shall be subject to the Employer site Engineer approval.

I. Layout of Equipment

1. Equipment is to be laid out properly in communication rooms and other locations in a way to reserve relevant space for maintenance activities. This space shall also include any future expansion of the system.

2. Equipment is to be laid out as per the approved shop drawings.
3. After the proper layout of all equipment is accomplished, all components are to be labeled, and marked according to an approved labeling designations and materials.

J. Installation Instructions

1. Install equipment to comply with Manufacturer's written instructions.
2. More precisely:
 - a. Use listed cable in environmental air spaces, including plenum ceilings.
 - b. Install cable using techniques, practices, and methods that are consistent with a Structured Cabling Network (SCN) category rating of components and that ensure SCN category performance of completed and linked signal paths, end to end. Limit amount of cable untwisting to those defined by the Standard.
 - c. Install cable without damaging conductors, shield, or jacket.
 - d. Do not bend cable in handling or in installing to smaller radii than minimums recommended by the Manufacturer.
 - e. Secure and support cable at intervals not exceeding 750 mm and not more than 150 mm from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - f. Wiring within communication rooms: Provide adequate length of conductors. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by the Manufacturer.
3. Cleaning: after completing system installation, inspect premises. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

K. Wiring Method

1. Install wiring in raceway.
2. Conceal cable and raceway.

L. Splices, Taps, and Terminations

1. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.

M. Impedance and Signal Levels

1. Match input and output impedance and signal levels at signal interfaces. Provide matching networks where required.

N. Identification

1. Identify system components complying with applicable requirements and the following Specifications.
2. Use a unique hierarchical alphanumeric designation in order to label:
 - a. IP Surveillance System equipment and components,
 - b. Ports to terminals connected to the equipment.
3. Provide an identification database (which can be included with the management tool).
4. Color code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.

O. Weatherproof Equipment

1. Install units that are mounted outdoors, in damp locations, or where exposed to weather consistent with weatherproof rating requirements as IP45 at least.

P. Cleaning

1. After completing system installation inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

Q. Demonstration

1. Engage a factory-authorized service representative to train Employer's maintenance personnel to adjust and maintain systems.
2. Train Employer's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
3. Schedule training with Employer, through Employer's Representative, with at least seven days advance notice.

R. Supervision

1. Installation shall be supervised and tested by a representative of the Manufacturer of the system equipment.
2. The work shall be performed by skilled technicians under the direction of experienced engineers, all of whom shall be properly factory trained and qualified for this work.

S. Security

1. Coordinate with the Employer to procure general security conditions during building site.
2. Check that drain conductors and equipment are grounded to eliminate shock hazard and to minimize ground loops, common mode returns, noise pickup and other impairments.
3. Patch wiring must be traceable; Keep a database of patches installation up to date.

3.5 WIRE AND CABLE

A. Principles

1. All wiring and cable shall be installed in metal raceways or within equipment.
2. Conductors within equipment enclosures shall be carefully cabled and laced.
3. Individual conductors shall be tagged with markers indicating the function, source, and destination of all cabling, wiring and terminals.
4. All cables and wires shall be identified, utilizing heat shrink, pre-printed, wire markers.
5. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
6. Separation of Wires: Comply with Standard rules for separating unshielded copper communication and data-processing equipment cables from potential EMI sources, including electrical power lines and equipment.

7. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect and patch panels.
 8. Use splice and tap connectors compatible with media types.
- B. Number of Conductors
1. As recommended by system Manufacturer for functions indicated.
- C. Check-In and Tests
1. After installation, and before termination, all wiring and cabling shall be checked and tested to ensure that there are no grounds, opens, or shorts on any conductors or shields.
 2. A V.O.M. shall be utilized to accomplish these tests and a reading of greater than 20 Mega ohms shall be required to successfully complete the test.
- D. Visual Inspection
1. Visually inspect wire and cable for faulty insulation prior to installation.
 2. Protect cable ends at all times with acceptable end caps except during actual termination.
- E. Protection
1. Protect wire and cable from kinks.
 2. Provide grommets and strain relief material where necessary, to avoid abrasion of wire and excess tension on wire and cable.
- F. Splices, Taps, and Terminations
1. Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- G. Identification
1. Identify components, conductors, and cables.
 2. Color code conductors, and apply wire and cable marking tape to designate wires and cables so media are identified and in coordination with system wiring diagrams.
- 3.6 RACEWAYS AND CABLE Trunk
- A. Raceways
1. Requirements:
 - a. Surface raceway shall be constructed and installed for all exposed communications outlets. The Contractor shall match as closely as possible the existing wall finish but shall not paint surface raceway. Surface raceway shall be:
 - 1) Constructed and installed per Article 352 of the NEC or any relevant local standard, mechanically and electrically continuous and shall be bonded in accordance with NEC.
 - 2) Securely supported at intervals not exceeding 3 meters or in accordance with Manufacturer's installation sheets.

2. Use communications cable tray wherever possible for low voltage cabling.
3. Exposed raceway below 2.4 meters and in dry locations shall be rigid steel conduit.

B. Cable Trunk

1. IP Surveillance containment including cable trucking, ducts etc. shall be loaded more than 60% of the available space. The Contractor is responsible to size the containment appropriately taking into account all systems and the type of cables to be used based on selected Manufacturer for each system.
2. In general, IP Surveillance containment route shall follow the electrical containment route with sufficient clearance. However, any other routes followed shall be to the approval of the Employer's Representative.

3.7 FIELD QUALITY CONTROL

- A. The Contractor shall submit to the Employer the manufacturing and shipment schedules for all equipment and/or materials at least one month prior to the time of packing for shipment as long as the lead time available is sufficient or such shorter period as may fit the actual circumstances. Should the Employer's Representative fail to attend on the specified date for inspection, the Contractor shall proceed with shipment and carry out the relevant tests itself. The Contractor shall provide the Employer a copy of the recorded factory results made under its cognizance before shipment. If the test results show that the equipment and/or materials do not comply with the Specifications, such non-complying equipment and/or materials shall be rejected and shall not be shipped until repaired or replaced and tested again. In such case, the Contractor shall be held liable for any resulting delay. In all cases, the Contractor shall be responsible for the compliance of his equipment and materials with the Contract's specifications.
- B. Testing: On installation of system components, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
- C. Correct malfunctioning units at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.8 LABELING AND ADMINISTRATION

- A. Labels
 1. They are required for equipment, cabinets, racks, bonding conductors, riser cables, access points, etc. Labels shall comply with EIA/TIA 606.
- B. Rack Labeling
 1. Rack labeling shall be labeled sequentially and shall be of the form "01" to "0 xs".
 2. Labels shall be of the minimum size of 100 x 50 mm, screwed yellow unit with 15 mm black letters/numbers.

3.9 GROUNDING

- A. Precaution
 1. Properly ground each piece of electronic equipment prior to applying power.

2. Properly ground all shielded wire shields to the appropriate clean earth ground at the equipment end only, not at the remote or device end.

B. Principles

1. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common mode returns, noise pickup, cross talk, and other impairments.

C. Grounding Considerations

1. General

- a. Grounding systems are normally an integral part of the specific signal and telecommunications wiring system that they protect. Besides helping protect personnel and equipment from hazardous voltages, the grounding system may reduce the effect of electromagnetic interference (EMI) on the structured cabling network. Improper grounding can produce induced voltages and those voltages can disrupt other data or telecommunications circuits.
- b. When compatible with required electrical codes, the grounding instructions and requirements of the equipment Manufacturer should also be followed. The grounding requirements of the EIA/TIA 607 shall be followed.

2. Considerations

- a. Ensure that the installation conforms to proper practices and requirements.
- b. Ensure that each cabinet and rack has an appropriate grounding bus bar that is connected to the dedicated building ground by a 35 mm² ground wire.
- c. Ensure that grounding is available for all system equipment and components and equipment required for maintenance and testing.
- d. Ensure that all metal cable trays shall be bonded to ground. Cable tray shall not be used for a ground path.

3.10 COMPLETION SERVICES

- A. The Contractor shall initiate system operation. The Contractor shall provide competent start-up personnel on each consecutive working day until the system is fully functional and ready to start the acceptance test phase.

B. Preparation for acceptance (prior to final inspection):

1. Temporary and old systems, facilities and utilities shall be properly disconnected, removed and disposed of off-site.
2. All systems, equipment and devices shall be in full and proper adjustment and operation, and properly labeled and identified.
3. All materials shall be neat, clean and unmarred and parts securely attached.
4. Test reports of each system component shall be complete and available for inspection and delivery as directed by the Employer's Representative.

- C. System acceptance requirements: Before final acceptance of work, the Contractor shall deliver six (6) composite "Systems Operation and Maintenance" manuals in three-ring binders, sized to hold the material below, plus 50% excess. Each manual shall contain, but not be limited to:

1. A Statement of Guarantee including date of termination and the name and phone number of the person to be called in the event of equipment failure.

2. A set of operational procedures for the overall system that includes all required activities and that allows for Employer's operation of all system capabilities. This procedure shall fully address Employer's established system operating objectives.
3. Individual factory-issued manuals, containing all technical information on each piece of equipment installed. In the event such manuals cannot be obtained from a manufacturer, it shall be the responsibility of the Contractor to compile and include them. Advertising brochures shall not be used in lieu of the required technical manuals and information. All manuals shall be printed to ensure their permanence. No "blue-line" type of reproduction is acceptable.

3.11 FACTORY TESTS

A. Factory Acceptance Tests

1. The Factory Acceptance Tests shall be carried out in a hardware and software environment, which simulates the final configuration of the system.
2. The Contractor shall carry out any Factory Acceptances Tests, in Manufacturer's factory itself, before any site delivery, in order to show to the Employer site Engineer that the system of both hardware and software and the system after integration of various sub-systems is able to satisfy site technical requirements of the equipment specifications.
3. Some of the functional or performance tests, which cannot be conducted in a simulated environment, due to their nature and complications, may subject to the Employer's Representative's approval be combined with the On Site Tests.
4. All travels and trips costs shall be provided by the Contractor for five (5) representatives to be nominated by the Employer.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.
2. The tests are to cover every aspect related to the specification of the system and its operation; including, but not limited to, visual inspections, measurements, and operation.
3. All Factory Acceptance Tests need to be carried out in the presence of the Employer's Representative unless otherwise agreed by the Employer's Representative. The Employer's Representative will sign off the testing document on satisfactory completion of the tests.
4. All Factory Acceptance Test Specifications, at every level, shall be subject to configuration management and change control by the Contractor.
5. The results of the Factory Acceptance Tests, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representative.

C. Equipment Tests

1. Equipment is to be tested for quality and operation at the factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Employer's Representative before dispatch of equipment to site.

3.12 ON SITE TESTS AND INSPECTION

- A. On Site Assembly Verification
 - 1. The purpose of this phase is to check the assembly and the connection of the equipment without any power supply.
 - 2. Any verification can give raise to a punch list item either because of an anomaly or a none-conformity with the tender documents.
 - 3. The punch lists are collated for each module and the phase report is only released when all the stipulations on the punch lists are cleared.
- B. Test Specifications
 - 1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.
 - 2. The tests are to cover every aspect related to the specification of the system and its operation including, but not limited to, visual inspections, measurements, and operation.
- C. On Site Cable Tests
 - 1. Cables are to be tested to ensure that no damage have occurred to them during transportation to site and/or during the course of pulling in and laying.
- D. Inspection
 - 1. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- E. Pre-Testing
 - 1. Align and adjust system and perform pre-testing of all components, wiring, and functions to verify compliance with specified requirements.
 - 2. Correct all deficiencies by replacing malfunctioning or damaged items with new items.
- F. Manufacturer's Field Services
 - 1. Engage a factory authorized service representative to inspect field assembled components and equipment installations and perform system pre-testing, testing, adjustment and programming.
 - 2. Report results in writing.
- G. Procedure
 - 1. Notify the Employer's Representative not less than 30 days in advance, of proposed schedule, procedures and tests to be used in operational testing.
 - 2. Conduct operational tests only with the Employer's Representative present.
- H. Report
 - 1. Prepare a written report of observations, inspections, tests, and results, including:
 - a. A complete listing of every device and circuit,
 - b. Date of each test and retest, and by whom,
 - c. Results of each test and, if failure occurred, corrective action taken prior to retest.

I. Certification

1. The Contract shall certify that all devices, circuits, and total system are finally tested successfully.

J. Operational Tests

1. Schedule tests after pre-testing has been successfully completed.
2. Perform operational system tests to verify compliance with Specifications.
3. Test all modes of system operation including:
 - a. Functional operation of each field mounted device,
 - b. Functional operation of each control circuit,
 - c. Supervision function of each initiating, indicating, monitoring, and control circuit,
 - d. Perform tests that include originating program and counting material at final outlets, controller inputs, and other inputs,
 - e. Signal Ground Test: Measure and report ground resistance at each global equipment pin.
 - f. Re-testing: Correct deficiencies, and re-test. Prepare written record tests.
 - g. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
4. Schedule tests with at least seven days advance notice of test performance.

K. Integrated Tests with Other Contractors

1. The Contractor shall make equipment available for testing and demonstrating various features specified.
2. The test procedures shall reflect the sequence of tests to be performed.
3. Typical test segments shall include but shall not be limited to the following:
 - a. Communication Tests shall be performed for the serial or LAN interface to ensure that proper communication can be established between the IP Surveillance System equipment and the interfacing systems.
 - b. Point-to-Point Tests shall be performed on the IP Surveillance System equipment to the interfacing systems in order to verify the functionality and correct animation of each I/O point/command including alarm messages.
4. Retesting: Correct deficiencies and retest until total system meets requirements of the Specifications and complies with applicable standards. Prepare written records of tests.
5. Schedule testing with at least seven days advance notice.

3.13 TRAINING

- A. The Contractor is required to conduct end-user training on the project premises, tailored specifically to the project's particular requirements in the use, configuration and maintenance of the IP Surveillance System equipment and components.
- B. Training shall be provided for Technical Staff of the Employer in the Testing, Maintenance and Fault Location of the IP Surveillance System.
- C. For each product and/or application, the Contractor shall provide a detailed description of the training the Manufacturer will provide.

D. Trainers

1. All training shall be certified training by Manufacturer and trainers shall be approved by The project before starting.
2. Engage a factory authorized service representative to explain programming and operation of system and to train Employer's personnel on procedures and schedules for maintaining, programming, operating, adjusting, troubleshooting, and servicing the system.

E. Trainees

1. Training for engineers on IP Surveillance System operation and maintenance shall be for a minimum of six (6) engineers.
2. Training for engineers on IP Surveillance System administration shall be for a minimum of four (4) engineers.

F. Training Program

1. Scope

- a. Training shall be in sufficient scope to ensure that all trainees who complete the program will be certified as capable to operate and/or maintain the equipment, systems, and facilities provided and installed under this Contract, and to ensure a smooth transition between construction and operations activities.

2. Language

- a. Training shall be conducted in English and Arabic.

3. Training Aids

- a. Training aids shall include:
 - 1) Approved Operation and Maintenance (O & M) manual(s) prepared by the Contractor as part of this Contract,
 - 2) Training manuals, including course outline, basic text of instructions modules, and trainee workbook,
 - 3) Films, slides, video tape(s),
 - 4) Charts, models, hand-outs, catalogues,
 - 5) Samples and other visual,
 - 6) Written aids to complement instruction.
- b. In addition, spare parts and other special hardware shall be provided to support “hands-on” familiarization with the equipment or systems.

4. Training Manuals

- a. Training manuals shall be provided for each training course covering both the class room and on-the-job phases.
- b. The organization of the manuals shall follow the same sequence as the course’s scheduled presentation of material, providing such additional background and supplementary information, as a trainee may need to understand the O & M manuals.
- c. There shall be as many Training Manual types as Trainees categories.

5. Training Execution

- a. Scope

1) Training shall be performed in accordance with an approved training program. All training aids shall be available and approved prior to start of training.

- b. Contents

- 1) Training course can be broken down into modules either classroom lecture or ‘On-the-job’ training.

- 2) In case of lecture, it is the Employer responsibility to provide the classroom for the duration of the course.
 - 3) No lecture module should exceed 2 hours time.
 - 4) “On-the-job” training can be scheduled for entire 8 hour shift.
 - 5) Handouts must support each module; the collation of the Handouts forms the Training Manual.
 - 6) Laboratory equipment, spare parts, and mock-up models may be used for theoretical orientation.
 - 7) However, practical “hands-on” familiarization shall be provided on equipment that is either installed and operable or ready to be installed and capable of being operated. System spares of special hardware items may be used to support “hands-on” familiarization as long as said spares are returned to inventory in satisfactory condition in accordance with approved procedures.
- c. Proficiency
- 1) At designated intervals each trainee’s proficiency levels shall be determined by written, oral and practical performance tests.
- d. Operations Training
- 1) Operators shall be provided with a thorough training in all aspects of system/sub-system operation under both normal and abnormal conditions. This training shall include, but not be limited to:
 - a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
 - b) Terminology,
 - c) Operations theory and interface,
 - d) Equipment appearance, functions, concepts and operations,
 - e) Operating mode, practices, and procedures under normal and emergency conditions,
 - f) Safety precautions,
 - g) On-the-job operating experience covering all system/sub-system operating functions, activities, and tasks including those associated with degraded operating modes, failure recognition, and recovery processes,
 - h) Familiarity with content and use of O & M manuals and related reference publications.
- e. Maintenance Training
- 1) Maintenance training shall cover all on-site routine, preventive, and remedial maintenance of the system/sub-system.
 - 2) This training shall include, but not be limited to:
 - a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
 - b) Terminology,
 - c) Operations theory and interfaces,
 - d) Equipment appearance, layout, functions, concepts and operations,
 - e) Operating modes, practice, and procedures under normal and emergency conditions,
 - f) Safety precautions,

- g) Use of tools and test equipment,
- h) Use of system utilities, diagnostic software and various software tools associated with the system maintenance,
- i) Preventive maintenance,
- j) Troubleshooting, diagnostics, and testing,
- k) Backup and restoration of software/configuration,
- l) Assembly and disassembly,
- m) Repair and parts replacement,
- n) Parts ordering practices and storage,
- o) Failure and recovery procedures,
- p) System/sub-system cabling,
- q) Familiarization with and use of O & M manuals and other reference material.

f. Administrator Training

- 1) Administrator course shall be provided so the system administration staff will be able to:
 - a) Configure the IP Surveillance System equipment and the access of all the users,
 - b) Identify and remedy software faults,
 - c) Upgrade and implement data and software changes,
 - d) Production of revised or new displays.
- 2) This training shall include, but not be limited to:
 - a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
 - b) Terminology,
 - c) Operations theory and interfaces,
 - d) Software design and organization,
 - e) Database structure, generation, and modification,
 - f) Assembly, compilation, linking, editing, debugging, distributing, testing and integration of program modules, Interface software design,
 - h) Configuration management and control of software,
 - i) Backup and restoration of software,
 - j) Use of system utilities, diagnostic software and various software tools associated with the design, development, and maintenance of the System,
 - k) Familiarization with and use of O & M manuals and other reference materials.

3.14 LOGISTICAL SUPPORT

- A. The Contractor should identify the address of the Manufacturer's local service centers and the number of service personnel trained on the system.

3.15 REPAIR RESPONSE

- A. The Contractor shall provide routine system monitoring to assure the continued operation of all system components.
- B. During the warranty period, the Contractor must supply no more than a 1 hour response to major problems, 24 hours a day, 7 days a week.

3.16 GUIDELINES FOR DOCUMENTATION TRANSMITTAL

- A. Content of the Transmittals
 - 1. Contractor to prepare detail drawings, design calculations, technical data sheets and samples and submit the same for review by the Employer's Representative. The Contractor shall submit the following key elements to the Employer's Representative for review:
 - a. Detailed layout showing the marking and/or the equipment as required,
 - b. Manufacturers' Catalogues,

- c. Provide all relevant Testing Certificates,
 - d. Inventory label for each item supplied under this Contract. Labels shall be submitted for review by the Employer's Representative and shall be attached to each individual item for easy reference.
2. The following documents are to be submitted to the owner prior to handing over:
- a. As-built drawings for the relevant areas,
 - b. Complete inventory list,
 - c. Three sets of the Maintenance Manuals are to be provided. Such manuals shall include a full technical description with block and schematic diagrams to allow the Employer staff to maintain the system equipment and components,
 - d. Three sets of the Operation Manuals are to be provided.

B. Drawings

1. The Contractor will have to establish plans to scale and diagrams as per the following presentation:
- a. IP Surveillance System schematic diagrams, detailed design, connection diagrams, etc.
 - b. Floor layout of each building and raceways will have to be on scale 1/100.
 - c. Equipment room layout will have to be on scale 1/50.
 - d. Racks and cabinet configuration, front and back view, as well as the plans of detail and service shafts, will have to be on scale 1/10.
2. All Design Development drawings, Construction Drawings, and As-Built Drawings shall be submitted in hard copy format as well as in electronic format in the quantities specified below.
3. Quantity of Submittals:
- a. Electronic Files: 1 set.
 - b. Reproducible hardcopies: 1 set.
 - c. Prints: 3 sets.

END OF SECTION 28 23 00

SECTION 28 31 00 - FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes fire detection and alarm system with manual stations, detectors, signal equipment, controls, and devices.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".
 - 2. Division 26 Section "Grounding and Bonding".
 - 3. Division 26 Section "Conductors and Cables" for fire alarm system power wiring.
 - 4. Division 26 Section "Raceways and Boxes" for fire alarm system wiring method and enclosure requirements.

1.3 DEFINITIONS

- A. FCC: Fire command center.
- B. MFACP: Main Fire Alarm Control Panel.
- C. SFACP: Satellite fire alarm control panel (referred to by some manufacturers as data gathering panel or transponder).
- D. LED: Light-emitting diode.

1.4 SYSTEM DESCRIPTION

- A. General: Fully integrated system with all low current systems like , security, alarm, BMS, parking control and communication systems... etc
- B. Fully integrated system with another security, parking control and communication systems.
- C. General: Non-coded, addressable system with manual and automatic alarm initiation, and multiplexed signal transmission dedicated to fire alarm service only.
- D. General: Non-coded, addressable-analog system with manual and automatic alarm initiation; automatic sensitivity control of certain smoke detectors, and multiplexed signal transmission dedicated to fire alarm service only.
- E. Fire alarm system shall be UL/FM.
- F. Scope of Work: Provide the following:
 - 1. Fire alarm control panel, manual stations, automatic fire detectors, interface with other systems, wiring, wire-ways and all accessories to form a complete system.

2. Remote annunciator(s).
3. Fire fighters telephone sub-system.
4. Connection to BMS system, including interface elements such as software protocol, relays, transducers, etc., as detailed in Division 25 Sections, BMS schedules, and shown on the Drawings.
5. Interface with the following systems, including interface elements such as software protocol, relays, transducers, etc., as detailed in applicable sections of Division 26 and shown on the Drawings.
 - a. HVAC
 - b. Firefighting systems
 - c. Conveying systems control panels
 - d. Security systems
 - e. Emergency power supply
 - f. Telephone system
 - g. Fire Pumps
 - h. Fire Smoke dampers
 - i. Fuel Tanks
 - j. Fire Pump
 - k. BMS system
 - l. Sound system

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
 1. Detectors characteristic curves of coverage area against ceiling height and air changing rate.
 2. Personal computer including dual processor type and speed, auxiliaries, software-package, printer and the ink.
- B. Shop Drawings: Include dimensioned plans and elevation views of components. Show access and workspace requirements. Include at least the following:
 1. Detailed floor layouts showing all outlets with label reference and exact routing of cabling and wire ways.
 2. Detailed system schematic diagram. Differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
 3. Detailed equipment layout in rooms and closets including elevations and typical installation details.
 4. Show details of graphic annunciator.
 5. Battery: Sizing calculations.
 6. Device Address List: Coordinate with final system programming and labeling.
 7. 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.
 8. Cause and Effect Matrix: Show in a matrix format, the effect of every initiating device on the [FACP], notification devices and all system peripherals.
- C. Coordination Drawings: Plans, sections, and elevations drawn to scale and coordinating installation of smoke detectors in ducts and access to them. Show the following near each duct smoke provision of detector installation:
 1. Size and location of ducts, including lining.
 2. Size and location of piping.
 3. Size and arrangement of structural elements.
 4. Size and location of duct smoke detector, including air-sampling elements.

- D. 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.
- E. Operating Instructions: For mounting at the [FACP].
- F. Product Certificates: Signed by manufacturers of system components certifying that products furnished comply with requirements.
- G. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.
- H. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- I. Maintenance Data: For fire alarm system to include in maintenance manuals specified in Division 1.
- J. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 1 Section "Submittal Procedures," make an identical submission to authorities having jurisdiction. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Engineer for review.
- K. Sound Levels: Measure and submit audible sound levels. Verify that 15 decibels (dB) above ambient noise levels or 5 dB above the maximum sound level that occurs at the location for 60 seconds or more, but not greater than 120 dB, are achieved.
- L. Test Results and Certificate of Completion: Comply with specified Standard.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of the fire alarm system manufacturer for both installation and maintenance of units required for this Project.
 - 1. Experience: Minimum 5 years.
 - 2. Demonstrate that installer has satisfactorily completed at least two system installations similar in design and extent to that indicated for this Project, and with a record of successful in-service performance.
- B. Manufacturer Qualifications: A firm experienced in manufacturing systems similar to those indicated for this Project and with a record of successful in-service performance.
- C. Source Limitations: Obtain fire alarm system components through one source from a single manufacturer and all system components shall be from the country of origin.
- D. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.
- E. Codes and Standards: Comply with the following:
 - 1. NFPA 70, "National Electrical Code".
 - 2. NFPA 72, "National Fire Alarm Code".
 - 3. NFPA 101, "Code for Safety to Life from Fire in Buildings and Structures".

4. BS 5839, "Fire Detection and Alarm Systems for Buildings".
5. BS 7443, Specification for Sound Systems for Emergency Purposes.

1.7 Walk Test Mode

- A. FACP shall support walk test mode by dividing the loops to number of groups to apply walk test mode for each group separately, all other groups shall not be affected by walk test mode and shall work in normal mode.
- B. Walk test mode shall be enabled by authorized person and through minimum 4 digits password.
- C. Walk test mode shall be programmed for amount of time up to 8 hours, if the programmed time had end without any activation of alarm device/enabled group, FACP shall automatically revert to normal operation
- D. In case of activation of alarm device, disconnection of communication, or signal circuit during walk test mode, the following actions shall be taken.
 - 1- Continues sound signal for 4 seconds on all audible notification appliance
 - 2- Archive alarm/trouble in FACP log.
 - 3- FACP reset after alarm test/reconnection.

1.8 Warranty

- A. Contractor shall submit warranty certificate signed by system Manufacture for all system component for a period not less than 2 years.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match product 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 2 percent of amount installed, but not less than one unit.
 2. Lamps for Strobe Units: Quantity equal to 2 percent of amount installed, but not less than one unit.
 3. Smoke Detectors, Heat Detectors, and Flame Detectors: Quantity equal to 2 percent of amount of each type installed, but not less than one unit of each type.
 4. Detector Bases: Quantity equal to 1 percent of amount of each type installed, but not less than one unit of each type.
 5. Printer Ribbons: Six spares.
 6. Keys and Tools: One extra set for access to locked and tamper-proofed components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
1. Edwards Systems Technology USA
 2. Honeywell, Inc. (USA).
 3. Notifier (USA).
 4. Siemens (Germany).
 5. Simplex (USA).
 6. Mircom
- B. FIRE ALARM CABLES , Subject to compliance with requirements, provide products by one of the following or approved equal:
1. Prysmain
 2. Cavicell
 3. MESC
 4. GC3

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Control of System: By the Main & Satellite FACP.
- B. System Supervision: Automatically detect and report open circuit, short circuit, and ground fault of wiring for initiating device, signaling line, and notification-appliance circuits.
- C. Priority of Signals: Automatic alarm response functions resulting from an alarm signal from one zone or device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.
- D. Noninterference: A signal on one zone shall not prevent the receipt of signals from other zones.
- E. System Reset: All zones are manually re-settable from the FACP after initiating devices are restored to normal.
- F. Transmission to Remote Alarm Receiving Station: Automatically route alarm, supervisory, and trouble signals to a remote alarm station by means of a digital alarm communicator transmitter and telephone lines.
- G. Transmission to Remote Alarm Receiving Station: Automatically route alarm, supervisory, and trouble signals to a remote alarm receiving station by means of a radio alarm transmitter.
- H. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.

1. Initiating Device Circuits (IDC) System Wiring: Class A,.
 2. Signaling Line Circuits (SLC) System Wiring: Class A,.
 3. Notification Appliance Circuits (NAC): Class A,.
- I. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground or open circuit occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.
1. Initiating Device Circuits (IDC) System Wiring: Class A,.
 2. Signaling Line Circuits (SLC) System Wiring: Class A,.
 3. Notification Appliance Circuits (NAC): Class A,.
- J. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when an open circuit, ground or wire-to-wire short occurs, or an open circuit and a ground occur at the same time in an initiating device circuit, signal line circuit, or notification-appliance circuit.
1. Initiating Device Circuits (IDC) System Wiring: Class A,
 2. Signaling Line Circuits (SLC) System Wiring: Class X.
 3. Notification Appliance Circuits (NAC): Class A,
- K. Loss of primary power at the FACP initiates a trouble signal at the FACP. The FACP indicates when the fire alarm system is operating on the secondary power supply.
- L. Loss of primary power at the FACP initiates a trouble signal at the FACP and the annunciator. An emergency power light is illuminated at both locations when the system is operating on the secondary power supply.
- M. Basic Alarm Performance Requirements: Unless otherwise indicated, operation of a manual station, automatic alarm operation of a smoke or flame or heat detector[, or operation of a sprinkler flow device] initiates the following:
1. Activation of pre-signal at FACP.
 - a. Local alarm in the control unit for the period of a programmable time T1.
 - b. During this delay time (T1), an internal (staff) alarm (stage 1) only is to be given. If the alarm is not acknowledged before timer T1 runs out, this is to result in notification-appliance operation (stage 2) as detailed in subparagraph 2.2M.2 below.
 - c. If the alarm is acknowledged while T1 is still running, T1 is to be reset and a programmable timer T2 is to be started. T2 is to delay the notification-appliance operation (stage2) further, and so provide time for human investigation of the alarm cause.
 - d. If no reset action takes place before T2 runs out, notification-appliance operation (stage 2) is to be given.
 2. Notification-appliance operation.
 - a. Alarm signal in floor of incidence floors above and below; alert signal in remaining parts of building.
 - b. Alarm throughout the building.
 - c. Activation of visual strobes.
 3. Identification at the FACP [and the remote annunciator(s)] of the zone originating the alarm.
 4. Identification at the FACP [and the remote annunciator(s)] of the device originating the alarm.
 5. Transmission of an alarm signal to the remote alarm receiving station.
 6. Unlocking of door locks in designated egress paths.

7. Release of fire and smoke doors held open by magnetic door holders.
 8. Recall of elevators.
 9. Shut off public address and music equipment.
 10. Shutdown of fans and other air-handling equipment serving zone when alarm was initiated.
 11. Closing of smoke dampers in air ducts of system serving zone where alarm was initiated.
 12. Recording of the event in the system memory.
 13. Recording of the event by the system printer.
- N. Alarm Silencing, System Reset and Indication: Controlled by switches in the FACP [and the remote annunciator(s)].
1. Silencing-switch operation halts alarm operation of notification appliances and activate an "alarm silence" light. Display of identity of the alarm zone or device is retained.
 2. Subsequent alarm signals, from other devices or zones, shall 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.
- O. Water-flow alarm switch operation initiates the following:
1. Notification-appliance operation.
 2. Flashing of the device location indicating light for the device that has operated.
- P. Operating a heat detector in the elevator shaft shuts down elevator power by operating a shunt trip in a circuit breaker feeding the elevator.
- Q. Water-flow alarm for connection 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.
- R. Smoke detection for zones or detectors with alarm verification initiates the following:
1. Audible and visible indication of an "alarm verification" signal at the FACP.
 2. Activation of a listed and approved "alarm verification" sequence at the FACP and the detector.
 3. Recording of the event by the system printer.
 4. General alarm if the alarm is verified.
 5. Cancellation of the FACP indication and system reset if the alarm is not verified.
- S. Sprinkler valve-tamper switch operation initiates the following:
1. A supervisory, audible, and visible "valve-tamper" signal indication at the FACP and the annunciator.
 2. Flashing of the device location-indicating light for the device that has operated.
 3. Recording of the event by the system printer.
 4. Transmission of supervisory signal to remote alarm receiving station.
- T. Fire-pump power failure, including a dead-phase or phase-reversal condition, initiates the following:
1. A supervisory, audible, and visible "fire-pump power failure" signal indication at the FACP and the annunciator.
 2. Recording of the event by the system printer.
 3. Transmission of trouble signal to remote alarm receiving station.

- U. Low-air-pressure switch operation on a dry-pipe or pre-action sprinkler system initiates the following:
 - 1. A supervisory, audible, and visible "sprinkler trouble" signal indication at the FACP and the annunciator.
 - 2. Flashing of the device location indicating light for the device that has operated.
 - 3. Recording of the event by the system printer.
 - 4. Transmission of trouble signal to remote central station.
- V. Remote Detector Sensitivity Adjustment: Manipulation of controls at the FACP causes the selection of specific addressable smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory and are printed out by the system printer.
- W. Removal of an alarm-initiating device or a notification appliance initiates the following:
 - 1. A "trouble" signal indication at the FACP and the annunciator for the device or zone involved.
 - 2. Recording of the event by the system printer.
 - 3. Transmission of trouble signal to remote alarm receiving station.
- X. Printout of Events: On receipt of the 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 printout of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- Y. FACP Alphanumeric Display: Plain-English-language descriptions of alarm, supervisory, and trouble events; and addresses and locations of alarm-initiating or supervisory devices originating the report. Display monitoring actions, system and component status, system commands, programming information, and data from the system's historical memory.

2.3 ADDRESSABLE MANUAL STATIONS

- A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
 - 1. Double-action mechanism requires two actions to initiate an alarm, [break glass type][non break-glass, lift-cover and pull lever type].
 - 2. Station Reset: Key or wrench operated; double-pole, double-throw; switch rated for the voltage and current at which it operates.
 - 3. Indoors Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false alarm operation.
 - 4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm.
 - 5. Integral Addressable Module: Arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.

2.4 ADDRESSABLE SMOKE DETECTORS

- A. General: Include the following features:
 - 1. Operating Voltage: 24-V dc, nominal.

2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
3. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
4. Integral Visual-Indicating Light: LED type. Indicates detector has operated.
5. Sensitivity: Can be tested and adjusted in-place after installation.
6. Mounting: Surface or semi-recessed ceiling mounted type, located as shown on Drawings, with head removable from fixed twist-lock base. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 100 m² at mounting height of 6 m.
7. Circuitry for two-way communication with the FACP: Each time the detector is polled, it is to communicate its type (ionization, optical etc.) and an analogue/digitally-encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.
8. Remote Controllability: Unless otherwise indicated, detectors are analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.

B. Addressable Photoelectric Smoke Detectors: Include the following features:

1. Sensor: LED or infrared light source with matching silicon-cell receiver.
2. Detector Sensitivity: Between 0.008 and 0.011 percent/mm smoke obscuration.

C. Remote Air-Sampling Detector System: Includes air-sampling pipe network, a laser-based photoelectric detector, a sample transport fan, and a control unit.

1. Pipe Network: Electrical metallic tubing connects control unit with designated sampling holes.
2. Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of three preset values.
3. Sample Transport Fan: Centrifugal type, creating a minimum static of 1.3 mm of water at all sampling ports.
4. Control Unit: Intelligent modular Multi loop unit as needed. Provides same system power supply, supervision, and alarm features as specified for the central FACP plus separate trouble indication for airflow and detector problems.
5. Signals to the Central FACP: Any type of local system trouble is reported to the central FACP as a composite "trouble" signal. Alarms on each system zone are individually reported to the central FACP as separately identified zones.

D. Addressable Duct Smoke Detector: Photoelectric type.

1. Sampling Tube: Design and dimensions as recommended by the manufacturer for the specific duct size, air velocity, and installation conditions where applied.
2. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.
3. Remote indicator: shall be supplied with invisible detector.

E. Heat Detector, Combination Type: Actuated by either a fixed temperature of 57 deg C or rate of rise of temperature that exceeds 8.3 deg C per minute, unless otherwise indicated.

1. Mounting: Adapter plate for outlet box mounting.
2. Mounting: Plug-in base, interchangeable with smoke detector bases.
3. Mounting: Surface or semi-recessed ceiling mounted type, located as shown on Drawings, with head removable from fixed twist-lock base. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 50 m².

4. Circuitry for two-way communication with the FACP: Each time the detector is polled, it is to communicate its type and an analogue/digitally-encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.

F. Multi sensor Detector, Combination Type:

1. Mounting: Adapter plate for outlet box mounting.
2. Mounting: Surface or semi-recessed ceiling mounted type, located as shown on Drawings, with head removable from fixed twist-lock base. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 50 m2.
3. Circuitry for two-way communication with the FACP: Each time the detector is polled, it is to communicate its type and an analogue/digitally-encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.

G. Continuous Linear Heat-Detector System: Consists of detector cable and control unit.

1. Detector Cable: Rated detection temperature 68 deg C. Listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short circuit wires at the location of elevated temperature.
2. Control Panel: Two-zone or multi zone unit as indicated. Provides same system power supply, supervision, and alarm features as specified for the central FACP.
3. Signals to the Central FACP: Any type of local system trouble is reported to the central FACP as a composite "trouble" signal. Alarms on each detection zone are individually reported to the central FACP as separately identified zones.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
5. Circuitry for two-way communication with the FACP: Each time the detector is polled, it is to communicate its type and an analogue/digitally-encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signaling loop.

H. Water earth leakage :

1. Control Panel
 - a. 2 Zone conventional control panels, with battery standby as well as common fault and alarm relay contacts, the panel shall maintain a user settable real time clock with time recorded to the nearest minute. All significant systems events including leak detection, locations, leak cleared, and alarm relay reset, etc. The panel shall be recorded to an Event History log and shall include a date and time stamp detection and Sounder circuit's constantly monitored for faults. Panel shall indicate the zone and locations of any leak. The display shall feature an interactive and dynamic leak location map, with the location of any leak displayed as a flashing icon positioned over the floor plan, piping layout, or photo of the piece of equipment at the user's discretion.
- 2- Sensing cable:
 - a. The water sensing cable for suspended pipe shall be a four (4) wire design, with two (2) sensing wires, one (1) alarm wire and one (1) continuity wire embedded in a flame retarded polymer carrier rod which can sense the presence of water at any point along its length and shall not detect hydrocarbons. The sensing cable design shall have the

ability to provide continuous verification of sensing circuit integrity. The sensing wires shall be jacketed with a conductive fluoropolymer and shall be constructed with no metal parts exposed to the environment for corrosion resistance. Sensing cable shall be supplied with an absorptive synthetic fiber braid that provides extra mechanical protection and designed to wick water along the cable even when the water leak is dripping from a single small pin hole or crack. Water sensing cable shall be pre-terminated and modular for quick connection to cables and leak detection components.

2.5 NOTIFICATION APPLIANCES

- A. Description: Equip for mounting as indicated and have screw terminals for system connections.
 - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.
- B. Addressable siren with strobe: 24-V dc with voltage variations between 18 V and 32 V and provision for housing the operating mechanism behind a grille.
 - 1. Addressable siren with strobe H1: For indoor applications, electric vibrating type, with die-cast zinc frames, aircraft aluminum alloy diaphragms, heavy duty tungsten contacts, stress-relieved stainless steel armature springs and Teflon-impregnated plastic molded strikers and breakers. Double projectors fitted to basic horn are to be die-cast aluminum finished red. Minimum sound level of 90 dB(A) at 3 m.
 - 2. Addressable siren with strobe Type H2: For outdoor applications, electronic type, with volume control incorporated inside the unit, mounted on flush box as shown on the Drawings, and giving 95 dB(A) sound level at 3 m in all directions, with a sound frequency in the range 500 Hz to 1000 Hz. The horn is to operate in both continuous and alternating tones.
 - 3. Horn Type H3: Identical to horn type H1 but with single projector.

2.6 REMOTE DEVICE LOCATION-INDICATING LIGHTS AND IDENTIFICATION PLATES

- A. Description: LED indicating light near each smoke detector that may not be readily visible, and each sprinkler water-flow switch and valve-tamper switch. Light is connected to flash when the associated device is in an alarm or trouble mode. Lamp is flush mounted in a single gang wall plate. A red, laminated, phenolic-resin identification plate at the indicating light identifies, in engraved white letters, device initiating the signal and room where the smoke detector or valve is located. For water-flow switches, the identification plate also designates protected spaces downstream from the water-flow switch.

2.7 Main fire alarm control panel (MFACP)

- A. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.
 - 1. Identify each enclosure with an engraved, red, laminated, phenolic-resin nameplate with lettering not less than 25 mm high. Identify individual components and modules within cabinets with permanent labels.
 - 2. Mounting: Flush.
 - 3. Mounting: Surface.

- B. Alarm and Supervisory Systems: Separate and independent in the FACP. Alarm-initiating zone boards consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.
- C. Control Modules: Include types and capacities required to perform all functions of fire alarm systems.
- D. Indications: Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.
- E. . Manual switches and push-to-test buttons do not require a key to operate. Controls include the following:
 - 1. Alarm acknowledge switch.
 - 2. Alarm silence switch.
 - 3. System reset switch.
- F. Resetting Controls: Prevent the resetting of alarm, supervisory, or trouble signals while the alarm or trouble condition still exists.
- G. Alphanumeric Display and System Controls: Arranged for interface between human operator at MFACP and addressable system components, including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 - 1. Display: Liquid-crystal type, [80][40] characters minimum.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- H. Alphanumeric Display and System Controls: Arranged for interface between human operator at the MFAC and addressable system components, including annunciation, supervision, and control.
 - 1. Display: A minimum of 80 characters; alarm, supervisory, and component status messages; and indicate control commands to be entered into the system for control of smoke detector sensitivity and other parameters.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

2.8 DATA NETWORK

- A. Network Architecture: Based on a Local Area Network (LAN), a firmware software package, which utilizes an inherently regenerative communication format and protocol.
- B. Basic Network Operation: Each FACP panel is a stand-alone control with direct communications into network is defined as a node. Although performing different functions, each FACP serves as a "peer-to-peer" (equal) partner in controlling network communications. Network information is sequentially transmitted from one node to another. At each node, the network message is captured and either retransmitted as received, or modified before retransmission to provide the network with a status update. The ability of the message to circulate through the network defines the network status and allows the nodes to respond accordingly. If a node goes "off-line", or if the wires between nodes either short, open, or have any other form of communication problem, the nodes will isolate that section of wiring. Nodes that cannot retransmit onto the next node of the network will transmit back to the previous node to maintain communications and to notify the network of the node status. In the event of multiple wiring problems, the remaining nodes will effectively "regroup" and establish new, smaller "sub-networks" that will maintain communications among the active nodes.

- C. Personal computer (PC) for network reporting terminal (NRT) is to be part of the data network with all information from the FACP relayed to the PC.
- D. Network Media: The network is to be capable of communicating via wire or fiber optic medium. The network is to also support the use of both wire and fiber in the same network (hybrid network). A wire network is to include a fail-safe means of isolating the nodes in the unlikely event of complete power loss to a node. The fail safe design is to allow the network communications signal to bypass the failed node which allows the continuation of normal communications activity if specified wiring distances are maintained.
1. Network Repeater: A network repeater is to be available to increase the twisted-pair distance capability in 1,000-meter increments.
 2. Copper Wires: Twisted pair to support distances of up to 1,00-m between nodes.
 3. Fiber Optic Network Communication: The network shall support single mode fiber optics with the following specifications:
 4. Single mode Fiber Optic Network Communication: The network shall support fiber optics with the following specifications:

Fiber cable types	Wavelength (nm)	Max. Attn. (dB/Km)
Single mode, Inside plant	1,310	1.0
	1,550	1.0

- E.
- a. Type: Single -mode, Dual fiber, LZSH
 - b. Distance: Maximum 10 dB total attenuation between network nodes
 - c. Connector type: ST or better.
2. Cables are to be class X, fire resistant or protected for 3 hours.
 3. Network Cards: Provide cards in all FACP to enable a loop data network.
Cards are to support twisted pair copper or fiber cables depending on distance limitations and in accordance to manufacturer recommendations.

2.9 REMOTE ANNUNCIATOR

- A. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble indications. Also duplicate manual switching functions of the FACP, including acknowledging, silencing, reset, and test.
1. Mounting: Flush cabinet.
 2. Mounting: Surface cabinet.
- B. Display Type and Functional Performance: Individual LED for each type of alarm and supervisory device, and LEDs to indicate "normal power" and "trouble."
1. An alarm or supervisory signal causes the illumination of a zone light, floor light, and device light.
 2. System trouble causes the illumination of all lights above and also the trouble light.
 3. Additional LEDs indicate normal and emergency power modes for the system.
 4. A test switch to test LEDs mounted on the panel. Switch does not require key operation.

5. Graphics: Integrate LED displays with graphic display panel to form a graphic annunciator.
- C. Graphic Display Panel for Remote Annunciator: Wall-mounted engraved panel indicating the building floor plan with a "You Are Here" designation. Engrave zone, area, and floor designations on the face of the panel.
1. Materials: Satin-finished stainless steel or brushed aluminum.
 2. Floor Plan and Zone Boundary Lines: Engraved in the surface and filled with colored paint. Floor plan lines are black and 6 mm wide; zone boundaries are red and 3 mm wide.
 3. Engraved Legends: 6-mm- high minimum, in letters filled with red paint.
 4. Mounting: Integral with lamp-type annunciator. Locate zone lamps in the floor plan zones they represent.
 5. Mounting: Adjacent to remote annunciator.
- 2.10 PERSONAL COMPUTER (PC) FOR NETWORK REPORTING TERMINAL (NRT)
- A. The Network Reporting Terminal is to utilize user-friendly software running on an industry standard operating system (such as Microsoft Windows or NT). Each NRT is to be capable of all annunciating and controlling all network activity.
- B. Personal Computer: Provide a state of the art personal computer with [32] inch color monitor, keyboard, mouse, DVD drive, printer and all necessary interface / network cards and auxiliaries. The central control unit is to be equipped with dual microprocessor in "hot - standby" mode in such a way that failure of either one, the other one will automatically take over all functions of the central control unit. The failure of any CPU is to be associated with an audible alert signal and distinctive visual signal "PROCESSOR FAILURE" presented at the system main console terminal. Central processor architecture is to have the following serial input-output interfaces:
1. Front interfaces for either point-to-point or loop communication network.
 2. Eight Asynchronous end interfaces for control and supervision of system consoles logging printer and color graphic display station.
 3. At least one additional end interface to drive a digital output device.
 4. At least one additional end interface to drive a function keyboard device for dedicated partial system operation.
- C. Software Configuration: The manufacturer shall be responsible for the provision of all system software packages, which make up the complete operational system. At least the following standard software modules are to be incorporated:
1. Operating program.
 2. System database (process image).
 3. Network monitoring and control.
 4. Display priority control.
 5. Command priority control.
 6. Output message generator.
 7. Peripheral drivers.
 8. Text/graphic editors.
 9. Help facility.
 10. Service assistance.
 11. Diagnosis.
 12. Auxiliary programs.
- D. Password Protection: Access to system operating functions is to be protected by a password. For each operator intervention, the identification number of the initiating password number is to be recorded in the system history file for subsequent reports.

- E. Alarms: The system console is to automatically display and log alarm and change-of-status messages received from FACP or SFACP's. The system console is to provide optimal conditions for successful intervention by means of rapid and simple processing and displaying all necessary data in plain text and graphics. The alarm message information is to contain the following information:
1. Time and date.
 2. Type and origin.
 3. Description of affected alarm location.
 4. Counter-action to be taken.
- F. Programming: The NRT is to use dialog box technology to address, interrogate, control, and/or modify intelligent points on each fire alarm node. This is to include, and not be limited to:
1. Activating outputs.
 2. Enabling or disabling points.
 3. Adding or removing intelligent points.
 4. Viewing intelligent detector sensitivity levels and modifying point information (custom messages, detector type, verification, day/night selection etc.).
- G. Operating Mode: The extended system operating procedure is to be based on a user adaptive, screen-oriented dialogue in the manner of menus and masks. No knowledge of technical codes shall be necessary for system operation. All messages and instructions needed for system operation are to be indicated in plain text and/or graphics. A keyboard is to be used for data entry communication.
- H. History File: The NRT is to be capable of storing network events in a history file. Events are to be stored on hard disk and be capable of back-up storage on a CD. The history buffer is to have three modes of display. The first mode is to allow the operator to view events in a chronological order. A filter is to be available for displaying chronological events by year, month, date, time, alarms only, troubles only, both alarms and troubles, security breaches, supervisory alarms, and points disabled. The second is to allow the operator to view events in a number of easy-to-read graph styles, such as, bar graph, point graph, line graph, or spline graph. Graphing is to include the ability to select alarms, troubles or alarms and troubles, then the ability to display on a by year, month, or day basis. The third mode is to allow the operator to display stored (hard or CD) events in a variety of useful formats. Selections are to be available for displaying events by year, month, date, time, alarms only, troubles only, and both alarms and troubles, security breaches, supervisory alarms, and points disabled. The ability to print NRT history files is also to be available.
- I. Graphical Information: The NRT is to include the ability to display system information in a graphical (floor plan and elevations) form. A pull-down menu is to be included allowing selection of graphical views of the facility, or subset thereof. Each view, created in a CAD environment, is to include icons created for intelligent devices. These devices are to change in color when an event occurs. The device is to annunciate in RED when in alarm, BLUE for security activation, and YELLOW for trouble or to confirm acknowledgement. Each device in the graphic display is to support a text memo file where pertinent information about the location of the device may be stored. By selecting a device in the graphic presentation, the operator of the NRT is to have the ability to log onto the corresponding node and interrogate the associated intelligent point. Graphics are to be stored in a resident RAM memory and backed-up by a CD with the possibility to compose, modify or edit the graphic schematics, text, symbols and zone allocations on-site without jeopardizing the fire alarm system operation. Provide license and tools to software to revise / add equipment, floors or areas. Selection and activation of a certain graphic display is to be either automatic (event driven) or by manual request via the terminal. Graphics presentation shall have a minimum of four hierarchical levels:
1. Area overview.

2. Building overview.
3. Floor overview.
4. Room overview.

- J. Annunciation: The NRT is to include an easy-to-read system interface window, which displays alarms and troubles in an 80-character text message format. Alarms are to display in RED, troubles in YELLOW and security alarms in BLUE. The system interface window is to also include reset, silence and acknowledge keys for local panels and for the complete network.
- K. Help: The NRT is to include help screens, available to aid the user without leaving the selected application screen.
- L. Passwords: The NRT is to have a flexible way of assigning operator passwords. There is to be an unlimited number of possible operators, each with specific levels of control. Each operator is to have his/her own password. Operator password and control selection is to be available to a high level "administrator" who is to have complete control over levels of control. If no action has taken place on the NRT after 10 minutes, the current operator is to be logged out and require a new log-in.
- M. Printer Port: The NRT shall include an industry-standard port for a printer complying with the latest technology.

2.11 POWER SUPPLY

- A. General: Contractor shall submit battery calculation and verify the cable size.
- B. Components include valve-regulated, recombinant lead acid battery; charger; and an automatic transfer switch.
1. Battery Nominal Life Expectancy: 10 years, minimum.
- C. General: Components include nickel-cadmium battery, charger, and an automatic transfer switch.
1. Battery Nominal Life Expectancy: 20 years, minimum.
 2. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails.
- D. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.
- E. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.12 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module listed for use in providing a multiplex system address for listed fire and sprinkler alarm-initiating devices with normally open contacts.
- B. Integral Relay: Capable of providing a direct signal to the elevator controller to initiate elevator recall or to a circuit-breaker shunt trip for power shutdown.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER (Auto Dialer)

- A. Functional Performance: Unit receives an alarm, supervisory, or trouble signal from the FACP panel, and automatically captures one or two telephone lines and dials a preset number for a remote central station. When contact is made with the central station(s), the signal is transmitted. The unit supervises up to two telephone lines. Where supervising two lines, if service on either line is interrupted for longer than 45 seconds, the unit initiates a local trouble signal and transmits a signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. When telephone service is restored, unit automatically reports that event to the central station. If service is lost on both telephone lines, the local trouble signal is initiated.
- B. Secondary Power: Integral rechargeable battery and automatic charger.
- C. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.14 SYSTEM PRINTER

- A. Description: Listed and labeled as an integral part of the fire alarm system.
- B. The system is to have a strip printer capable of being mounted directly in the main FACP enclosure. Alarms are to be printed in easy-to-read RED, other messages, such as a trouble, are to be printed in BLACK. This printer is to receive power from the system power supply and shall operate via battery backup if AC mains are lost.
- C. The printer is to provide hard-copy printout of all changes in status of the system and shall time-stamp such printouts with the current time-of-day and date. The printer is to be standard carriage with 80-characters per line and is to use standard pin-feed paper. The printer is to be enclosed in a separate cabinet suitable for placement on a desktop or table. The printer shall communicate with the control panel using an interface complying with Electrical Industries Association (EIA) standard and with the latest technology interfaces standards.

2.15 GUARDS FOR PHYSICAL PROTECTION

- A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
 - 1. Factory fabricated and furnished by the manufacturer of the device.
 - 2. Finish: Paint of color to match the protected device.

2.16 WIRE

- A. Non-Power-Limited Circuits: Contractor shall submit calculation of voltage drop / and verify the cable size.
- B. Wires /cables : shall be Fire resistance cables (Loop cable , Audio line cable , 24 VDC ...) , UL listed, LZSH , 950C.
- C. Solid-copper conductors with 300/ 600-V rated, color-coded insulation.
 - 1. Low-Voltage Circuits: 2x1.5 mm² minimum.
 - 2. Line-Voltage Circuits: 2x2 mm² minimum.
 - 3. Line-Voltage Circuits: 2x2.5 mm² minimum.

- D. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer.
- E. Wires and Cables: and Comply with BS 5839 Part 1, section 17.3 and certified to have passed IEC 60331 and 60332 flame resistance and fire resistant tests. Cables are to be MICC or silicone rubber insulated, with overall PVC sheath bonding to coated aluminum foil (FP 200 by Pirelli Cables) or other equal and approved.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Connect the MFACP & SFACP with a disconnect switch with lockable handle or cover.
- B. Manual Pull Stations: Mount semi flush in recessed back boxes.
- C. Water-Flow Detectors and Valve Supervisory Switches: Connect for each sprinkler valve station required to be supervised.
- D. Ceiling-Mounted Smoke Detectors: Not less than 100 mm from a side wall to the near edge. For exposed solid-joint construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 9 m apart in any direction.
- E. Wall-Mounted Smoke Detectors: At least 100 mm, but not more than 300 mm, below the ceiling.
- F. Smoke Detectors near Air Registers: Install no closer than 1520 mm.
- G. The selection and placement of smoke detectors shall take into account both the performance characteristics of the detector and the areas into which the detectors are to be installed to prevent nuisance alarms or improper operation after installation. Smoke detectors shall not be installed in areas where air velocity is greater than 1.5m/sec, and shall not be located in a direct airflow. If siting of detectors in such areas is unavoidable, use detectors specifically designed for use in such conditions.
- H. Duct Smoke Detectors: Comply with manufacturer's written instructions.
 - 1. Verify that each unit is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - 2. Install sampling tubes so they extend the full width of the duct.
- I. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
- J. Audible Alarm-Indicating Devices: Install not less than 150 mm below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.
- K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 150 mm below the ceiling.
- L. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- M. FACP: Surface mount with tops of cabinets not more than 1800 mm above the finished floor.

- N. Annunciator: Install with the top of the panel not more than 1800 mm above the finished floor.
- O. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist 160-km/h wind load with a 1.3 gust factor without damage.

3.2 WIRING INSTALLATION

- A. Wiring Method: Install wiring in raceway according to Division 16 Section "Raceways and Boxes." Conceal raceway except in unfinished spaces and as indicated.
- B. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by the 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.
- C. Cable Taps: Use numbered terminal strips in junction, pull and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- D. 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.
- E. 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 one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signal from other floors or zones.
- F. Wiring to Remote Alarm Transmitting Device: 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 "Basic Electrical Materials and Methods."
- 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 cable shields and equipment according to system manufacturer's written instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.

- C. Install grounding electrodes of type, size, location, and quantity as indicated. Comply with installation requirements in Division 16 Section "Grounding and Bonding."
- D. Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
- E. Ground radio alarm transmitter system and equipment as recommended by the manufacturer.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and connections and to supervise pre-testing, testing, and adjustment of the system. Report results in writing.
- B. Pre-testing: After installation, align, adjust, and balance the system and perform complete pre-testing. Determine, through pre-testing, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. Report of Pre-testing: After pre-testing is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.
- D. Final Test Notice: Provide a minimum of 10 days' notice in writing when the system is ready for final acceptance testing.
- E. Minimum System Tests: [Test the system according to procedures outlined in NFPA 72.] Minimum required tests are as follows:
 - 1. Verify the absence of unwanted voltages between circuit conductors and ground.
 - 2. Test all conductors for short circuits using an insulation-testing device.
 - 3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record (as-built) drawings.
 - 4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
 - 5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
 - 6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
 - 7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, and quality, freedom from noise and distortion, and proper volume level.
 - 8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.
- F. Re-testing: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets specified requirements and complies with applicable standards.

- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.
- H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

3.6 CLEANING AND ADJUSTING

- A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Employer's maintenance personnel on procedures and schedules for operating, adjusting, troubleshooting, and servicing system. Refer to Division 1 Section "[Demonstration and Training] [Closeout Procedures]."

- 1. Provide a minimum of eight hours' training in operation and maintenance.

- 3.8 ON-SITE ASSISTANCE Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

END OF SECTION 28 31 00

SECTION 337119 - UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes underground conduits and ducts, duct banks, pull boxes and equipment foundations, bases, earth pits, sleeves and manholes and hand holes.
- B. Related Sections include the following:
 - 1. Division 26 Section "Basic Electrical Materials and Methods".

1.3 SYSTEM DESCRIPTION

- A. Underground Ducts for Electrical Utility Service: UPVC underground conduit, and will be encased in concrete where deemed necessary.
- B. Underground Ducts for Electrical Branch Circuits: UPVC conduit.

1.4 SUBMITTALS

- A. Product Data: For metal accessories for, conduits and ducts, duct-bank materials, and miscellaneous components.
- B. Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures. Include plans and sections drawn to scale.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- D. As-Built Drawings: At project close-out, submit record drawings of installed electrical ducts, and manholes, in accordance with requirements of the Specification.

1.5 QUALITY ASSURANCE

- A. Comply with specified Standards.
- B. Applicable standards for Cable Protection Covers/Tapes:
 - 1. Except where modified by this specification, the Cable Protection Covers/Tapes shall be tested in accordance with the following British Standards:
 - a. BS 2782: Methods of Testing Plastics. Part 3: Mechanical Properties and BS ISO 6721: Part 10.

- b. Methods: 320A to 320F: Tensile strength and Elongation and Elastic Modulus.

- 2. If any other National Standards are proposed by the Tendered, English versions of those standards shall be submitted for the approval of the Engineer.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to the Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.7 COORDINATION

- A. Coordinate layout and installation of ducts with final arrangement of other utilities as determined in the field.
- B. Coordinate elevations of duct and duct-bank with final profiles of conduits as determined by coordination with other utilities and underground obstructions.

PART 2 - PRODUCTS

2.1 Un-Plasticize POLYVINYL CHLORIDE (UPVC) DUCTS

- A. UPVC Ducts for Outdoor Power and Lighting Cable Installations: Non-sparking type, suitable for direct burial in ground, minimum tensile strength 500 kg/cm², impact strength 5 kg/cm², supplied in standard 6 m lengths, with one end of each length tapered.
 - 1. Nominal Size: As shown on the Drawings.
 - 2. Minimum Wall Thickness: 3.2 mm for 100 mm ducts; 4.7 mm for 150 mm ducts.
- B. Duct supports are to be pre-formed, non-metallic of approved type. Supports containing metal are to have the metal non-continuous and not forming a magnetic loop in any manner.
- C. Duct Sealing Compound: Non-hardening, safe for human skin contact, not deleterious to cable insulation, and workable at temperatures as low as 1 deg. C (34 deg. F). Capable of withstanding temperature of 149 deg. C (300 deg. F) without slump and of adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- D. All ducts to be provided with non-corrosive pull wires/ropes.

2.2 COVERS FOR MANHOLES AND HANDHOLES

- A. Frames and Covers: BS 497, checkered cast iron or cast steel, recessed type, and of suitable duty for the particular application. Machine cover-to-frame bearing surfaces
 - 1. Covers: Cast-in legend "ELECTRIC" or "TELECOM" as appropriate.

2.3 Manhole /Hand Hole

- A. Provide accessible space in an outside plant pathway system for the pulling, placing, and splicing of cables, as well as for maintenance and operations equipment. Also used to segment the pathway system into lengths compatible with standard reel lengths for outside plant cable and to conform to maximum pathway lengths as defined in the TIA/EIA standards.
- B. Man holes /Hand holes are used for pulling, placing, and splicing cables, and for providing accessible space for cable maintenance and operation equipment.
- C. Duct bank depth, obstructions, and other utility pathways may necessitate placement of a manhole below normal depth. If this is the case, the roof of the manhole shall be placed at normal depth and riser extensions shall be used to increase the depth of the manhole. By doing so, the need for a deep collar (neck) will be eliminated.
- D. Hand holes / are used to facilitate cable placement in a pathway system.
- E. Hand holes should not be used in place of manholes or for splicing cables. (TIA/EIA 758)
- F. The primary use of a hand hole/pull hole is to segment the pathway system.
- G. When the bends in a section of duct will exceed 180-degrees.
- H. When the length of the section of duct will exceed the TIA/EIA standard maximum length).
- I. Hand hole shall be of sleeve design and easily assembled. It shall be composed of a bottomless box, bolt-down accommodations, and a hardware kit.
- J. The hand holes bases shall have a rigid, flat, and stable top surface.
- K. Units must have been tested/evaluated to verify performance under ASTM designation A-16 (AASHTO HS20-44) loads. Testing performed in accordance with ANSI/SCTE 77 using the loads specified in ASTM C857.
- L. The hand holes must not be affected by asphalt, transformer oil, other common chemicals, weather, or other normal service conditions that it might be exposed to.
- M. The hand holes must not warp, rust, be UV degradable, or sustain combustion.

With equipment installed; the hand holes shall be capable of withstanding temperature variations of -40° Fahrenheit to 149° Fahrenheit without cracking, splitting, or otherwise deforming. Material shall be have been tested and conform to ASTM C666/C666M-03.

2.4 COMPOSITE CONSTRUCTION

- A. Concrete: Comply with Division 3 for concrete and reinforcement.
- B. Concrete Envelope: For duct banks for power distribution systems and Telecommunication cable installations crossing water, gas and sewage mains, under roadways and where required or shown on the Drawings, is to be 21 MPa, 28-day, compressive-strength reinforced concrete using sulfate-resisting Portland cement. Reinforcement is to consist of 12-mm diameter longitudinal bars at approximately 300-mm centers along bottom and sides of duct bank with 10-mm diameter U-shaped

transversal bars at 400-mm centers. Extend concrete envelope at least 300 mm beyond each side of crossing, etc.

- C. Cable Manholes and Hand holes: 21 MPa, 28-day, compressive strength reinforced concrete using sulfate-resisting Portland cement, with approved waterproof membrane on external surfaces, and with cable supports where necessary, pull-eyes, and drain pit and drain pipe as required. Dimensions and reinforcement are to be as shown on the Drawings or in accordance with approved standard details shown on shop and construction drawings.

2.5 PULL BOXES

- A. Cast-Metal Boxes: Cast aluminum, sized as indicated, with outside flanges and recessed, casketed cover for flush mounting. Nonskid finish on cover.
- B. Fiberglass Boxes: Molded fiberglass, sized as indicated, with 150-mm square cable entrance at each side and weatherproof cover with nonskid finish.
- C. Cover Legend: "ELECTRIC."

2.6 CONSTRUCTION MATERIALS

- A. Brackets, supports, rails and tracks for supporting electrical installations are to be hot dipped galvanized steel, fixed with stainless steel expansion bolts of approved size and material.

2.7 MANUFACTURERS:

- A. Approved Manufacturers: refer to HAP approved vendor list.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions to receive ducts and utility structures for compliance with requirements for installation tolerances and other conditions affecting performance of underground ducts and utility structures. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Excavation and Backfill: do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Trenches: Width is to be as small as practicable with sides vertical. Remove mud, rock projections, boulders and hard spots from trench bottom and trim level. Inform the Engineer in advance to give him reasonable opportunity to inspect trench for each section of the work.

- C. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

3.3 INSTALLATION OF CABLES AND ACCESSORIES

- A. Depth of Laying: The depth of laying cables for tendering purposes shall be as shown on the drawings. Variation may be necessary to satisfy the requirements of the local and other authority or to suit particular installation requirements. Any variations from the specified depth shall be subject to approval.

3.4 ENDS OF DUCTS

- A. Ducts ending in cable manholes or handholes are to be neatly cut and reamed and set behind chamfered precast concrete duct end blocks or terminated with appropriate bell-mouth bushing set in concrete wall. Ducts not ending in cable manholes or handholes are to be properly capped.
- B. Sealing Ends Of Ducts: Completely seal conduits and ducts, active or spare, at entry into buildings or manholes, with approved plastic moulds or wooden bungs to prevent entry of rodents, gas and vapor.

3.5 SLEEVES OR DUCTS IN EQUIPMENT FOUNDATIONS

- A. Provide sleeves or ducts in equipment foundations, whether or not shown on the Drawings, in accordance with approved Shop and Construction Drawings or as instructed by the Engineer. Obtain approval of sleeve or duct installation prior to pouring concrete.
 - 1. Install unit's level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
 - 2. Support units on a level bed of crushed stone or gravel, graded from the 25 mm sieve to the 4.75 mm sieve and compacted to the same density as adjacent undisturbed earth.
- B. Trenching for Duct or Cable Laying:
 - 1. Trenches shall be excavated to the depth shown on the Drawings in any material including soil, sand or rock, in level of sloping ground in the locations shown. The trenches shall be wide enough to accommodate the ducts or cables at the spacing indicated. Excavation to link the trenches with every location into ducts at road crossings and into enclosures shall be included.
 - 2. A bed of sand of 100 mm to 200 mm thick shall be laid in the bottom of the trench prior to the ducts being laid.
 - 3. After laying of the ducts, a surrounding and covering layer of sand or concrete encased 200 mm deep shall be placed over the ducts, followed by the interlocking cable tiles (for surround only), then the backfill incorporating the marker PVC tape which is to be to ASTM standards incorporating a steel wire (to enable magnetic identification) and the whole then compacted. These operations shall be carefully coordinated with the duct layer who shall supervise the duct covering operations to ensure there shall be no damage to the ducts.

- C. Ducts ending in cable manholes or handholes are to be neatly cut and reamed and set behind chamfered precast concrete duct end blocks or terminated with appropriate bell-mouth bushing set in concrete wall. Ducts not ending in cable manholes or handholes are to be properly capped.
- D. Conduits and ducts, active or spare, at entry into building or manhole, are to be completely sealed with approved plastic moulds or wooden bungs to prevent entry of rodents, gas and vapor.
- E. Sleeves or ducts in equipment foundations are to be provided, whether shown on the Drawings or not, and in accordance with approved Shop and Construction Drawings or as instructed by the Engineer. Obtain approval of sleeve or duct installation prior to concreting.

3.6 FIELD QUALITY CONTROL

- A. Inspection of Duct Systems: Inspect directly buried ducts and underground duct assemblies in the

Presence of the Engineer, before backfilling or concreting. Steel mandrel or other approved device, diameter equal to 90 percent of inside diameter of duct and 500 mm long, is to be pulled through entire run of duct and is to pass through without getting stuck. Ducts, which do not allow mandrel to be pulled through, are to be repaired or replaced to the satisfaction of the Engineer.
- B. Testing: Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
- C. Correct installations where possible and retest to demonstrate compliance. Remove and replace defective products and retest.

3.7 CLEANING

- A. Pulling of mandrel is to be demonstrated in all ducts. No mandrel diameter less than 1 inch to the diameter of duct shall be used.
- B. Clean ducts with stiff bristle brush pulled through each duct prior to pulling in cables. Pull brush through full length of ducts. Use round-bristle brush with a diameter 12 mm larger than the ID of duct.
- C. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 337119