KAUST Hotel

JEDDAH – KSA

TENDER PHASE

VOLUME 3A (6 OF 6)

ELECTRICAL SPECIFICATIONS

SEPTEMBER 2017

CLIENT	OPERATOR	LEAD CONSULTANT	INTERIOR CONSULTANT	COST CONSULTANT
OFC OLAYAN	الخزامى AL KHOZAMA MANAGEMENT COMPANY	MZ ARCHITECTS	SG SIBLEY GROVE	FAITHFUL GOULD

ELECTRICAL SPECIFICATION
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DIVISION 16 – ELECTRICAL

DIVISION 16 - ELECTRICAL

SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 16.

1.2 SCOPE OF WORK

A. The scope of electrical work for the Building will include but is not necessarily limited to:
   1. Power Supply and Distribution consisting of:
      a. Co-ordination with KAUST & SCECO for power supply and transformer substation,
      b. Main distribution boards,
      c. Distribution, sub-distribution and final branch circuit panelboards,
      d. Cables, wires and related accessories,
      e. Conduits, wireways, supporting systems and related accessories,
      f. Earthing system.

B. Standby Emergency Power Distribution capable of catering to essential and emergency loads and consisting of:
   1. Diesel engine driven generator,
   2. Totalizing board housing the electrically operated contactors and motorized breakers or switches, load management system and the totalizing module,
   3. Automatic transfer switch.

C. Lighting and Power Installations including:
   1. Functional and decorative indoor and outdoor lighting installations,
   2. Lighting control and KNX system,
   3. Wiring devices including all lighting switches, isolating switches, socket - outlets, plates,
   4. Emergency lighting.

D. Lightning protection system

E. Communication, life safety and low current systems consisting of:
   1. Telephone/Data system, and tie-in to KAUST/ City's trunk lines,
   2. Fire detection and public address system,
   3. IP Video Surveillance system,
   4. A/V System,
   5. IPTV System,

F. The project shall be LEED Silver certified. The contractor to follow all LEED requirements as stated in relevant specifications sections and ASHRAE mandatory requirements and all credits applicable and stated for this project. The Contractor shall implement practices and procedures to meet the project's environmental performance goals which include achieving the LEED targeted Silver Certification. The Contractor shall ensure that the requirements related to these goals, as defined in the LEED Assessment Report, are implemented to the fullest extent. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification. In

case of contradiction or discrepancy between the LEED requirements and the project specifications, the Contractor shall incorporate whichever is more stringent while ensuring compliance with LEED criteria. Where a question remains on which requirement is more stringent, Contractor shall submit the issue to the owner's Engineer/Representative in writing.

G. Unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the Drawings and/or described in the Specification together with all associated ancillary work, support work and builder's work in connection.

H. Incoming power supply and connection will be provided by the KAUST at 13.8 kV and stepped down to 230/400 V (all equipment shall be able to operate continuously at full load under 230/400 V) to the location shown on the Drawings.

I. Telephone/Data fiber optic cables will be brought into the premises by KAUST to the location shown on the Drawings and/or to be agreed with the Authority.

1.3 GENERAL REQUIREMENTS

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 co-ordinated with all other work
3. Installations are to be carried out by qualified personnel
4. 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. EQUIPMENT SPACES AND ROOMS: check that dimensions, structure, ventilating and cooling arrangements and other provisions in equipment spaces and rooms are suitable for installation, operation and maintenance of proposed equipment. Note any discrepancies on the shop and construction drawings. The Contractor is responsible of planifiyng the erection of the electrical equipment such that it is not interfering with any other trade in the building.

C. POWER SUPPLY: liaise with KAUST / the Local Power Authority 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.

D. KWH-METERING: liaise with KAUST / the Local Power Authority and provide necessary instrumentation, enclosures and accessories required by them to effect a complete kwh-metering installation.

E. TELEPHONE PUBLIC EXCHANGE LINES: liaise with KAUST / the Local Telephone Authority to confirm location of connection of public telephone exchange lines into the premises.

F. Systems used before substantial completion for the benefit of the Contractor are to have all consumable elements, such as lamps etc. and defective equipment replaced by new, within 7 days prior to the date of substantial completion.

1.4 DESIGN CONDITIONS

A. Nominal characteristics of power supply and distribution are as follows:
   1. medium voltage : 13.8 kV, 3 phase,
   2. low voltage : 400 V, 3 phase, 4 wire, solidly earthed neutral
   3. frequency : 60 Hz.

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

C. 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.

D. KWH-METERING to be coordinated with KAUST / SCECO, and as shown on the Drawings.

E. CLIMATIC CONDITIONS: equipment, including transformers, switchgear, cables, relays, lighting fixtures, motors etc., is to be designed and derated for continuous and trouble free service under the following climatic conditions:
   1. altitude : at sea level
   2. maximum ambient temperature: 45 deg. C (in the shade)
   3. minimum ambient temperature: 4 deg. C
   4. maximum relative humidity: 90 %
   5. atmospheric conditions: 1 bar
   Where design and operating conditions, different from the above are required for particular equipment, they are described in the specification of the equipment concerned.

F. REGULATIONS: carry out electrical work in accordance with the current issue of the local codes of practice, local power authority regulations and IEC Regulations for Electrical Installations, where not in contradiction with the local codes of practice and regulations, herein referred to collectively as 'the Regulations'.

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

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

IEC : The International Electro-technical Commission

ISO : The International Standardization Organization

EN : European Norm

NF-USE : The French Regulation

BS : The British regulation

CCITT : The International Telephone and Telegraph Consultative Committee

CCIR : The International Radio Consultative Committee

CISPR : The International Special Committee on Radio Interference

EIA/TIA : Electronics Industries association / Telecommunications Industry Associations.

IEEE : Institute of Electrical and Electronics Engineers, Inc.

NFPA : National Fire Protection Association

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

1.5 THE DRAWINGS

A. EQUIPMENT LOCATIONS shown on the Drawings indicate the approximate locations and general layout of equipment. Exact and final locations and layouts together with dimensions, weights, mounting methods and accessories, where relevant are to be shown on the shop and construction drawings. All protecting device shall show: the short circuit current value for single and three phase current, the voltage drop, the indirect protection function in case of a fault with respect the earthing system.

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

C. WIRING LAYOUTS shown on the Drawings for work not included in the Electrical Work, are shown for convenience and reference only.

D. SYMBOLS: in order to provide sufficient detail and a minimum degree of clarity on the drawings, the symbols used for the various electrical devices, particularly wall mounted devices, take up more space on the drawings than the device does on the wall. Because of drafting limitations these locations must be considered as being symbolic rather than exact physical locations of the devices.

E. The devices shall be installed with prime regard for convenience of operation and the best usage of the wall space for this and other purposes rather than string the devices out along the wall so as to coincide with the scaled locations of the symbols. In locating the outlets, follow the criteria provided on detail drawings where provided, and co-ordinate with furniture. Submittal of detail drawings is required for this purpose before execution. Do not scale from design drawings.

1.6 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 the 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. As certain 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. The Contractor is to 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 the Engineer. Labels are to be laminated plastic or anodised aluminium discs with black surface and white core with incised lettering in English or Arabic to the satisfaction of the Engineer. 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 the Engineer.

L. EQUIPMENT NAMEPLATES are to be non-corroding, robust metal, inscribed in English, and firmly fixed to equipment at factory. Nameplates are to indicate name and address of manufacturer, model, serial number, basic characteristics and ratings of equipment and are to include elementary diagrams etc., all in accordance with the Standards.

M. FIREPROOFING: Where cables, cable trays, busducts or conduits pass through floors and fire rated walls, pack space between wiring and sleeve full with materials and seal with approved caulking compound.

1.7 SUBMISSIONS

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. TECHNICAL LITERATURE is to include detailed manufacturers' specifications and original catalogues or catalogue cuts, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy the Engineer that proposed equipment and systems are suitable and adequate.

C. SHOP AND CONSTRUCTION DRAWINGS are to demonstrate to the Engineer that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings are to clearly state the name and location of the work, the names of the Engineer and Contractor, submission date, cross-references to the Drawings and Specification and the specific reference number, location, service and function of each item.

D. LIST OF PROPOSED MANUFACTURERS of all equipment and materials, including all items for which choice of manufacturer is at the discretion of the Contractor, is to be submitted for approval.

E. TEST CERTIFICATES AND REPORTS: where required by the Specification, 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.

F. LABORATORY TESTS: if manufacturer's test certificates are considered unsatisfactory, then independent laboratory tests are to be carried out on equipment in accordance with the Specification and the Standards, as required by the Engineer.

G. 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.

H. TOOLS AND INSTRUMENTS SCHEDULES: submit with the Tender itemised 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.

I. LABELLING SCHEDULE: submit for approval, prior to installation, a schedule of all equipment and devices to be labelled and the suggested details, lettering, position and fixing methods of each label indicating its application.

J. 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.

PART 2 - SPECIAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

2.1 REQUIREMENTS

A. CONSTRUCTION: electronic components of communication systems, security systems and special systems and electronic components forming part of the power generation and distribution system are to be solid-state integrated construction, unless otherwise approved.

B. TEMPERATURE LIMITS: manufacturer is to indicate maximum and minimum ambient temperatures acceptable for the equipment to operate continuously and normally and beyond which electronic components may suffer permanent damage.

C. ALTERNATIVE ELECTRONIC EQUIPMENT may be submitted for approval, provided such equipment meets or exceeds the functional capabilities and/or performance parameters of the equipment specified. Proposals for alternative equipment will be considered only if accompanied by the following information:

1. list of operational characteristics and performance parameters
2. list of differences in operation and performance between proposed and specified equipment
3. list of changes required and resulting implications
4. drawings indicating changes required to system wiring
5. statement of advantages of proposed equipment over that specified.

D. PROTECTION: solid state equipment under normal conditions of operation is to withstand any surges which might be produced by sudden mains or standby power switching operations. Protective devices are to be provided to protect against surges, failure of output stages due to open circuit, short-circuit or impedance mis-match. In the absence of IEC standards comply with IEEE standard 472 (ANSI/IEEE C37.90 "Guide for Surge Withstand Capability Tests". System/equipment which may be adversely affected by short duration power blackouts shall be capable of riding through such a disturbance by having an internal battery back-up to the memory / microprocessor, etc.

E. INDICATOR LIGHTS shall be Light Emitting Diodes (LEDs).

F. ELECTROMAGNETIC RELAYS and control/small power transformers are to be designed to withstand the 500 V a.c. test voltage between winding and winding or winding and core.

G. DUST COVERS, easily removable for inspection and servicing, are to be provided for all relays and sensitive elements.2.1.8. OUTDOOR EQUIPMENT, electronic or other, is to be designed for maximum ambient temperature or direct sun and is to be protected/enclosed, as applicable, against dust and weather conditions.

H. EXTERNAL INTERFERENCE: carry out field investigations and tests to determine possible interference from outside sources. Design electronic equipment to ensure trouble-free operation.

I. SEGREGATION OF WIRING: design wiring so that low current circuits are segregated from power wiring, using different conduits and wireways for the purpose. Composite wiring is acceptable for the same system in accordance with the relevant codes. Cable insulation is to be same grade for all conductors in a common enclosure.

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

PART 3 - TESTS ON SITE, RECORDS, TRAINING AND MAINTENANCE

3.1 TESTS ON SITE

A. GENERALLY: carry out inspection and acceptance tests on site on each complete system, before final placement into service, in accordance with the Regulations and Standards, as described in the Specification and required by the Engineer.

B. TEST SCHEDULES AND PROCEDURES are to be submitted for approval and are to include details of testing equipment to be provided.

C. WITNESSING: inspection and acceptance tests are to be carried out in the presence of the Engineer and when required, by an authorised representative of the Local Power Authority.

D. VISUAL INSPECTION: visually check proper installation, connections and nameplate data before testing.

E. INSULATION RESISTANCE: test the feeders, lighting and power circuits, motors and other power equipment of low voltage installations with a megger of not less than 500 V d.c. for installations rated up to 500 V (r.m.s. value of a.c. supply) and 1000 V d.c. for installations rated above 500 V up to 1000 V, and as required by the particular Section of the Specification.

F. INSULATION RESISTANCE: unless otherwise specified or approved, test the circuit insulation resistance related to communications and security systems with a megger of not less than 500 V operating voltage, with equipment disconnected.

G. CONTINUITY: test all feeders and circuits for continuity.

H. OPERATIONAL TESTS: carry out operational tests on all equipment and complete systems to verify proper performance in compliance with the Specification. Tests are to be carried out under normal operating conditions for not less than 3 days, and as required by the Engineer.

I. SPECIFIC TESTS: carry out specific tests required by the Specification and any other tests required by the Engineer to verify compliance of the installations with the Specification.

J. LOAD BALANCE: upon completion of the building and immediately prior to final inspection and take-over, check load balance on all feeders and at distribution centers, panels, etc. Conduct tests by turning on all possible loads in the building and checking the load current balance. If load unbalance exceeds 15% , rearrange and reconnect circuits to balance the load after Engineer's approval.

K. VOLTAGE CHECKS: perform voltage checks throughout the building and if directed by the Engineer, adjust the transformer tap settings where a transformer is provided on the supply end, or report to power authority for adjustment necessary.

L. CURRENT CHECKS: In cooperation with the mechanical sub-contractor, take clip-on ammeter readings on all phases of all mechanical equipment motors with motors operating under full load conditions. Test readings shall be submitted to the Consultant.

3.2 RECORDS

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

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

C. AS-INSTALLED DRAWINGS are to contain the complete assembled information included on the construction drawings, prepared in the same manner, and up-dated to indicate the systems, labelling, referencing, mounting methods, routing etc. as installed. Submit complete drawings for approval. Provide the Engineer with one set of transparencies in addition to the four copies required.

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

E. OPERATING AND MAINTENANCE MANUALS are to contain the following:

1. technical description of each system and item of equipment installed, written to ensure that the Employer's staff fully understand the scope and facilities provided.
2. diagrammatic drawings of each system indicating principle components and items of equipment.
3. schedules (system by system) of equipment installed giving manufacturer, catalogue list numbers, model, rating, capacity and operating characteristics; each item is to have a unique code and number, cross- referenced to the diagrammatic drawings and layout drawings.
4. name, address, telephone, telex and fax numbers of the manufacturer of every item of equipment.
5. name, address, telephone and telex numbers of equipment agents/representatives for emergency services and procedures.
6. manufacturer's service manual for each major item of equipment, assembled specifically for the project, including detailed drawings, illustrations, circuit details, operating and maintenance instructions, modes of operation, control provisions, sequences and interlocks and preventative maintenance programme.
7. schedules of all fixed and variable equipment settings established during commissioning.
8. procedures for fault finding, where applicable.
9. manufacturers' lists of recommended spare parts for items subject to wear and deterioration, giving expected running period and indicating specifically those items which may involve extended deliveries.

F. OPERATING AND MAINTENANCE MANUALS: prepare two temporary copies with provisional record drawings and preliminary performance data and make available at time of testing and commencement of commissioning to enable the Employer's staff to familiarise themselves with the installations. Temporary copies are to be in the same format as the final manuals with temporary insertions for items which cannot be finalised until installations are commissioned and performance tested.

3.3 TRAINING

A. OPERATION AND MAINTENANCE TRAINING: before the date of substantial completion, explain and demonstrate to the Employer's maintenance staff the purpose, function and operation of the installations including all items and procedures listed in the operating and maintenance manuals. Include for not less than thirty days for this purpose.

3.4 MAINTENANCE

A. MAINTENANCE CONTRACTS: where required by the Specification, submit supplementary proposals for annual maintenance contracts. The proposals are to:

A include for maintaining the installations in efficient working order including routine and emergency service checks, adjustments, lubrication and the supply and replacement of damaged parts etc.

B set out the terms of the offer, the work to be carried out, the guarantees of performance and the price of the work or part thereof for the first twelve months after substantial completion.

The proposals will not be considered as part of the Tender.

SECTION 16084- THROUGH-PENETRATION FIRE STOPPING FOR ELECTRICAL & MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Section, apply to work specified in this section.

1.2 DEFINITIONS

A. Fire stopping: Material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and hot gases through penetrations in fire rated wall and floor assemblies.

1.3 GENERAL DESCRIPTION OF THE WORK OF THIS SECTION

A. Only tested firestop systems shall be used in specific locations as follows:

B. Penetrations for the passage of duct, piping, and other mechanical equipment through fire-rated vertical barriers (walls and partitions), horizontal barriers (floor/ceiling assemblies), and vertical service shaft walls and partitions.

C. Repetitive plumbing penetrations in fire-rated floor assemblies. Penetrations exist for the installation of tubs, showers, aerators and other plumbing fixtures.

1.4 REFERENCES

A. Test Requirements: ASTM E 814, "Standard Method of Fire Tests of Through Penetration Fire Stops"

B. Test Requirements: UL 1479, “Fire Tests of Through-Penetration Firestops”

C. Underwriters Laboratories (UL) of Northbrook, IL publishes tested systems in their "FIRE RESISTANCE DIRECTORY" that is updated annually.

1. UL Fire Resistance Directory:
   a. Firestop Devices (XHJI)
   b. Fire Resistance Ratings (BXRH)
   c. Through-Penetration Firestop Systems (XHEZ)
   d. Fill, Voids, or Cavity Material (XHHW)
   e. Forming Materials (XHKU)

D. International Firestop Council Guidelines for Evaluating Firestop Systems Engineering Judgments

E. Inspection Requirements: ASTM E 2174, “Standard Practice for On-site Inspection of Installed Fire Stops.”

F. ASTM E84, “Standard Test Method for Surface Burning Characteristics of Building Materials.”

G. All major building codes: ICBO, SBCCI, BOCA, and IBC.

H. (Note to specifier: Retain or delete building codes listed above as applicable)

I. NFPA 101 - Life Safety Code

1.5 QUALITY ASSURANCE

A. A manufacturer's direct representative (not distributor or agent) to be on-site during initial installation of firestop systems to train appropriate contractor personnel in proper selection and installation procedures. This will be done per manufacturer's written recommendations published in their literature and drawing details.

B. Firestop System installation must meet requirements of ASTM E 814 or UL 1479 tested assemblies that provide a fire rating equal to that of construction being penetrated.

C. Proposed firestop materials and methods shall conform to applicable governing codes having local jurisdiction.

D. Firestop Systems do not reestablish the structural integrity of load bearing partitions/assemblies, or support live loads and traffic. Installer shall consult the structural engineer prior to penetrating any load bearing assembly.

E. For those firestop applications that exist for which no UL tested system is available through a manufacturer, a manufacturer's engineering judgment derived from similar UL system designs or other tests will be submitted to local authorities having jurisdiction for their review and approval prior to installation. Engineering judgment drawings must follow requirements set forth by the International Firestop Council.

1.6 SUBMITTALS

A. Submit Product Data: Manufacturer's specifications and technical data for each material including the composition and limitations, documentation of UL firestop systems to be used and manufacturer's installation instructions.

B. Manufacturer's engineering judgment identification number and drawing details when no UL system is available for an application. Engineering judgment must include both project name and contractor's name who will install firestop system as described in drawing.

C. Submit material safety data sheets provided with product delivered to job-site.

D. Sound Insulation Test Reports: Provide Test Certificates from qualified independent laboratories showing clearly a minimum of 54 dB sound reduction for Firestop Systems is achieved

E. Ageing Test Report showing Firestop Systems which have been tested and rated to withstand aging in normal service life between 25 and 30 years in accordance with DafStb Guidelines for the repair and protection of building components part 4, Section 2.4.5.6 with subsequent fire testing to ensure long term functionality.

F. Submit certificate by firestopping manufacturer that products supplied comply with LEED requirements for indoor environmental quality credit

1.7 INSTALLER QUALIFICATIONS

A. Engage an experienced Installer who is certified, licensed, or otherwise qualified by the firestopping manufacturer as having been provided the necessary training to install manufacturer's products per specified requirements. A manufacturer's willingness to sell its firestopping products to the Contractor or to an Installer engaged by the Contractor does not in itself confer qualification on the buyer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials undamaged in manufacturer's clearly labeled, unopened containers, identified with brand, type, and UL label where applicable.

B. Coordinate delivery of materials with scheduled installation date to allow minimum storage time at job-site.

C. Store materials under cover and protect from weather and damage in compliance with manufacturer's requirements.

D. Comply with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

E. Do not use damaged or expired materials.

1.9 PROJECT CONDITIONS

A. Do not use materials that contain flammable solvents.

B. Scheduling

1. Schedule installation of CAST IN PLACE firestop devices **after** completion of floor formwork, metal form deck, or composite deck but **before** placement of concrete.

2. Schedule installation of other firestopping materials after completion of penetrating item installation but prior to covering or concealing of openings.

C. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.

D. Weather conditions: Do not proceed with installation of firestop materials when temperatures exceed the manufacturer's recommended limitations for installation printed on product label and product data sheet.

E. During installation, provide masking and drop cloths to prevent firestopping materials from contaminating any adjacent surfaces.

PART 2 - PRODUCTS

2.1 FIRESTOPPING, GENERAL

A. Provide firestopping composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by the firestopping manufacturer based on testing and field experience.

B. Provide components for each firestopping system that are needed to install fill material. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.

2.2 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with through penetration firestop systems (XHEZ) listed in Volume II of the UL Fire Resistance Directory, provide products of the following manufacturers as identified below:

1. HILTI

2. FISHER

2.3 MATERIALS

A. Use only firestop products that have been UL 1479 or ASTM E 814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.

B. Cast-in place firestop devices are installed prior to concrete placement for use with noncombustible and combustible pipes (closed and open systems), and conduit penetrating concrete floors.

C. Sealants, caulking materials, or foams for use with non-combustible items including steel pipe, copper pipe, rigid steel conduit and electrical metallic tubing (EMT.

D. Sealants or caulking materials for use with sheet metal ducts.

E. Intumescent sealants, caulking materials for use with combustible items (penetrants consumed by high heat and flame) including insulated metal pipe, PVC jacketed, flexible cable or cable bundles and plastic pipe.

F. Foams, intumescent sealants, or caulking materials for use with flexible cable or cable bundles.

G. Non curing, re-penetrable intumescent putty or foam materials for use with flexible cable or cable bundles.

H. Wall opening protective materials for use with U.L. listed metallic and specified nonmetallic outlet boxes.

I. Firestop collar or wrap devices attached to assembly around combustible plastic pipe (closed and open piping systems).

J. Materials used for large openings and complex penetrations made to accommodate cable trays and bundles, multiple steel and copper pipes, electrical busways in raceways.

K. Non curing, re-penetrable materials used for large openings and complex penetrations made to accommodate cable trays and bundles, multiple steel and copper pipes, electrical busways in raceways.

L. Provide a firestop system with a "F" Rating as determined by UL 1479 or ASTM E 814 which is equal to the time rating of construction being penetrated.

PART 3 - EXECUTION

3.1 PREPARATION

A. Verification of Conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.

1. Verify penetrations are properly sized and in suitable condition for application of materials.

2. Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, rust, laitance, release agents, water repellents, and any other substances that may affect proper adhesion.

3. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

4. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

5. Do not proceed until unsatisfactory conditions have been corrected.

3.2 COORDINATION

A. Coordinate location and proper selection of cast-in-place Firestop Devices with trade responsible for the work. Ensure device is installed before placement of concrete.

B. Responsible trade to provide adequate spacing of field run pipes to allow for installation of cast-in-place firestop devices without interferences.

3.3 INSTALLATION

A. Regulatory Requirements: Install firestop materials in accordance with UL Fire Resistance Directory.

B. Manufacturer's Instructions: Comply with manufacturer's instructions for installation of through-penetration joint materials.

1. Seal all holes or voids made by penetrations to ensure an air and water resistant seal.

2. Consult with mechanical engineer, project manager, and damper manufacturer prior to installation of UL firestop systems that might hamper the performance of fire dampers as it pertains to duct work.

3. Protect materials from damage on surfaces subjected to traffic.

3.4 FIELD QUALITY CONTROL

A. Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas.

B. Keep areas of work accessible until inspection by applicable code authorities.

C. Inspection of through-penetration firestopping shall be performed in accordance with ASTM E 2174, “Standard Practice for On-Site Inspection of Installed Fire Stops” or other recognized standard.

D. Perform under this section patching and repairing of firestopping caused by cutting or penetrating of existing firestop systems already installed by other trades.

3.5 ADJUSTING AND CLEANING

A. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

B. Clean all surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

SECTION 16113 - STANDBY / EMERGENCY POWER PLANT

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. Drawings Electrical work generally is to be in accordance with the requirements of Section 16010 of the Specification.

1.2 SUMMARY

A. Description of work: standby / emergency power plants installation comprises the followings:

1. Diesel operating generating set(s), with associated auxiliaries, exhaust system, fuel-water separator filter, start-up, cooling & fuel systems, batteries & charger etc.
2. Fuel storage and transfer system.
3. Instrumentation, protection and control equipment.
4. Manually operated overhead hoist.
5. Totalizing panel and load management system.
6. Mains failure automatic transfer switch control.
7. Inter-plant cabling and wiring.
8. Earthing.

1.3 STANDARDS:

A. Equipment and component parts are to comply with ISO 3046, IEC 85 and CISPR, or equivalent NEMA, NFPA, 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.

1.4 EQUIPMENT DATA:

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

B. 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% and 25% of rated load.

C. 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 and radiator, air filters, fuel filters, oil filters and pumps.

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

E. Battery type, make, charge / discharge characteristics, capacity and constructional features. Battery charger, method of charging, equalizing and trickle charging.

F. Fuel tanks, pipes and accessories; Materials and construction.

G. Exhaust system and silencers; Materials, construction and supports.

H. Cool instruments, protection, alarms, cut-outs, indicating lamps, indicating instruments and all other devices or components.

I. Automatic transfer switch and control gear control.

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

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

1.5 ROUTINE TESTS:

A. Fully assembled plants 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 specifications.

1.6 SHOP DRAWINGS:

A. Submit drawings for approval including, but not limited to, the followings:
   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 bulk fuel storage tanks and daily service tank, including outline drawings showing piping arrangements, connections and dimensions.
   5. Complete execution drawings of associated auxiliaries.
   6. All protecting device shall show: the Short circuit current value, the voltage drop, the indirect protection function in case of a fault with respect the earthing system.

1.7 SPARE PARTS:

A. Provide manufacturer’s recommended spare parts for 1000 hours operation of the standby plant. Provide list of manufacturer’s spare parts for 2000 hours operation together with current prices.

1.8 TOOLS AND INSTRUMENTS:

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

1.9 WARRANTY:

A. Provide two year full warranty for replacing and repairing any equipment or auxiliary specified in this section.

1.10 MAINTENANCE CONTRACT:

A. Obtain an undertaking by the equipment manufacturer and his authorized local representative to provide an annual maintenance contract, available after substantial

completion of the work, covering routine service and emergency service by trained employees, and to ensure supply of necessary standard spare parts.

PART 2 - PRODUCTS AND SYSTEMS

2.1 APPROVED MANUFACTURERS:

A. Obtain generator sets from one of the following or other equal and approved:

1. Caterpillar (U.S.A.)
2. MAN (Germany)
3. Deutz (Germany)
4. Cumins (England)
5. F.G Wilson (England)
6. S.D.M.O. (France)

B. 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. Locally assembled generators are totally rejected. All generators shall be from country of origin specified above, any generator or parts of it from Far East or China is strictly prohibited.

2.2 PLANT DESCRIPTION

A. GENERALLY

1. GENERATOR SET ASSEMBLY: compact package type, with all equipment mounted on one rigid steel bed frame suitable for skidding. Design is to permit easy operation, maintenance and repair.

2. PERFORMANCE CLASS: Diesel generator set is to be class G2 (20% voltage drop / free drop at 100% loading) to IS08528-1.

3. 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 and/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.

4. NOISE REDUCTION: is to be achieved by approved methods at source of noise, with sound level measured at 1 m limited to 55dBA in accordance with ISO standards for residential areas. Special treatment is required to attain NC40 in the occupied spaces above the genset room.

5. COLD STARTING: engine is to be fully equipped to start and pick up initial load specified at specified minimum ambient temperature. Cold starting aids, such as engine jacket water heater, lubricating oil heater, intake-air heater, oversize standby battery and all devices, accessories, connections, thermostatic switches and off-duty disconnects with pilot lights and necessary protection, are to be supplemented as recommended by the manufacturer and approved.

6. EQUIPMENT RATINGS: are to be as indicated on the bill of Quantities or the next higher standard ratings provided by the manufacturer. Ratings are to be net

continuous output to consumer, excluding fan and any auxiliary drives and losses, delivered at specified frequency, voltage and power factor and under worst climatic conditions on site.

B. DIESEL GENERATOR SET

1. 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.

2. GOVERNING: is to be AI Class to ISO 3046/TV or BS 5514, using electronic type governor with limits of speed control as specified.

3. STARTING AND STOPPING: when in the automatic mode the set is to start automatically by a signal sent through an auxiliary contact in the load transfer switchgear. The set is to stop, after an adjustable cool-down period (2-30 minutes).

4. DUTY: The generator is to reach full speed within 10 seconds of start impulse. Priority loads are then connected and the first connected generator shall accept immediately 50% of net rated output (load being mixed, steady and inductive, with motor starting loads as shown on the drawings). The second priority loads shall then be connected following the same conditions. The non – priority loads are energized according to measured connected load and remaining available capacity. During the whole process (Load connection, generator disconnection), 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 within +/-2% within a few cycles. The maximum time allowance for the loads to be energized shall be as follows:
   a. First priority loads: 10 seconds (priority 1);
   b. Second priority loads: 15 seconds (priority 2);
   c. Spare;
   d. Spare.

5. FAILURE TO START: should engine fail to start following a start impulse, the system is to come to rest for a few seconds and 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, while a distinctive alarm is communicated to the Mini B.M.S.

6. HAND OPERATION: is to be possible for testing or normal operation through a test/manual/off/auto selector switch.

7. REGULAR EXERCISING: while on “auto”, the set is to start regulary and automatically by-wee key and is to operate for a preset time (5-30) minutes before stopping.

2.3 EQUIPMENT AND ACCESSORIES

A. DIESEL ENGINE AND AUXILIARIES

1. 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.

2. ENGINE TYPE: compression-ignition type with direct solid- injection, turbo-charged after-cooled, in line or V-type cylinder arrangement, 1500 rpm, operating on number 2 diesel oil (distillate), suitable for direct coupling to driven machine. Flywheel is to be suitably sized for type of service and constraints specified, and capable of being rotated at 125% of rated speed without failure. Torsional vibration dampers are to be

provided. Engine to be preheated in order to reach 70% of the load in 10 seconds and 100% of the load in 3 minutes.

3. ENGINE RATING: The prime power rating of the generator shall be of minimum as defined by ISO 8528-1. The generator must be capable of supplying 100% of its prime KW rating with variable load given that the average load during the total operating hours does not exceed 70% of rated power of the generator, plus the generator shall be capable of supplying 100% of its prime KW rating up to 20% of operating hours, with 10% overload capability for one hour in every twelve hours of operation, with temperature rise not exceeding rise allowed by the standards.

4. ACCESSIBILITY: it shall be possible to:
   a. Remove rocker-box covers without disturbing fuel injection pipes or other components.
   b. Remove and replace pistons and rods, liners, big and small end shells and caps without discoupling engine.
   c. Bar engine over by hand for spill timing check and adjustment.

5. MEASURING INSTRUMENTS: engine mounted instruments shall include, at least, water temperature gauge, lubricating oil pressure gauge, running time meter, coolant temperature at lower end of radiator, air depression after air filter, air boost and temperature sing methods recommended by manufacturer. Instrument accesses are to be normally sealed by threaded blanking caps.

6. 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 guard 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 15 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 and anti-corrosion and anti-freeze additives are to be used as recommended by manufacturer for specific conditions of installation.

7. 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.

8. CYLINDERS: are to have removable 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.

9. 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 load by-pass valve to permit oil circulation if filters become clogged. Audible and visual alarms are to cut-in when valve starts opening. Lubrication 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.

10. 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.

11. AIR INTAKE SYSTEM: plant room is to have heavy duty air-filter of the locker panel, all metal, cleanable, viscous impingement type, complete with duct and frame, as shown on the drawings. Engine air filter is to be either dry filter with replaceable paper filter elements or oil-bath filter dipstick and provision for adding oil while engine is running. Filters are to be capable of removing particles 10 microns and larger.

12. ELECTRIC STARTING SYSTEM: engine starting shall be manual by push-button or automatic through control system at control panel. System shall consist of heavy duty 24 V 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.

13. STORAGE BATTERY: lead-acid, sealed-in-plastic type, complete with battery rack and intercell connectors. Battery is to have sufficient capacity to provide minimum six (6) cranking periods.

14. BATTERY CHARGER: to be European, Japanese or American made, 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 is to be mounted in control cubicle, unless otherwise approved. The charger is to monitor the battery and an alarm signal shall be sent to the Mini B.M.S. in case of battery or charger break-down.

15. ELECTRONIC GOVERNOR: shall provide isochronous governing, paralleling and load sharing of generators sets. Governor is to have zero percent (isochronous) setting and adjustable drop from zero percent to 10% drop. 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 included speed adjustment to +/-5% of normal, while running, and with remote control interface. Frequency deviation under 25% sudden load change is not to exceed 1 Hz, recovering to stable speed condition of +/-0.1 Hz in 1 second.

16. GOVERNOR OVERSPEED TRIP: is to automatically close fuel pump racks in event of engine overspeed. Device is to be separate and independent from govering mechanism.

17. PROTECTIVE SYSTEM: is to comprise automatic engine shutdown and generator trip with visual and audible alarm in event of overspeed, low lubricating oil pressure, high cooling water temperature and over cranking.

B. GENERATOR (ALTERNATOR)

1. 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 two bearing construction with bearings of the sleeve or sealed ball type.

2. LEADS AND CABLES: phase leads are to be brought out fully insulated to a terminal cables box of heavy gauge sheet steel, protection IP44 to IEC 529. Control and protection cables are to be brought out to a separate terminal box.

3. MAXIMUM VOLTAGE DIFFERENCE: between the three phases at 100% balanced load is not to exceed 1%. With unbalanced load up to 30% 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 5%.

4. CHARACTERISTICS:

a.	Number of phase:	3
b.	Rated voltage, Frequency, and Net rated output:	as shown on the drawings.
c.	Rated power factor:	0.8
d.	Winding connection:	reconnectable with ends Brought out and fully insulated
e.	Unbalanced load current with none of the phase currents exceeding rated current	30% minimum
f.	Overload:	10% nameplate rating for 1 hour every 12 hours
g.	Rotor:	Salient pole type. Incorporating damping grid.
h.	Excitation:	brushless, with rotating Armature rectifiers and discharge resistors.
i.	Voltage regulator:	automatic with an adequate filter such that THD (Total Harmonic Distortion) is less than 4% under non linear load together with readily accessible controls for voltage level.
j.	Insulation:	class H for stator, class H for Rotor and exciter.
k.	Enclosure:	drip proof and screen protected (IP 23 TO IEC 529)
l.	Cooling:	built-in centrifugal fans.

5. 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 wave-from deviation factor is not to exceed +/-5%. Total harmonic content is not to exceed 4% and that of one harmonic not to exceed 2%. Radio interference suppression grade is to be within the limits set by the Standards; better than grade (N).

6. EXCITER: armature is to be 3-phases, 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.

7. 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 singles or parallel operation. Optional manual adjustment to +/-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. The voltage regulator has to monitor the 3-phases outputs. Voltage regulator power is to be supported by a permanent magnet to maintain excitation field power (PMG).

8. OPTIONAL TWO POSITION SWITCH: is to be provided for selection of manual or automatic mode of regulated voltage control.

C. INSTRUMENTATION, PROTECTION AND CONTROL EQUIPMENT

1. 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.

2. 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:
   a. Output air circuit breaker (ACB) with solid state trip unit. The solid state trip unit has to include the following features:
      1) Tripping threshold setting (1r) range between 0.5 to 1 times maximum trip rating with adjustable clearing time.
      2) Short time delay (Im) range 1.5 to 10 times maximum trip rating with adjustable clearing time, and instantaneous protection (Ii) fixed (according to continuous rating setting).
      3) Fault type indication, by leds on front face & by dry contacts.
   b. Over-voltage protection with voltage and time lag adjustment.
   c. Loss-of-field protection.
   d. Negative phase sequence protection.

3. 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 galvanized sheet steel construction, indoor type ventilated, vermin and dust-proof (IP 44 to IEC 529), 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 the galvanized 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, arranged in modules 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 with drawable, mounted in standard racks.

4. 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.

5. INSTRUMENTS: are to be housed in enameled metal cases for switchboard flush installation, with scales and markings protected and sealed. Including meters are to be minimum 76 mm square. Accuracy is to be within 2% unless otherwise specified. Voltmeters and moving coil type for d.c. measurements.

6. CURRENT TRANSFORMERS: class 2 for measuring and protection.

7. VOLTAGE TRANSFORMERS: single phase, dry type, 0.5 accuracy class.

D. TOTALIZING SWITCHBOARD:

1. SWITCHBOARD: is to be of the automatic random access system type with automatic load shedding. The switchboard internal temperature shall be kept below 40 °C. It is the contractor's duty to evaluate the external temperature (that of the room where the switchboard is located) and the thermal dissipation of all power and

controls equipment inside the switchboard. Adequate means of temperature control inside the switchboard shall be provided to the satisfaction of the engineer.

2. TYPE: dead front, rigid frame, free standing, metal enclosed steel structure with hinged, key locking front doors for access to control circuitry; one panel section per generator and power components are to be grouped separately. Bus is to be rigid fully sized tinned copper, three phase, with full size neutral and earth. Bus bracing is to be for a minimum of 1.5 times maximum calculated fault level at point of connection in the system (including motor contribution). Paralleling motorized with drawable air switch disconnectors, outgoing feeders protections to be as specified on drawings and to the satisfaction of the engineer. Construction to be TTA form 3B as per IEC EN 60439-1, IP44 to IEC 529. Glazed doors are to be provided for all cubicles except busbars or cables compartments. 25% spare space & capacity shall be provided for future use. If Plexiglas (or any other material) is used for segregation, it has to be fire retardant.

3. 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.

4. 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. Cables glands and gland plates are to be provided.

5. EACH GENERATOR CONTROL PANEL is to include:

   a. Manual Controls and Meters:
      1) Digital power meter as specified on the drawings.
      2) Running time meter.
      3) Alarm and status indication lamps for:
      4) Generator running status indication.
      5) Automatic mode status indication (required if manual synchronizing option is required).
      6) Demand mode standby status indication.
      7) Cool down mode status indication.
      8) Fail to start trouble alarm indication.
      9) High engine temperature alarm – shutdown.
      10) Low oil pressure alarm – shutdown.
      11) Low engine temperature trouble alarm indication.
      12) Low daytank level trouble alarm indication.
      13) Generator overcurrent alarm – shutdown.
      14) Loss of field alarm – shutdown.
      15) Reverse power alarm – shutdown.
      16) High temperature shutdown shutdown alarm – shutdown.
      17) Low oil pressure shutdown alarm - shutdown.
      18) Overcranck alarm - shutdown.
      19) Overvoltage alarm – shutdown.
      20) Overspeed alarm – shutdown.
      21) Control locked out alarm – shutdown.
      22) Low coolant level alarm – shutdown.
      23) Alarm silence push - button to shutoff horn but maintain lamps- on.
      24) Lamp test push- button to test simultaneously all lamps on the panel.
      25) Auto - Off- Manual selector switch.
      26) Control reset push button.
      27) Breaker control push button/ switch for circuit breaker on- off switching.
      28) Locking voltage and frequency adjustment potentiometers.
      29) Complete engine control including DC gauges.
      30) Emergency stop for each generator.
      31) General Stop emergency switch.

32) General Stop emergency switch outside the premises of the generators.

6. THE TOTALIZING CONTROL UNIT is to include:
   a. Manual Control and Meters:
   b. Digital power meter.
   c. Alarm and status indication lamps for:
   d. Priority 2 load pickup status indication.
   e. Priority 3 load pickup status indication.
   f. System test status indication.
   g. Low fuel main tank trouble indication.
   h. Utility power failure status indication.
   i. First load shed alarm indication .
   j. Second load shed alarm indication .
   k. Emergency bus under frequency alarm indication (Optional).
   l. Alarm silence push – button.
   m. Lamp test push – button.
   n. Alarm horn.
   o. Under frequency alarm reset (Optional).
   p. Load demand control switch.
   q. Lead unit selector switch.
   r. Load restore key-switch to allow restoration of loads shedded.
   s. Load priority override keyswitches.
   t. System test keyswitch.
   u. Mode Selector switch for Auto- Off- Manual to perform sequence specified. (Required only if manual synchronizing option is required).
   v. Automatic Control Components:
   w. Programmable controller to manage the load demand, priority control and load shedding.
   x. Load priority and shedding control relays.
   y. System starting controls.
   z. Bus under- frequency relay.
   aa. Master first start sensor.
   bb. Time delay start relay.
   cc. Ni – Cd battery similar to SAFT (France), with appropriate electronic charger similar to AAES (France), with charger fault alarm and battery fault + undervoltage alarm.

2.4 FUEL SYSTEM

A. DAYTANK: Freestanding, factory-fabricated assembly, with integral, float-controlled transfer pump and the following:
   1. Construction: Black steel, With retention tank the same capacity than the tank, inclined at least 3 degrees from horizontal and fitted with drain plug, inlet and outlet pipe connectors and breather pipe.
   2. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
   3. Adequate to supply fuel to engine for an uninterrupted period of four hours' operation at 100 percent of rated power output of engine generator system without being refilled.
   4. Retention Tank: located under the tank with same capacity. When filled activates fuel pump to pump back to storage tanks.
   5. Low-Level Alarm Sensor: Separate device operates alarm contacts at 75 percent of normal fuel level.
   6. High-Level Alarm Sensor: Separate device operates alarm and redundant fuel shutoff contacts at 106 percent of normal fuel level.
   7. Piping Connections: Include fuel suction and return lines to fuel storage tank; fuel supply; and return lines to engine, local fuel fill, vent line, overflow line, and tank drain line complete with shutoff valve.

8. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor and/or leak detector in day tank. It operates a separate motor device that closes a solenoid valve in fuel suction line from fuel storage tank to day tank. Both items remain in shutoff state until manually reset. It also initiates retention tank pump to operate. Shutoff action initiates an alarm signal to control panel but does not shut down engine generator set.

B. FUEL LINES:

1. Heavy gauge, black seamless steel, to ISO/R65 or equal, treated internally with corrosion resistant paint and with joints sealed with PTFE 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 pipe fittings. Field fabricated and bent fittings are not to be used.
   a. Fuel feed line to daytank is to have by-pass with stop-cock. Size of fuel return line from daytank to main fuel tank is to be manufacturer's recommendations.
   b. Connection to engine shall be made with adequate flexible connection.

2. Expansion Joints: stainless steel, packless bellow type, suitable for working pressure and temperature of service, of same size as pipe on which installed, with screwed ends for pipe sizes not exceeding 50 mm and flanged ends for sizes over 50 mm.
3. Valves Generally: 125 psi steam working pressure rating and 200 psi cold water non-shock pressure rating and type that can be under pressure.

4. Pipe Hangers And Supports: factory made galvanized steel include anti-vibration rubber.

2.5 ENGINE EXHAUST SYSTEM

A. Muffler: Critical type, sized as recommended by engine manufacturer. Rated sound level reduction of 25 dBA or more.

B. Connections from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe.

C. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liners.

D. Insulation for Mufflers and Indoor Exhaust Piping: 7 cm mineral wool.

E. Supports for Muffler and Exhaust Piping: Spring hangers and all-thread rods and vibration hangers as specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints"; attached to building structure.

F. Exhaust Piping External to Engine: Prefabricated double wall stainless steel chimney, inner wall to be 6/10mm SS316 and Rockwool insulation of 50mm, ceramic seal and 5/10mm stainless steel SS304 outer wall. Chimney shall be complete with supports, compensators and end gap, comply with EN 1856 similar to Dinak, Poliedra or equivalent.

G. Flexible Connections: Provide Flanged spring stainless steel type bellows to compensate for pipe thermal expansion.

2.6 AIR-INTAKE and exhaust SYSTEM

A. Sound Absorber (silencer).

1. Construction: shall be fabricated from Galvanized steel sheet 1.1 mm minimum, reinforced when required according to SMACNA "Duct construction Standard".

2. Baffles: Absorbing material of protected mineral fiber blankets 2x10cm thick and perforated galvanized sheet steel facing on both sides.

3. Flexible Connector: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1; and factory fabricated with a strip of fabric 89 mm wide attached to two strips of 70-mm- wide, 0.7-mm, galvanized steel sheet or 0.8-mm aluminum sheet. Select metal compatible with connected duct system. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA's "HVAC Duct Construction Standards".

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 manufacturers equipment 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.

E. GENERATING SET: install to maintain alignment and minimize engine and generator stresses. Protect instrumentation and control equipment including engine mounted instruments from machine vibration. Mountings and method of mounting are to be as recommended by the manufacturer and approved by the Engineer.

F. 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.

G. ENGINE HOT- AIR EXHAUST DUCT: install approved canvas duct with metal frames between radiator and louvered opening in wall for radiator exhaust air.

H. SOUND ABSORBERS FOR INLET AND OUTLET AIR: Is to be designed according to Manufacturer recommendation, quality of mineral fibers absorbing material to be approved with the metal perforating sheets protections. Resulting noise to the nearest occupied area shall not exceed NC40.

I. TANK VENT PIPE: extend to nearest shaft 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 Section 16119 of the Specification. The earthing system is TN-S.

3.2 INSPECTION AND TESTS ON SITE

A. EQUIPMENT: and report any loss inspect equipment upon delivery to site or damage to the Engineer.

B. EARTHING RESISTANCE TESTS: if any are to be carried out to verify specified requirements.

C. 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.

D. 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, transfer of load and load-sharing as applicable.

4. Operation of engine shut- down and alarm a signaling and indication, under simulated fault conditions.

5. Measurement of vibration transmission to building structure.

E. 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.

F. PIPING SYSTEM: using carbon dioxide or nitrogen from pressurized cylinder, test each system to 1.5 times normal operating pressure. Do not subject equipment, apparatus or devices to pressure exceeding prescribed test pressure obtained from nameplate data or from manufacturers published data. Apply tests before connecting piping to equipment. Remove or disconnect and blank off relief valves, instruments and devices that might be damaged by test pressure. Maintain test pressure on system for 24 hours during which time there is to be no noticeable drop in pressure. Check for leaks using soap solution. Isolate source of pressure during testing.

SECTION 16115 — MAIN DISTRIBUTION BOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

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

C. STANDARDS:
1. Switchgear and control gear assembly are to comply, as a minimum, with IEC EN 61439-1&2 factory-built Tested Assemblies, Design and Routine verified, as indicated in BOQ or drawings.
2. Circuit breakers are to comply with IEC 947- 2 as specified.
3. Other components, where not otherwise specified, are to comply with the relevant IEC standards.

D. EQUIPMENT DATA: submit for approval detailed description of main distribution boards and major components supported by manufacturer's catalogues, indicating compliance with the Standards, equipment characteristics, details of construction, operating data, dimensions and weights etc. Give details of miscellaneous items including incoming and outgoing feeder terminal arrangement, connections at busbars, isolating, earthing, interlocks, control devices, digital indicating and metering instruments etc.

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

F. SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:
1. Plans and elevation 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 types and locations of protective gear (relays, instruments, CT s, VT s etc.)
5. All protecting device shall show: the Short circuit current value, the voltage drop, the indirect protection function in case of a fault with respect the earthing system.
6. Schematic and elementary diagrams of control circuits.
7. Foundation details, grouting holes, installation details.
8. Arrangement of incoming and outgoing feeders, terminal fittings, instruments, busbar connections etc.

G. 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 current 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.

H. SPARE PARTS: provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the followings:
   1. One set of fixed and moving contact for every type of replaceable (consumable) contact set.
   2. One operating motor and/ or coil for each type of electrically operated circuit breaker
   3. Two sets of each type of indicating lights, fuses, LEDs etc.

I. 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.

J. APPROVED SWITCHGEAR & CONTROLGEAR MANUFACTURERS: subject to compliance with the specifications and drawings, obtain main distribution board equipment, from one of the following:
   1. Schneider Electric (France).
   2. Eaton (Germany).
   3. Siemens (Germany).
   4. ABB (Germany).

K. APPROVED ENCLOSURE AND BUSBAR SYSTEM MANUFACTURERS: subject to compliance with the specifications and drawings, obtain main distribution board enclosure and busbar system, from one of the following:
   1. Schneider (Merlin Gerin) (France).
   2. Rittal (Germany)
   3. Eaton (Germany)
   4. Siemens (Germany)
   5. Holec (Holland)
   6. Logstrup (Ireland)
   7. ABB (Germany)

PART 2 - PRODUCTS AND SYSTEMS - MAIN DISTRIBUTION BOARDS AND ACCESSORIES

2.1 GENERAL REQUIREMENTS

A. GENERALLY: main distribution boards are to be dead- front type, metal enclosed, multi-cubicle, floor mounted, free standing, 600 V class of service switchboards, with fixed or draw- out Switchgear, manually or manually and electrically operated, as shown on the Drawings, with matching vertical sections to from a continuous integral and rigid structure. « Form 2B» as per IEC EN 61439-1&2 but with separate sections for outgoing distribution feeders and as indicated on drawings for each panelboard.

B. GENERAL CONSTRUCTIONS: rigidly framed and bolted, with electro-galvanized sheet steel enclosures, minimum thickness 1.5 mm, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating, gray color (RAL 7703 or ANSI 61) to approval. Switchgear is to be vermin, dust and rodent proof, IP43 protection to IEC 529 for indoor installations and IP 65 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. IP 65 panel boards shall include anticondensation heaters and all panel boards shall be thermally studied as indicated below.

C. VENTILATION: compartments are to be ventilated and cooled, where required, by approved methods complying with the Standards. Temperature inside the compartments shall be limited to 40 °C, where ambient temperature is 35 °C.

D. Where the panel is outdoor mounted and subject to direct sunlight, special measures shall be provided to limit the temperature inside the compartments to 40 °C

E. FASTENINGS: between structural members are to be bolted.

F. EXTENSION: of structure and busbars is to be possible at either end of switchboard

G. 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. **Form 2B are the requested configurations but with separate sections for outgoing distribution feeders (for the Form 2B), and separate functional unit compartment when indicated.**

H. 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.

I. SPARE AND SPACE POSITIONS are defined as follows:
   1. Spare position: fully equipped enclosure with swithchgear.
   2. Space position: fully equipped enclosure ready to receive switchgear with all necessary accessories.

J. BUSBARS: Shall be rigid, fully rated and have the same rating of main circuit breaker frame size plus 30%, and braced for a symmetrical rms short- circuit duty equal to or higher than main circuit breaker interrupting duty, for minimum of one second unless otherwise specified or shown on the Drawings. Busbars are to be tinned copper and all connections to be tinned, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to maximum 30 °C. Above average ambient temperature of 50 °C outside enclosure. Connections and buswork are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance.

K. CONNECTIONS: from busbar to switchgear are to be rated to carry full continuous current rating of switchgear frame and are to be insulated.

L. 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.

M. 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.

N. SWITCHBOARD TYPE: switchboard(s) are to be of the front accessible wall aligned, with fixed main circuit breaker sections (type and rating as shown in schedules) and fixed group mounted outgoing MCCB distribution section(s), busbars section(s), feeders' section(s). All compartments shall have glazed doors except for busbars & cable compartments. If each functional unit is arranged in a separate compartment, a solid door shall be provided for each compartment where the disconnecting element's toggle shall be extended to outside the compartment.

O. FIXED MAIN CIRCUIT BREAKER SECTION: is to individually accommodate main circuit breaker, main cable entry with terminal fitting assembly and metering compartment. Where required an additional cable pull section is to be provided, depending on actual configuration shown on the Drawings. Where placed against a wall, accessibility is to be possible from front and sides or only from front of section.

P. FRONT ACCESSIBLE FIXED, FEEDER MCCB (or ACB) DISTRIBUTION SECTIONS – FEEDERS SECTIONS – BUSBARS SECTION: 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 section(s). 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 times, and secured by self-tapping screws. If Plexiglas (or any other material) is used for segregation, it has to be fire retardant. Busbars are to be accommodated in separate horizontal and vertical sections. The electrical link from the busbars to each distribution MCCB (or ACB) could be by rigid or flexible insulated busbars (the electrical link within the same functional unit have to be done by rigid busbars, flexible busbars and cables are not allowed) unless the MCCB or ACB 's frame size is greater than 600 Amperes. In this case, the electrical link shall be rigid busbars.

2.2 MOULDED 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 4 poles (protected) unless otherwise shown on drawings.

B. CONSTRUCTION: totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials, for normal operation at 70 °C within enclosures, to approved standards, provided with quick-break, trip- free switching mechanism manually operated by front toggle type handle and automatically tripped under over-current and short circuits conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Contacts are to be non-construction. Cables terminals are to be solderless 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 bimetallic inverse time-delay over-current trip element for small overloads and instantaneous magnetic over-current trip elements for operation under short- circuit conditions. Circuit breakers 250 A frame size or where shown on drawings, shall have adjustable short time trips (I_m).

D. THERMAL OVERCURRENT TRIPS: are to be compensated to allow for ambient temperature higher at breaker than at protected circuit or device. Compensation is to be

applicable between 25 and 50 °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: unless otherwise specified on drawings, electronic trip circuit breakers are to have solid state trip units with long time delay setting range at least between 0.4 and 1.0 times maximum trip rating, adjustable short time delay (range 2 to 10 times maximum trip rating) with adjustable clearing time and instantaneous protection adjustable from 2 to 11 times continuous rating (fixed at 11 times continuous rating for circuit breakers 250A frame and lower). Solid state trip units are to be insensitive to changes in ambient temperature between -20 and + 55 °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. Maximum adjustable time delay of 0.4 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 100 A to 630 A frame sizes 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 947-2, sequence II (rated service short- circuit) breaking capacity, and maximum trip rating as shown on the Drawings. Interrupting capacities at specified voltage and frequency are to meet IEC 947- 2 test sequence I, II and III for circuit breakers of utilization category A for circuit breakers with frame size 630 A and less.
Interrupting capacities at specified voltage and frequency are to meet IEC 947-2 test sequence I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability) for circuit breakers with frame size 800 A and larger including air circuit breakers (ACB)

J. ACCESSORIES: circuit breaker design is to allow addition of electrical operator, control and interlocking functions, under- voltage release, shunt- trip coils, alarm and auxiliary switches, padlocking devices, key-lock devices and the like. Such accessories are to be provided where shown on the Drawings.

2.3 MINIATURE CIRCUIT BREAKERS (MCBs)

1. TYPE: thermal magnetic non-adjustable type, tested in accordance with IEC 947.2 & IEC 898. Breaker type and short circuit interrupting ratings are mentioned on design drawings.
2. MINIMUM SHORT-CIRCUIT BREAKING CAPACITIES are to be as shown on drawings. Contractor to check and confirm those levels (according to final equipment location: Transformers, MDBs, Panel Boards,….)
3. CONSTRUCTION: MCBs are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panelboard enclosure and humidities up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg. C. MCBs and combinational devices are to be modular, of unified profile and mounted to a standard DIN rail.
4. 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 (curve C characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milli-seconds.

5. RATINGS: preferred rated currents are to be 6, 10, 16, 20, 25, 30, 40, 50, 60, 80 and 100 A, 120A, calibrated at 40 deg.C, available as 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg.C, and loading is not to exceed 70% of circuit breaker rating.
6. 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 1+N, 2-pole and 4-pole circuit breakers.
7. AUXILIARIES, where required or shown on the Drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.

2.4 AIR CIRCUIT BREAKERS (ACBs)

A. GENERAL:

a. The ACBs shall comply with IEC 947-2.

b. The ACBs are to be electronic solid- state trip type. All circuit breakers are to be 4 poles (protected) unless otherwise shown on drawings.

c. The breaking capacity performance certificates shall be available for category B to the above mentioned standards. The test shall be carried out with a breaking performance during operation (Ics) and admissible short time withstand (Icw) equal to the ultimate breaking capacity (Icu).

d. The ACBs must be able to be supplied both from the top and bottom terminals without reduction in performance and without jeopardizing their functionality.

e. All ACBs shall be fully tropicalized (T2) as standard.

f. The ACBs shall comply with the isolating function requirements of IEC 947-2 section 7.1.2.

g. The ACBs shall have a rated service voltage of 690V AC (50/60Hz) and a rated voltage of 1000V.

h. The ACBs shall have a rated impulse withstand voltage of 12KV.

B. CONSTRUCTION:

a. The air circuit breakers shall be designed to be maintained;

b. They shall be available in fixed or drawout models and in three or four poles versions. On four poles version, from 800 up to 4000Amps, the neutral pole shall have the same current rating as the other poles and half of the current rating from 5000 to 6300Amps.

c. The main contacts of the air circuit breakers shall be encased in a reinforced polyester casing and offer double insulation from the operators on the breaker front face. The circuit breaker also shall offer total insulation of the control part with respect to the power part.

d. The operating mechanism shall be of the opening-closing-opening (O.C.O.) stored energy spring type with a closing time of less than or equal to 80ms.

e. The springs are charged manually by operating the front lever or using a motor operator. In the case of motor charged spring, the maximum time to charge the springs shall not exceed four seconds, it shall also be possible to charge the springs manually.

f. Contacts shall be designed to be maintenance free in normal usage.

g. On the front level, the circuit breakers must indicate the exact position of the main contacts and the condition of springs (charged/discharged) by means of precise and reliable signals without measurements nor specific tools.

h. Arc chutes shall be common on the whole range and removable on site to allow inspection of arc chutes and main contacts.

i. Drawout mechanism:

- General:

  Three positions of the moving part shall be possible:

  - Connected position – all auxiliary and main circuits engaged.
  - Test position – all auxiliary circuits engaged, all main circuits disconnected.
  - Isolated position – all circuits disconnected.

- Safety requirements:

  A door interlock shall be provided so that it shall not be possible to open the door until the air circuit breaker moving part is in the disconnected position.

  Insulated safety shutters shall be provided over the incoming and outgoing main circuits and over the auxiliary circuits. An interlocking shall be provided to prevent insertion of a circuit breaker having a rating higher than the current rating of the fixed part, into that fixed part.

  The racking handle shall be stowed on the air circuit breaker in such a manner as to be accessible without defeating the door interlocking.

  The safety perimeter shall be reduced to zero for the drawout version above and to the sides of the ACB.

C. ELECTRONIC TRIP CIRCUIT BREAKERS:

a. General requirements:

The overcurrent relay shall be a solid state type

- It shall be microprocessor based and use digital programming techniques for highest accuracy and be integrated as part of the circuit breaker;
- The sensors and the wiring shall be integrated within the case;
- The overcurrent relay shall be self powered;
- The current sensors shall be located within the case of the circuit breaker;

The overcurrent relay shall have a wide adjustment range to allow flexibility of setting on site. The trip unit shall measure the true RMS value of any waveform of current.

The control unit shall be equipped with a push to reset mechanical indicator. For anti-pumping function the control unit may communicate with other equipment on a communication BUS.

b. Characteristics:

- Long time protection (LT):
  - Adjustable from 0.4 to 1.0 of the sensor rating (In);
  - Time delay adjustable.
- Short time protection (ST):
  - Adjustable from 0.4 to 15 times the long time protection setting (Ir);

- Time delay adjustable;
- Time inverse characteristic (I2t) may be switched in order to improve discrimination.

- Instantaneous (INST)
  - Adjustable from 2 times up to:
  - ➢ At least 20 times the rated current for sensor ratings up to 2000 Amps;
  - ➢ At least 10 times the rated current for sensor ratings above 2000 Amps.

c. Control functions:

In order to optimize the operation, maintenance and monitoring of the breaker in complete safety, the following standard control items shall be supplied as an integral part of the control unit:

- Local overcurrent LED indication with 2 levels – LED steady or flashing – on the front face and one volt free output contact shall indicate as a pre trip alarm;
- Two NO and two NC output contacts plus one CO fault trip contact (SDE) shall be available;
- Thermal memory: The control unit shall optimize the protection of the equipment or the circuit conductors in the event of repeated overloads or faults by using thermal integration to memorize temperature rises;
- Safety: internal overheating of the control unit shall be signaled.

d. Options:

Without increasing the volume it shall be possible to combine the following functions into the air circuit breaker control unit:

- Load monitoring and control: Two adjustable settings with output contacts shall be available. These settings to be related to the long time protection setting;
- Zone selective interlocking for the short time and earth fault protection;
- Earth fault protection;
- Remote indication of one particular fault as selected by a switch on front face;
- Fault trip indication – indicating the element (long time, short time/instantaneous, earth fault protection if supplied) that has caused the circuit to trip, indicated locally by a led;
- Measurement:
  - A digital display ammeter shall indicate the RMS value of the circuit breaker phase currents with a switch on the front face for selection;
  - A bar graph shall display the load indication of each phase;
  - The highest value of phase current shall be stored and displayed on demand.
- Communication:

  The data or action needed for the control and indication functions shall be available on a BUS via a specific modular system, ie:
  - Circuit breaker state;
  - Control unit settings;
  - Cause of circuit breaker trip;
  - Circuit breaker operation.

D. CIRCUIT BREAKER RATINGS: are to be non-current limiting, fully rated (100%) with continuous duty at site conditions, and with frame size and interrupting capacity to IEC 947-

2, sequence II (rated service short- circuit) breaking capacity, and maximum trip rating as shown on the Drawings.
Interrupting capacities at specified voltage and frequency are to meet IEC 947-2 test sequence I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability) for air circuit breakers (ACB).

E. ACCESSORIES:

a. Electrical accessories:

All electrical accessories including the motor spring charging mechanism shall be field adaptable without adjustment or the necessity for any tool (except a screwdriver). They shall be fitted into a compartment which under normally loaded conditions has metalwork energized from the main poles exposed with it. Thus any adaptation carried out shall not increase the breaker volume.

It shall be possible to connect all auxiliary wiring from the face of the air circuit breaker; this wiring shall be taken through a set of disconnecting contacts, so that all auxiliary wiring is automatically disconnected in the isolated position.

b. Mechanical indicators

Mechanical indication on the front of the air circuit breaker shall be provided to indicate the following:

- Main contacts closed “ON”;
- Mains contacts open “OFF”;
- Springs charged;
- Springs discharged;
- Circuit breaker in “connected” position (drawout only);
- Circuit breaker in “test” position (drawout only);
- Circuit breaker in “disconnected” position (drawout only).

All indicators must be clearly visible.

2.5 DIGITAL POWER METERING INSTRUMENTS (DIGITAL POWER METER)

A. GENERALLY: Power meters shall combine the following functions in a signal unit:
1. True RMS measurements up to the 31st harmonic for voltage, current, frequency, power and power factor.
2. Measurement of power quality, i.e. the level of harmonic distortion (THD) in voltage and current.
3. Metering of active and reactive energy.
4. Indication and control via two output relays that can be assigned to power or power factor to trip alarms or initiate load shedding.
5. Transmittal of all the measurements indicated below to the BMS system.

B. MEASUREMENTS
1. Phase to neutral voltages (V_{1N}, V_{2N}, V_{3N}): 115 to 500 VAC, ± 1% accuracy.
2. Phase to phase voltages (U_{12}, U_{23}, U_{31}): 115 to 500 VAV, ± 1% accuracy.
3. Currents (I_1, I_2, I_3 and I_N): 15 to 2500 A, ± 1% accuracy.
4. Maximum Current.
5. Frequency: 45 to 65 H_Z, ± 0,02% accuracy.
6. Power factor: ± 1,5% accuracy.
7. Active Power: ± 1,5 accuracy.

8. Reactive Power: ± 1,5% accuracy.
9. Apparent Power: ± 1,5% accuracy.
10. Active energy consumed.
11. Reactive energy consumed.
12. Apparent energy consumed.
13. Reset of meters (including maximeter).
14. Harmonic distortion of currents I_1, I_2, I_3 and I_N: ± 1% accuracy.
15. Harmonic distortion of voltages V_{1N}, V_{2N}, V_{3N}, U_{12}, U_{23} and U_{31}: ± 1% accuracy.
16. Assignment of output relays for power (active, reactive, apparent), demand power and power factor.
17. Measurement shall be available on the front panel of the power meter, by an LCD screen.

C. Mechanical Characteristics:
1. Degree of protection IP 40.
2. Vibrations F_C test: 2 to 13,2 H_Z-1 mm and 13,2 to 100 H_Z-0,7 g.
3. Operating temperature: -20 to +55 °C.

2.6 DIGITAL ENERGY METERING INSTRUMENTS (DIGITAL KWH- METER)

A. STANDARDS: The electricity meters shall comply with the following standards
The following standards are applicable to all communications processes of the Automatic Meter Reading (AMR) system.

1. EN 13757-2:2004 Communication system for and remote reading of meters.
2. Part 2: Physical and link layer.
3. EN 13757-3:2004 Communication system for and remote reading of meters.
4. Part 3: Dedicated application layer (M-Bus).
5. EN 13757-4:2005 Communication system for meters and remote reading of meters
6. Part 4: Wireless meter readout (radio meter reading for operation in the 868 MHz to 870 MHz SRD band)
7. All distributed standalone and unitary controllers supplied shall comply with the CE Electro Magnetic Compatibility standard, where two or more codes are in conflict, the most restrictive shall apply. Nothing in this specification or related documentation shall accept work not confirming to applicable codes.

B. AUTOMATIC METER READING SYSTEM:
The Automatic Meter Reading (AMR) System shall operate as a Client/Server Technology enabling maximum flexibility. The system shall allow a manual and automatic backup function. The reading of the meters installed and connected to the AMR system shall automatically be read out in defined sequences. On demand, the system shall be capable of reading and monitoring the meters online.
1. In case of errors the system shall automatically inform the operator, by setting an alarm signal on the screen or by sending an email/SMS.
2. The readout interval shall freely be selectable e.g. 15 minutes 1, 3, 6, 12, 24 hours and up to two readings per month.
3. The meter data shall automatically be stored in a powerful Oracle© database. The AMR system should be able to read the meters values at any time.
4. The system shall provide accurate metering data to enable the correct billing.
5. Export of meter data shall be very flexible (e.g. ASCII, Excel or ODBC database connection) to be compatible to the customers' billing software. It shall be possible to do this export manually or automatically.
6. The visualization of meter data shall be available in tables and diagrams.
7. It shall be possible to do a user access management to provide a safe data storage where only allowed people will have access.
8. The functionality of a virtual meter shall be provided by the AMR system. In that way it's possible to calculate the values of several meters to only one.
9. A direct access from the AMR system to the M-Bus System shall be possible to get the current value of a meter.

10. A possibility to validate meter values shall be integrated in the AMR system
11. Managing reading and data handling of wireless and wired readouts in one system
12. Modular Software structure to fit exactly on individual needs and to reduce complexity.

C. ELECTRICITY METER:
The electricity meter shall measure the energy consumed via a digital measuring principle, to ensure optimum accuracy and durability. The electricity meter has to be equipped with an internal M-BUS module. The electricity meter shall measure the active energy for automatic billing purposes.

1. The system shall measure with exceptional accuracy according to class 1 with a current transformer.
2. 4 wire meter with 3x230/400V
3. The Digital Energy Meter shall be certified by an independent approval authority.
4. The Digital Energy Meter shall provide an internal AMR interface (no pulse conversion allowed).
5. The Digital Energy Meter shall be equipped with M-BUS module as per DIN EN 13757-2, -3 (300...9600 baud).
6. The Digital Energy Meter shall have a minimum 8 Digit LCD Display for active energy and instantaneous power display, phase and phase sequence display, reversed current transformer polarity and exceeded ranges, positive or negative active or reactive power, parameters enabling.
7. Rail Bar mounting DIN EN 60715.

2.7 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. Terminal boards shall be WAGO or approved equal.

B. CONNECTIONS: are to be made at front of terminal boards 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 mm^2 section, to nearest earthing bar.

D. CONTROL WIRING: copper. PVC insulated, 85 °C, 600 V grade, and PVC sheathed for multi- core cables running from the control terminal blocks to outside the panel. Finely stranded copper conductor, silicon rubber insulated cables are to be used inside the panel.

E. FERRULES: wires are to be fitted with numbered ferrules of approved type at each termination.

2.8 MISCELLANEOUS

A. SCHEMATIC AND WIRING DIAGRAM: is to be provided suitably located within each cubicle.

PART 3 - MAINS FAILURE AUTOMATIC TRANSFER SWITCHES (ATS)

A. TYPE: wall or floor mounted, Form 2B (as indicated on drawings & BOQ) as per IEC EN 61439-1&2 but with separate sections for outgoing distribution on feeders, galvanized sheet steel cubicle of equal construction to control cubicle, comprising contactors with manual by-pass switches or withdrawable air circuit breakers (as specified on drawings) and controls necessary for automatic transfer of power supply from normal source to standby source, voltage sensing control relay and time delay relays to signal generators start and stop, auxiliary switches and indicating lights etc. as necessary for the required operation of the system. Contactors and by-pass switches ratings and specifications are specified on drawings.

B. The busbars shall be rigid and fully sized. The electrical link from the busbars to each switchgear or control gear shall be by flexible insulated busbars unless the switchgear or control gear's frame size is greater than 600 Amperes. In this case, the electrical link shall be rigid busbars.

C. All compartments shall have glazed doors except for busbars & cable compartments. If each functional unit is arranged in a separate compartment, a solid door shall be provided for each compartment where the disconnecting element's toggle shall be extended to outside the compartment. If Plexiglas (or any other material) is used for segregation, it has to be fire retardant.

D. OPERATION: when voltage and/or frequency of any phase drops below an adjustable setting (85- 100%) of normal supply for an adjustable period of 1- 300 seconds, power failure relay is to actuate engine starting control, whilst normal mains contactor or breaker is to open. After an adjustable period of 0- 10 seconds from sensing stabilized rated voltage and frequency of generators at the ATS, Voltage pick- up adjustable from 85% to 100% nominal; frequency pick- up adjustable 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 contractor is to open and after a presentable pause 0.5 to 30 seconds minimum, normal mains contactor is to close; time delay is to be effective in both directions.

E. ENGINE SHUTDOWN: is to be initiated of the load to normal source (Refer to generator set controls upon shut- down).

F. MECHANICAL AND ELECTRICAL INTERLOCKS: are to prevent contactors/ circuit breakers from being closed simultaneously at any time. Transfer mechanism is to be powered from the source to which the load is being transferred.

G. SELECTOR SWITCHES: are to be provided as follows:
   1. Operating selector switch is to include the following:
      a. Normal: Generator set is set for automatic operation and the generator set starts if a power outage occurs, as described above.
      b. Test: Stimulates a power outage, starts and runs the generating set as Normal position.
      c. Stop: Shuts down the generating set and prevents it from starting. This is used when servicing the generator.
      d. Another selector switch is to be provided for two positions, "With load" and "without load" for testing or exercising:
      e. "With load": the generating set is to carry the load during testing or exercising periods.
      f. "Without load": generating set is to start but not assume the load.

H. PILOT LIGHTS (LEDS): are to indicate which contactor is closed.

I. H. INSTRUMENTS: are to include power meters (as specified).

J. CONTACTORS: are to comply with IEC 947, 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 contractor.

K. 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.

L. 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. Cables glands and gland plates are to be provided.

M. METAL CASES: of instruments, control switches, relays etc. are to be connected by flexible protective conductors, of not less than 2.5 mm 2 section, to nearest earthing bar or terminal.

N. EARTHING: earthing bar is to be provided for connection of protective earthing conductors, using set- screw or bolted antiturn pressure termination's.

O. FERRULES: wire ends are to be fitted with numbered ferrules of approved type at each termination.

PART 4 - FIELD AND INSTALLATION WORK

4.1 INSTALLATION

A. EQUIPMENT BASES: ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and equipment manufacturer's drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

B. 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.

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, cable trenches or building structure are provided as and when required and that they are properly installed.

D. EQUIPMENT: install on concrete bases etc., and assemble completely plumb and level, before grouting in holding- down bolts.

E. SUPPORTS AND TERMINATION'S: install all incoming and outgoing cable supports, cables ends and termination fittings required for power and control cables.

F. RELAYS: set in accordance with manufacture's instructions and in accordance with an approved scheme.

G. MAKE GOOD: damaged painted surfaces, clean and apply rustinhibiting prime coat and two finishing coats of approved enamel upon delivery of equipment to site, or as required by the Engineer.

4.2 INSPECTION AND TESTS ON SITE

A. EQUIPMENT: inspect- equipment upon delivery to site and report any damage to the Engineer.

B. SWITCHGEAR: inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.

C. TEST: after installation and before hand over, carry out all tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including insulation resistance tests and operational tests.

D. 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.

E. PRIMARY INJECTION TESTS: provide portable test equipment to test time- delay characteristics of circuit breakers by simulating an overload or faults condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.

F. INSTANTANEOUS TRIP ELEMENTS: test by high current primary injection, using high-current primary injection test- sets and report all readings.

G. ROUTINE TEST AT FACTORY AND ON SITE: are to be carried out on every main distribution board in accordance with the Standard specified (IEC 61439) for FBAs (feeder branch assembly) assembled from standardized components outside the works of the manufacturer. Routine tests are also to be carried out on every FBA, delivered to site.

SECTION 16116 — DISTRIBUTION, SUBDISTRIBUTION AND FINAL BRANCH CIRCUIT PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

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

C. STANDARDS: panelboards generally are to comply with the requirements of IEC 61439-1&2, Tested Assembly, Design and Routine verified, Factory-Built assembly of Low Voltage Switchgear and Control Gear.

D. DESIGNATIONS: panelboards are designated on the Drawings and in the Schedules as follow:
   1. PB or SDB (except where mentioned in the B.O.Q that the SDB shall follow M.D.B. specifications).
   2. Final branch circuit panelboards, power panelboards and subdistribution panelboards respectively, for secondary lighting and power distribution with either miniature circuit breaker (MCB) or moulded case circuit breaker (MCCB) protection on subfeeder or branch circuits, as shown on the Drawings.

E. 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 (cascading and discrimination).

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

G. 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 or continuous rating 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.

H. All protecting device shall show: the Short circuit current value, the voltage drop, the indirect protection function in case of a fault with respect to the earthing system.

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

J. APPROVED SWITCHGEAR & CONTROLGEAR MANUFACTURERS: subject to compliance with the specifications and drawings, obtain main distribution board equipment, from one of the following:

1. Schneider (Merlin Gerin, Télémecanique) (France).
2. Eaton (Germany).
3. Siemens (Germany).
4. ABB (Germany).

K. APPROVED ENCLOSURE AND BUSBAR SYSTEM MANUFACTURERS: subject to compliance with the specifications and drawings, obtain main distribution board enclosure and busbar system, from one of the following:

1. Schneider (France).
2. Eaton (Germany).
3. Siemens (Germany).
4. Holec (Holland).
5. Logstrup (Ireland).
6. ABB (Germany).

PART 2 - PRODUCTS AND SYSTEMS

2.1 DISTRIBUTION, SUBDISTRIBUTION PANELBOARDS

A. GENERAL REQUIREMENTS

1. RATED INSULATION VOLTAGE is to be in accordance with the respective Standards.
2. PANELBOARDS are to be totally enclosed, dead front type, protection code IP 43 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 529, and are to be factory designed and assembled.
3. EARTHING BAR is to be provided in every panelboard.
4. PROTECTION is to be fully rated throughout the systems.
5. SERIES (CASCADE) AND DISCRIMINATION COORDINATED PROTECTION. All calculation notes shall show the conformity of the protective devices to the « cascading » and discrimination characteristics and levels.
6. CIRCUIT BREAKERS are to be non-fused type.
7. CIRCUIT BREAKER ARRANGEMENT: panelboards are to have one main incoming circuit breaker or switch disconnector and the required number of branch circuit breakers, arranged as shown on the Schedules, including spare circuit breakers and spaces for future expansion. Three or four-phase panelboards are to be designed for sequence phase connection of branch circuit devices. Electrical circuits for sockets up to 32A shall be protected with an earth leakage circuit breaker with 30mA sensitive trip, same protection shall be applied to the lighting circuit of the toilets unless class II and/or extra low voltage (12 volts) lighting fittings are used with Class II isolation transformers.

B. PANELBOARD ENCLOSURES

1. 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.
2. CONSTRUCTION: box, trim and doors where required, are to be electro-galvanized sheet steel of gauges not less than specified and in accordance with the Standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the Standards, but are not to be less than 100 mm on all sides. Enclosure is to have predesigned angles or threaded end studs to support and adjust mounting of interior panelboard assembly. Enclosures shall have glazed doors.
3. 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.
4. 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. Enclosures shall have glazed doors.
5. FINISH: inner and outer surfaces of cabinet/boxes, trims, doors etc. are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, ageing and corrosion and of standard grey colour to the approval of the Engineer.
6. DIRECTORIES under glass, 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.

7. 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.

C. BUSBARS

1. TYPE: one piece, 98% pure electrolytic copper, based on maximum total temperature rise of 40 deg. C over an ambient of 50 deg. C at full continuous rating. Bolted contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminium is not to be used for busbars or panelboard parts.
2. 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. Busbars are to be full size without reduction. Busbar System and blank plates are to allow installation of future circuit devices, where indicated on the Drawings.
3. RATING: busbar rating is to be at least equal to main-circuit breaker frame size plus 20%. 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.
4. SHORT-CIRCUIT DUTY: busbars are to carry maximum short-circuit duty of main protective device, which is to be at least maximum short-circuit at point of application for one second, without showing any signs of degradation.
5. TERMINALS AND CONNECTIONS are to be anti-turn, solderless 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).
6. NEUTRAL BAR is to be solid and fully insulated from cabinet or box. One solderless box type set-screw connector is to be provided for neutral wire of each branch circuit and one bolted clamp-type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral is to be fully sized and rated as for phase busbars.
7. 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.

D. MOULDED CASE CIRCUIT BREAKERS (MCCBs)

1. TYPE: tested to approved standards, totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials, for normal operation at maximum temperature within enclosures at point of application, and provided with front operated single toggle type handle mechanism for manual operation of main contacts in addition to automatic operation under overcurrent and short circuits conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws, suitable for copper or aluminium conductors.
2. 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 overcurrent element for small overloads and instantaneous magnetic overcurrent trip element for operation under short-circuit conditions on each pole. Circuit breakers 250 A and larger are to have adjustable instantaneous trips. Where solid state electronic trip circuit breakers are required these are indicated in the Schedules suffixed with the designation SSTU.
3. 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.
4. TRIP CURRENT RATING (AMPS) indicates nominal maximum rating at which overload element is set to operate.
5. MCCBs FOR SDB: To comply with IEC947-2 test sequences I, II, III, utilization category A, and are to have rated service short circuit breaking capacities to meet the electrical requirements at the panelboard location.

6. FRAME SIZE is defined as maximum continuous current rating of circuit breaker which corresponds with its maximum trip range 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.
7. FRAME SIZES are generally to be selected (according to schedules and drawings indications) with minimum interrupting capacities and discrimination considerations at specified voltages and rated frequency, in accordance with the calculations showing for each protective device (the circuit breaker) its minimum rating, frame size and discrimination level. The shop drawings shall indicate these values and should be justified by the contractor.
8. TRIPPED POSITION: when tripped automatically by overcurrent condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.
9. INTERCHANGEABLE TRIPS: thermal-magnetic trip circuit breakers 100 A frame size to 600/630 A frame size are to have interchangeable trip units.
10. 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.
11. COMPENSATION: thermal overcurrent trips are to be ambient temperature compensated between 25 and 50 deg. C.
12. ELECTRONIC TRIPS UNITS, unless otherwise specified or shown on the drawings are applicable to circuit breakers 400 A frame size and larger, are to be solid state with long time delay settings between 0.4 and 1.0 times maximum trip rating, short time delay range of 2 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 2 to 11 times continuous rating (fixed at 11 times continuous rating for circuit breakers 250A frame and lower). 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. Maximum adjustable time delay shall be 0.4 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.
13. 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 overcurrent and short-circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be 30 mA, and 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.
14. CURRENT LIMITING CIRCUIT BREAKERS: moulded 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.
15. 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.

E. MINIATURE CIRCUIT BREAKERS (MCBs)
1. TYPE: thermal magnetic non-adjustable type, tested in accordance with IEC 947.2 & IEC 898. Breaker type and short circuit interrupting ratings are mentioned on design drawings.
2. MINIMUM SHORT-CIRCUIT BREAKING CAPACITIES are to be as shown on drawings. Contractor to check and confirm those levels (according to final equipment location: Transformers, MDBs, Panel Boards,….)
3. CONSTRUCTION: MCBs are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panelboard enclosure and humidities up to 95%, and are to be

constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg. C. MCBs and combinational devices are to be modular, of unified profile and mounted to a standard DIN rail.

4. 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 (curve C characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milli-seconds.
5. RATINGS: preferred rated currents are to be 6, 10, 16, 20, 25, 30, 40, 50, 60, 80 and 100 A, calibrated at 40 deg.C, available as 1+N, 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg.C, and loading is not to exceed 70% of circuit breaker rating.
6. 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 1+N, 2-pole and 4-pole circuit breakers.
7. AUXILIARIES, where required or shown on the Drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.

F. MOULDED CASE SWITCH (MCS)

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

G. MODULAR CONTRACTORS FOR SECONDARY PANEL BOARDS

1. Comply with section 16140 of the specification: wiring devices and disconnects.

2.2 PANELBOARDS

A. ARRANGEMENT: to comprise set of homogeneous branch circuit breakers with unified profile and base, one main circuit breaker or switch-disconnector (as shown on drawings) as indicated on drawings. 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.

C. FINAL BRANCH CIRCUIT PANELBOARDS SDB- TYPE MCB

1. INTERNAL ASSEMBLY: to comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for single and three phase panels. Assembly is to be complete with earthing bar and one piece insulated bolt-on/comb-type phase busbar. Busbars are to be single-phase and neutral or 3-phase and neutral 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 NFC and IEC standards. If the busbars rating exceeds 100 Amp (where the frame size of the main breaker is larger than 100 Amps), comb busbars shall not be used but still clause 2.1.C. of this specification shall apply.

2. SINGLE PHASE TYPE PANELBOARDS are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.
3. SINGLE PHASE TYPE PANEL BOARD MAIN CIRCUIT BREAKER OR SWITCH DISCONNECTOR is to be double-pole, with or without earth leakage device (RCD), as shown on the Schedules.
4. SINGLE-POLE + NEUTRAL (1 + N) AND DOUBLE-POLE (2P) MCBs for 240 V service, are to have trip ratings between 6 A and 50 A, with ICU (n)/ICS as required in the Schedules.
5. THREE PHASE 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 4 pole switch-disconnector or circuit breaker, main incoming, as shown in the Schedules or on the Drawings.
6. FOUR-POLE BRANCH CIRCUIT BREAKERS are to have trip ratings between 6 A and 100 A, with ICU/ICS as required in the Schedules.
7. THREE PHASE TYPE PANELBOARD MAIN SWITCH-DISCONNECTOR OR CIRCUIT BREAKER is to be four-pole, with or without earth leakage device (RCD), as shown on the schedules.
8. SHORT-CIRCUIT RATING: THREE PHASE panelboards may only have integrated equipment (series) short-circuit rating in accordance with calculations.

PART 3 - FIELD AND INSTALLATION WORK

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: to be neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections are to be split and bolted type, fully insulated. Wiring shall be arranged on terminals and connection blocks with marking as indicated in section 16120 of the specifications.

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 water-proof compound prior to installation.

3.2 INSPECTION AND TESTS ON SITE

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

B. CIRCUIT BREAKERS: tests are to include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by the Engineer, by applying necessary short-circuit, overload and earth leakage current for tripping circuit breaker as applicable and compare with manufacturer's data/characteristic curves. Measure and report ambient temperature inside enclosure.

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 AT FACTORY AND ON SITE are to be carried out, in accordance with the Standards (IEC 61439-1&2), on all panelboards assembled from standardized components of the manufacturer outside the works of the manufacturer.

SECTION 16118 - CONDUITS, WIREWAYS, SUPPORTING SYSTEMS AND RELATED ACCESSORIES.

PART 1 - GENERAL

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

1.2 **DESCRIPTION OF WORK:** raceways including conduits, wireways, cable trays and related installations and accessories necessary to support and protect cables, feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.

1.3 **REGULATIONS AND STANDARDS**: conduits, wireways, cables 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. Local production is prohibited if not tested and approved by a legal authority.

1.4 **TECHNICAL DATA:** submit data for approval including, but not limited to, the following:

A. Manufacturer's catalogues with specifications of raceways including conduits, trunking etc. and related accessories.

B. Samples of each type of raceway and accessory.

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

A. Exact routing of conduits, trunking etc. With indication of boxes, accessories and expansion joints, size of conduits and boxes

B. Typical assembly details of installation of trunking, trays etc.

C. Construction details of pull boxes.

D. Typical installation details including connection of conduits to metal enclosure. Connections of flexible conduits, vapour- tight installations in cold rooms, liquid tight flexible metallic outdoors etc. and earthing connections.

1.6 **APPROVED MANUFACTURERS:** obtain conduit, wireways and related accessories from one of the following or other equal and approved:

A.	UNIVOLT	(Austria)
B.	EGA Tubes	(England)
C.	DIELECTRIX	(England)
D.	Bahra Conduits	(KSA)
E.	Decoduct	(UAE)
F.	Steel City	(USA)

PART 2 - PRODUCTS AND SYSTEMS

2.1 CONDUITS AND ACCESSORIES

A. RIGID & FLEXIBLE METAL CONDUIT
1. 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.
2. Black enameled or hot dipped galvanized, L= 3m, screwed on both ends to NF-C-68-100. Locally manufactured conduits shall not be accepted.
3. LIQUID- TIGHT FLEXIBLE CONDUIT: is to have PVC jacket extruded over core.
4. FITTINGS GENERALLY: threadless, hinged clamp type, hot dipped galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
5. STRAIGHT CONNECTORS: one piece body, female type, hot dipped galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
6. 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.

B. RIGID HEAVY GAUGE PVC CONDUIT Locally manufactured conduits shall not be accepted
1. MATERIAL: rigid unplasticized, could form a bend or with PVC accessories, polyvinyl chloride with high impact and high temperature resistance, flame retardant, non hygroscopic and non- porous, compressive strength ≥ 1250 N, to CEE 26, BS 4607 and BS 6099, DIN 49026, NFC 68-107 or other equal and approved standards conforming to IEC 423.
2. FITTINGS GENERALLY: unbreakable, non-inflammable, self-extinguishing, moulded plastic.
3. ASSEMBLY: conduits, boxes and accessories are to be assembled by cementing, using manufacturer's recommended products and appropriate connectors or spouts are available use smooth bore male PVC bushes and sockets.

C. FLEXIBLE HEAVY GAUGE PVC CONDUIT
1. MATERIAL: flame retardant, heat resistant, non-hygroscopic PVC, high resistance to impact, ribbed on circumference for flexibility.

D. ELECTRICAL METALLIC TUBING (EMT)
1. MATERIAL: EMT Conduits and Fittings as per ANSI C80.3. UL 797 of 3m standard length of circular cross section, sheet metal galvanized steel body of sizes ¾'' up to 4''.

2. FITTINGS GENERALLY: Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
   a. Fittings: Set-screw or compression type.
   b. Fittings: Set-screw type.
   c. Fittings: Compression type.
   d.

3. OUTLET AND DEVICE BOXES: Boxes shall be constructed of feraloy cad/zinc electroplated with aluminum cellulose lacquered. Blank covers shall be constructed of sheet steel with gasket and stainless steel screws except for damp and wet locations.
   a. Sheet Metal Boxes: NEMA OS 1.
   b. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box with gasketed cover.

4. FLOOR BOXES

a. Floor Boxes: Cast metal, fully adjustable, rectangular with 5” minimum deph. The floor boxes have the incorporate the following:
b. Three separate compartments that accommodate a combination of bolt power and communication devices. This combination is accomplished due to a built-in service metallic dividers.
c. Hinged lid and trim flange for tile applications.
d. Black tile cover and trim.
e. Metallic single-gang plate for:
   1) Duplex devices,
   2) Blank;
   3) Meyco bushing / opening,
   4) For interlink technologies activate modules.

5. PULL AND JUNCTION BOXES
   a. Small Sheet Metal Boxes: NEMA OS 1.
   b. Cast-Metal Boxes: NEMA FB 1, cast aluminum with gasketed cover.

PART 3 - FIELD AND INSTALLATION WORK

3.1 CONDUIT AND WIREWAYS GENERALLY

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. Separate conduit and wireways installations are to be used for LV cables/wires normal light and power circuits, emergency light and power circuits and communication, signal and other low current systems wiring.

B. BOXES: junction, pull and splice boxes of ample capacity are to be provided as indicated or required. Boxes are to remain permanently accessible.

C. 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 manufacturer's instructions.

D. FIXING: conduits and wireway installations are to be concealed as much as possible.

E. SIZES: Unless otherwise specified conduits and wireways sizes, not shown on the Drawings, are to be selected in accordance with the tables and in relation to the number and size of conductors. Minimum size of conduit for all applications is to be 20 mm diameter, unless otherwise shown on the Drawings.

F. 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 protective earth conductor is required or not.

3.2 RACEWAY APPLICATIONS AND INSTALLATIONS GENERALLY

A. RIGID HEAVY GAUGE PVC CONDUIT: is to be used generally in underground installations and in screed (technical and common areas) and in duct banks.

B. RIGID HEAVY GAUGE PVC CONDUIT: is to be used for low current, communications and signal system wiring, except where otherwise shown on the Drawings or described in the particular section of the Specification.

C. RIGID HEAVY GAUGE PVC CONDUIT: unless otherwise mentioned rigid PVC conduit is to be used in screed embedded in concrete and under tiles for lighting and power low current systems.

D. FLEXIBLE HEAVY GAUGE PVC CONDUIT: is to be used for lighting, power and low current circuits for connection to fixtures installed in false ceilings, unless otherwise specified or mentioned on the drawings.

E. ELECTRICAL METALLIC TUBING (EMT): unless otherwise mentioned EMT conduit is to be used in exposed and surface installation above false ceiling that is used as return air plenum both for lighting, power and low current system in technical and common areas.

F. RIGID AND FLEXIBLE STEEL CONDUIT: of same material as corresponding conduit system is to be used for connection to motors, vibrating and non-rigidly fixed equipment and fixtures installed in false ceiling.

G. Rigid Steel Conduit: is to be used for exposed installations in technical areas (Except Pump Room and Boiler Room where additional PVC coating is required), Roof Floor (exposed instalations) and where requested by NFC 15-100

H. 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.

I. CROSSINGS: conduits are not to cross pipe shafts, vents or openings.

J. CLEARANCES: install conduits at least 100 mm clear of and preferably above pipes of other non-electrical services.

K. SLEEVES: obtain approval for positioning sleeves where conduits pass through reinforced concrete. Additional openings may be allowed in finished slabs but are to be drilled and not broken. fix sleeves rigidly to maintain position and alignment during construction work.

L. EXPANSION FITTINGS: provide in each conduit run over 30 mm in length and at crossing of expansion joint in structure.

M. WATERPROOF CONSTRUCTION: conduits are not to cross waterproof construction unless permitted by the Engineer. Specially designed and approved fittings are to be used.

N. MAKE GOOD all holes for conduits passing through walls, floors and ceilings with cement or similar fire-resisting material to full thickness.

O. BENDS: conduit runs between outlet, fitting and fitting or outlet and fitting are not to contain more than the equivalent of 2 quarter bends (180 degree total).

P. BENDING is to be made without damaging conduit or tubing and without reducing internal diameter. Methods of field bending are to be approved.

Q. CUT ENDS are to be reamed to remove burrs and sharp edges.

R. CONDUITS ENTERING COLD STORES are to be made vapor tight, so that vapor from outside cannot enter conduit.

S. DRAINING: arrange conduits so that condensed moisture can drain to screwed plug at lowest point.

T. 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.

U. CAPPING: conduits are to be properly capped until wiring conductors are drawn in.

V. 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.

W. TERMINATIONS: do not terminate or fasten rigid conduits to motor frame or base.

X. 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.

Y. FLEXIBLE CONDUIT FOR SLIDE RAIL MOUNTED MOTOR is to have sufficient slack to allow for movement of motor over entire slide rail length.

Z. 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).

AA. STANDARD ELBOWS are to be used for conduit sizes equal or greater than 20mm.

BB. 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 systems.

3.3 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 non-spouted enclosures etc, with smooth bore male PVC bushes and sockets.

C. ENDS OF CONDUIT end conduit fittings are to be cleaned and jointed using PVC cement recommended by manufacturer.

D. SEMI-PERMANENT ADHESIVE: use in joints requiring expansion couplers.

3.4 EMBEDDED CONDUITS

A. CONDUITS IN CONCRETE SLABS: place conduits parallel to main reinforcing steel.

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 in formed in the concrete, if approved.

3.5 EXPOSED CONDUITS

A. CONDUITS ON WALLS: 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:

Conduit Size mm (inches)	Maximum Spacing of Supports meters
20 (3/4)	1.5 m
25 (1)	1.5 m
32-38 (1-1/4-1-1/2)	2 m

D. SPACING OF CLAMPS OR CLIPS for supporting PVC conduits is not to be greater than.

Conduit Size mm (inches)	Maximum Spacing of Supports meters	
Conductors Rated 60 deg. C and below	Conductors Rated more than 60 deg. C	
20 (3/4)	1.25	0.60
25-50 (1-2)	1.50	0.75
63-75 (2-1/2-3)	1.80	0.90

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 one conduit to any surface wall outlet. Install junction box on home run near to ceiling level and tap-off vertical conduit to outlet box below.

SECTION 16119 - EARTHING SYSTEM

PART 1 - GENERAL

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

1.2 **DESCRIPTION OF WORK**: complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TN-S system arrangement, including:

A. Main earthing system.

B. Main earthing terminals or bars.

C. Transformers room earthing terminal.

D. Exposed conductive parts of electrical equipment.

E. Extraneous conductive parts.

F. Standby generators earthing terminal.

1.3 REGULATIONS AND STANDARDS: carry out work in accordance with the following:

A. IEC publications 364-3 and 364-41 Electrical installations in Buildings.

B. Latest edition of NFC 15-100 Regulations.

1.4 **DEFINITIONS OF TERMS** used on the Drawings and in the Specification are as follows:

A. EARTH: conductive mass of the Earth whose electric potential at any point is conventionally taken as zero.

B. EARTH ELECTRODE: conductor or group of conductors in initial contact with, and providing electrical connection to, Earth.

C. EXPOSED CONDUCTIVE PART: any part which can be readily touched and which is not a live part, but which may become live under fault conditions.

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

E. PROTECTIVE CONDUCTOR: conductor used for some measure of protection against electric shock and intended for connecting together any of the followings 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)

F. ELECTRICALLY INDEPENDENT EARTH ELECTRODES: earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other (s)

G. MAIN EARTHING TERMINAL OR BAR: the terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.

H. EQUIPOTENTIAL BONDING: electrical connection to put exposed and extraneous conductive parts at a substantially equal potential

I. EARTHING CONDUCTOR: protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.5 **EQUIPMENT DATA:** prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for earth rods, connecting clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits and tools etc., and samples of samples conductors as requested.

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

A. Exact location of earth pits, rods and details of installation and connection.

B. Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.

C. Cross sectional area of all earthing, protective and bonding conductors

D. Layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

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

A.	BICC	(England)
B.	Copperweld	(U.S.A.)
C.	ERICO	(U.S.A.)
D.	Furse	(England)
E.	Kingsmill	(England)
F.	G.E.C.	(England)

or other equal and approved.

PART 2 - PRODUCTS AND SYSTEMS EARTHING SYSTEM (TYPE TN-S)

2.1 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
   3. Earthing conductors
   4. Protective conductors
   5. Equipotential bonding conductors
   6. Electrically independent earth electrodes for special systems with transient earth clamp (similar to ERICO TEC 100C) for connection to standard earthing electrodes (Following the recommendation of the NFC 15-100 with this respect.)
   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 3 ohm other wise use additional earth rods. 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 general bus collecting all the earth at the building and to other earth electrode (s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.

D. ALTERNATIVE EARTH ELECTRODE: other types of earth electrode may be used, after approval, including:
   1. Cast iron pipes with special surround material
   2. Copper plate (s)
   3. Tape mats (strips)
   4. MAIN EARTHING BAR is to be provided at point of service entrance or main distribution room, and as described in the Specification or shown on the Drawings, to which all earthing conductors, protective conductors and bonding conductors are to be connected. Two insulated main earthing conductors are to be provided, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 95 mm2 bare copper conductor or as otherwise required by the particular Section of the B.O.Q.

   5. TESTING JOINTS (TEST LINKS) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar earth electrode. A bus system shall allow the disconnection of the lightning earth cable from the other earth cable in order to provide a separate test for each earth.

   6. 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. Unless otherwise mentioned the selection of sizes is to be in accordance with Table 54F of IEE Regulations.

   7. PROTECTIVE CONDUCTORS are not to be formed by conduit, trunking, ducting or the like. Where armored cable is specified and armour is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.

8. CONTINUITY OF PROTECTIVE CONDUCTORS: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/ or brazing to continuous protective conductors which are to be insulated by moulded materials.

9. EARTH FAULT LOOP IMPEDANCE: for final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on overcurrent occurs within 0.4 seconds, and for final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds. Use appropriate tables and present same approval by the Engineer (IEE Regulations: Tables 41A1 and 41A2, Appendix 7 and Regulation 543).

10. SUPPLEMENTARY EQUIPOTENTIAL BONDING: all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armour are to be connected to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor is not to be less than half of the protective conductor connected to respective earthing terminal, and minimum 4 mm2.

11. MAIN EQUIPOTENTIAL BONDING: main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premises side of the meter. Cross-sections of conductors are not to be less than half of the earthing conductors connected thereto, and minimum 6 mm2.

12. IDENTIFICATION: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labelled in accordance with the Regulations, as follows:

13. SAFETY ELECTRICAL CONNECTION- DO NOT REMOVE.

14. IDENTIFICATION: protective and earthing conductors are to be identified by combination of green- and - yellow colours of insulation or by painting bar conductors with these colours, as approved.

15. IDENTIFICATION: source earthing conductor is to be identified along its entire length by continuous green/yellow insulation labelled ‘earthing’.

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

A. MAIN EARTHING BAR is to be provided in location mentioned on drawings and connected to earth network by insulated conductor (size as mentioned on drawings) via testing joints.

B. EARTHING BARS OF GENERATORS AND TRANSFORMERS to be connected, by insulated earthing conductor, directly to main earthing bar.

C. 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 building earthing bar.

D. 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.

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

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

2.3 TRANSFORMER SUBSTATION EARTHING

A. TRANSFORMER NEUTRAL (STAR POINT) is to be connected by insulated earthing conductor to LV side main transformers earthing bar. Neutral earthing conductor size to be as mentioned on drawings.

B. LIGHTNING ARRESTERS is to be directly connected to earthing terminal, following the shortest path.

2.4 GENERATOR PLANT EARTHING

A. GENERATOR NEUTRAL (STAR POINT) is to be connected by insulated earthing conductor through the neutral earthing link or device to main generators 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, as required by NFC 15-100, with a minimum of 50 mm2.

B. GENERATOR EARTHING TERMINAL is to be connected to main generators earthing bar by insulated copper conductor of cross section as required on Drawings.

C. SWITCHGEAR (ATS) AND CONTROL GEAR: switchgear and control gear enclosurer are to be connected by separate protective conductors to earthing 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.

2.5 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 center at its earthing bar, and to motors, switches and other electrical equipment etc. at their earthing terminals, using 20 x 2mm bare copper strips or 50 mm2 bare copper conductor (minimum size) or as required on drawings 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 network, 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 center, panel or distribution unit.

2.6 MATERIALS AND PRODUCTS

A. EARTH ROD: copper clad steel, 20 mm diameter, 4.0 m length, extendible as necessary to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.

B. BURIED EARTH CONDUCTORS: annealed copper conductors 50 mm2 cross-section.

C. TAPS 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 25x25 mm strip conductor.

D. 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.

E. EARTHING CONDUCTORS: insulated (green/yellow) or bare copper conductor as described in the Specification for the particular application.

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

G. PROTECTIVE CONDUCTORS: single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming parts of a multi-core cable, colour coded.

H. MAIN EARTHING BAR: hard drawn copper, 40x4 mm where formed into a closed loop, and 50x6 mm where open ended. Earth bar is to be labelled Main Earth Bar and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.

I. PROTECTIVE BONDING CONDUCTORS: bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross- sectional area as described in sub-section 1 hereof.

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

PART 3 - FIELD AND INSTALLATION WORK

3.1 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 rocks 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 be 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.

G. PROTECTION AGAINST CORROSION: protect bolted connections against corrosion either by filling with vaseline or coating with a special anti-corrosion compound and proper capping.

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

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

3.2 TESTS ON SITE AND RECORDS

A. COMBINED RESISTANCE of earth electrodes is to be measured during dry season and checked against specified resistance.

B. ELECTRICAL CONTINUITY of all earthing and protective conductors including main supplementary equipotential bonding conductors is to be checked.

C. EARTH FAULT LOOP IMPEDANCE of all circuits is to be measured and checked against calculated impedance figures.

D. OPERATION of residual current protective devices is to be checked.

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

4. Test conditions and results obtained.

SECTION 16120 - WIRES & CABLES

PART 1 - GENERAL

A. The section shall cover all wires and cables.

1. The Contractor shall supply and install all wires and cables necessary for the complete Electrical System, as indicated on the Drawings, as required, and as specified herein.

B. APPROVED MANUFACTURERS: obtain materials from one of the following:

1. BICC (U.K.)
2. Pirelli (U.K.)
3. SAUDI CABLES (K.S.A.)
4. RIYADH CABLE (K.S.A)
5. NEXAN CABLE (U.S.A.)
6. GULF CABLES (U.A.E)

or other equal and approved.

C. LEED Silver requirements

1. The contractor shall limit the voltage drop to a maximum of 2% (total) on feeder conductors (that is from transformer up to Secondary Distribution Boards) and 3% on branch circuit conductors.

PART 2 - WIRES & CABLES - LIGHTING & POWER

2.2 SINGLE CORE WIRES (NYA) CU/PVC TO IEC 227

A. This specification covers single core, PVC insulated wires, intended for internal wiring in dry locations, concealed in conduits.

B. Conductors shall be of high conductivity annealed plain copper with concentric stranded conductors, to IEC 228.

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

D. All wires for lighting and power systems pulled inside conduits shall be single core, insulated with PVC compound, of grade not less than 300 / 500 volts, to IEC 227.

2.3 MULTICORE CABLES CU/XLPE/PVC TO IEC 502

A. Cu/XLPE/PVC cables shall be used for supply of power to main distribution boards, secondary distribution boards, pumps, HVAC equipment and all external lighting and equipment.

B. This specification covers single, two, three or four core cables, XLPE insulated and PVC sheathed, rated at 600V/1000 V unarmored and armored type.

C. Conductor shall be plain, annealed electrolytic copper, circular or sectoral stranded, conforming to the applicable requirements of IEC 228.

D. The insulation shall be cross-linked polyethylene material conforming to the applicable requirements of IEC 502.

E. The assembly shall consist of insulated conductors filled where necessary with non-hygroscopic material and covered with an additional layer of extruded thermoplastic material or non-hygroscopic binding tape.

F. The sheath shall be PVC based thermoplastic material, conforming to the applicable requirements of IEC 502.

G. Flexible cords for connection of fixtures to circuit-wiring shall have finely stranded copper Conductor with a PVC insulation, type NYFAF, 500 V grade. Connection caps shall be "3M" instead of WAGO in this case only.

PART 3 - FLEXIBLE CORDS

H. Cords used for water heater connections shall be of high conductivity tinned copper wires, (2.5 mm2 unless otherwise indicated) insulated with ethylene propylene rubber, three cores twisted together, filled and sheathed with chlorosulphonated polyethylene (EPR CSP), 300/500 V rated, and shall withstand an operating temperature of 85 °C.

I. Cords used for pendant lighting points and between 220 V / 12 V transformers to lighting fixtures, shall be circular three core (1.5 mm2) silicon rubber insulated, glass fiber braided 300/500 V rated and shall withstand an operating temperature of 150 °C.

J. Cords used for extract fans and fan coil units shall be of plain annealed copper conductor (2.5 mm2 unless otherwise indicated), PVC insulated, circular three cores twisted together, PVC overall sheeted 300 / 500 V rated and shall withstand an operating temperature of 70 °C.

K. Cords shall be manufactured by BICC (England), AEI (England) Pirelli (England or approved equal.

PART 4 - WIRES AND CABLES - TELEPHONE

L. Unless otherwise indicated, telephone cables shall be CAT5E UTP for backbone and shall have the following characteristics of construction:

1. Copper conductor, tinned, 0.5 mm (24 AWG) diameter.
2. PVC colored insulation with surface ring marking for identification.
3. Pair Twisting.
4. Concentric assembly protected with overlapped non hygroscopic tape.
5. Outer PVC sheath, gray color, with a rip cord laid up under sheath for easy stripping.
6. Maximum conductor resistance = 30 ohms per Km.
7. Maximum capacitance unbalance pair to ground 3400 pF/ Km.
8. Minimum insulation resistance = 150 Mega ohms/Km.
9. Characteristic impedance = 100 ohms.

PART 5 - CONTROL CABLES

M. Control cables where used underground direct burial shall comprise stranded annealed copper conductor of minimum 2 mm2 cross-section insulated with high dielectric polyvinyl chloride, nylon sheathed with a tape binder applied over the assembly, overall PVC jacketed Control cables shall comply with IEC 502.

N. Number of conductors shall be equal to the maximum number of functions plus 20% spare.

O. Cable shall be 600 /1000V insulated and sheathed grade.

P. Junction boxes shall include all necessary terminal connector boards with proper labels.

Q. Contractor shall make sure that the cross-sectional area of the conductors are sufficient to cater for the voltage drop due to the long runs involved.

R. Control cables where used in ducts underground or in conduits above ground shall comprise stranded annealed copper conductor of minimum 2 mm2 cross-section for cables in ducts and 0.75 mm2 for cables in conduits insulated with high dielectric polyvinyl chloride, and PVC sheathed. Control cables shall comply with IEC 502.

PART 6 - INSTALLATION OF WIRES & CABLES

S. All wires shall be installed in accordance with the applicable provisions of the approved codes and as indicated on the Drawings.

T. The number of wires and sizes of conduits indicated on the Drawings are a guide only and are not necessarily the correct number and sizes necessary for actual equipment installed. The Contractor shall install as many wires and conduits as required and necessary for a complete electrical system, and shall provide adequately for the equipment actually to be installed.

U. Where more than one conductor is used per phase, each phase, neutral if any and ground wires shall be run in each metallic or non-metallic conduit.

V. Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes.

W. At every outlet and pull box, wires and cables passing through, shall be left slack by an amount equivalent to 20 cm of cable length to allow inspection and connection to be made therein.

X. No cable bend shall have a radius of less than eight times its diameter.

Y. The Contractor shall not change any circuit number, especially from a phase to a different phase. If such a change is necessary due to modification on site, the Contractor shall bring this matter to the attention of the engineer.

Z. All conductors to be contained within a single conduit shall be drawn in at the same time.

AA. A wire pulling compound shall be applied to conductors being drawn through conduit. Pulling compound shall be soap tone or other approved material.

BB. Only cables forming part of a lift installation if any may be run in a lift shaft.

CC. Wires and cables for feeders, sub-feeders, control, and branch circuit wiring shall be color coded as follows:

Color	Conductor Function	Alternative Color
Brown	L 1	Red
Black	L 2	Yellow
Orange	L 3	Blue
Light Blue	Neutral (N)	Black
Green/Yellow	Equipment grounding (PE)	Green/Yellow

DD. Wire and cable sizes shall be as indicated on the Drawings; however in no case shall their size be smaller than required by the approved Code.

EE. Unless otherwise indicated, no conductor for lighting and power wires shall be smaller than 2.5 mm2.

FF. All branch circuits for internal lighting and appliances shall be single conductor cables run inside conduits, unless otherwise indicated.

GG. Feeder and sub-feeders shall be multi-conductor cables run exposed on cable trays or in underground ducts as shown on the Drawings.

HH. Single cables unless otherwise specified and shown on drawings, could be fixed directly to walls or ceilings. Where 2 or more cables are run in parallel, they shall be fixed on hot dip galvanized steel perforated trays or other approved special cable supporting and protecting arrangement.

II. Cables shall be fixed to supporting structures with approved hot dip galvanized cast steel clamps at distances not exceeding 20 diameters.

JJ. No joints or splices shall be accepted on main feeders.

PART 7 - IDENTIFICATION OF WIRES & CABLES

KK. Individual conductor or circuit identification shall be carried throughout, with circuit numbers or other identification clearly installed on terminal boards and printed on directory cards in distribution cabinets and panelboards. System shall be similar to Legrand CAB3 or approved equal.

LL. In junction boxes, cabinets, and terminal boxes where the total number of control, indicating, and metering wires is three or fewer and no terminal board is provided, each wire including all power wires, shall be properly identified by means of a plastic, wire marker. System shall be similar to Legrand Mémocab or approved equal.

MM. Wires including motor leads and other power wires too large for connection to the terminal boards shall be identified by wire markers as specified above.

NN. In manholes, handholes, pull boxes, junction boxes and at both terminals each cable shall be properly identified by a plastic tag located so as to be easily seen. System shall be similar to Legrand Duplix or approved equal. Wires and cables shall be identified by cable number indicated on the Drawings.

PART 8 - CONNECTORS AND TERMINAL BLOCKS

OO. For the wiring of circuits consisting of wire sizes 6 mm2 and smaller such as for lighting, branch circuits etc…, WAGO, self insulated pressure type connectors shall be utilized for all splices or joints. Where flexible cables (NYFAF) are used from ceiling outlet box to recessed lighting fixtures, 3M caps shall be utilized.

PP. For the wiring of circuits consisting of wire sizes 10 mm2 and larger, connectors shall be of the bolted pressure type, with a preinsulated sleeve. WAGO or Legrand Viking shall be used.

QQ. Connectors shall be manufactured from high conductivity copper, electro tin-plated.

RR. Connector bodies shall be manufactured from Polyamide.

PART 9 - CABLE GLANDS

SS. Cable glands shall be provided at the termination of all cables at the enclosure of a distribution board or any other equipment.

TT. Cable glands shall be indoor or outdoor type, ordinary or weatherproof according to the location of the termination, the installation standard and to the approval of the Engineer.

PART 10 - FIRE RATED CABLES

UU. Description

1. Fire resistant cable 600/1000 Volts rated, for use where fire resistance, flame retardance and low smoke and corrosive gas emission properties are required.

2. It shall provide uninterrupted power supply and preserve circuit integrity in the event of fire.

3. “X” x CSA mm2, plain or stranded Copper, Mica/Glass tape, cross-linked insulation and LSOH sheath overall; rated 600/1000V.

VV. Fire Resistance/Low Smoke

1. The cable shall meet the requirements of IEC331 and BS6387 for categories C, W and Z (950°C for 3 hours, water spray test and mechanical shock test).

2. When the complete cable is tested in accordance with BS7622 Pt 2 (IEC1034-2) it shall meet the minimum light transmittance requirements as stated in BS7622 Pt 2 (IEC 1034-2).

3. When tested in accordance with BS6425 Pt 1 (IEC754-1), all non metallic components shall give a level of HCl not greater than 0.5%.

WW. Flame Retardance: The cable shall meet the requirements of BS4066 Pt 1 (IEC332 -1) and comply with BS6387 categories “Flame Retardant”.

XX. Certification: The cable shall be certified by an approved authority to comply with the standards and requirements listed herein.

YY. Construction Conductors: 1.0 mm2 to 630mm2. Plain copper stranded circular conductor complying with BS6360 Class 2.

ZZ. Insulation: Mica/Glass Fire Resistant tape, covered by an extruded cross-linked insulation, complying with BS7655 type GP8 or type GP6, operating temperature 90°C. The cross-linked insulation shall prevent thermoplastic flow and give high short circuit withstand ratings.

AAA. Core identification
Cores shall be identified as follows:
Single core black or red
2 core black, red
3 core red, yellow, blue.
4 core red, yellow, blue, black.
7+ core white with black printed numbers.

BBB. Sheath: Abrasion resistant extruded LSOH sheath complying with BS7655 type LTS4.

CCC. Sheath color: Orange.

DDD. Sheath Marking
1. Marked as follows: Fire Rated Cable LSOH “X” x CSA ELECTRIC CABLE 600/1000V

EEE. Installation
1. Cables should be installed in accordance with the appropriate regulations including IEC 364, IEE Wiring Regulations, NF C 15-100 or any other national regulations.

FFF. Range and Availability
Single core 1.0 - 630mm2
2 core 1.0 - 300mm2
3 core 1.0 - 300mm2
4 core 1.0 - 300mm2
7, 12, 19, 27 & 37 core 1.0 - 2.5mm2

GGG. Temperature Limits:
The cables shall be suitable for operation in the range of -25°C to +90°C.

HHH. Quality Assurance:
The cables shall be manufactured under a strict Quality Management System that is certified to meet the requirements of ISO 9001.

SECTION 16121 - CONTROL/SIGNAL TRANSMISSION MEDIA

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 types of control and signal transmission media:
   1. Coaxial cable.
   2. Twisted-pair cable.
   3. Multiconductor control cable.

B. Related Sections include the following:
   1. Division 16 Section "Basic Electrical Materials and Methods" for building wire used for control or signal circuits.
   2. RETAIN SUBPARA ABOVE OR BELOW.
   3. Division 16 Section "Wires and Cables" for building wire used for control or signal circuits.

1.3 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

1.4 SUBMITTALS

A. Product Data: For control/signal transmission media.

B. Product Certificates: Signed by manufacturers of transmission media certifying that the products furnished comply with requirements and that they are have been coordinated with and accepted by manufacturer of connected equipment.

C. EDIT PARA BELOW FOR SPECIAL CABLE TYPES.

D. Samples of each of the following cable types for approval:
   1. Coaxial cable (1 for each type).
   2. Twisted pair cable (1 for each type).
   3. Multiconductor cable (1 for each type)

E. Maintenance Data: For transmission media to include in the maintenance manuals specified.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain all cable of each type through one source from a single manufacturer.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in CENELEC, IEC and or UTE.
   2. SUBPARA BELOW IS REQUIRED BY SOME FEDERAL AGENCIES.
   3. Listing and Labeling Agency Qualifications.

C. Comply with IEC.

1.6 PROJECT CONDITIONS

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

1.7 COORDINATION

A. Coordinate with and obtain review of cable characteristics and certification for use with the connected system equipment by the connected equipment manufacturers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. RETAIN ABOVE FOR NONPROPRIETARY OR BELOW FOR SEMIPROPRIETARY SPECIFICATION. REFER TO DIVISION 1 SECTION "MATERIALS AND EQUIPMENT."

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

   1. Electronic Cables:
      a. American Insulated Wire Corp.
      b. AT&T Technology, Inc.; Cable and Wire Division.
      c. Alcatel.
      d. BICC Brand-Rex Company.
      e. Cooper Industries; Belden Division.
      f. Guardian Products; General Cable.
      g. Mohawk Wire and Cable Corp.
      h. Pirelli Cable Corp.; Power Cable Division.
      i. Libancable.

2.2 ELECTRONIC CABLE

A. Single-Conductor Coaxial: 75-ohm characteristic impedance, solid polyethylene core, 97 percent coverage, copper-braid shield, polyethylene jacket; complying with MIL-C-17, Type RG-6A/U.

B. TWO PARAS BELOW SPECIFY CABLE FOR OUTDOOR APPLICATION.

C. Multiconductor Cable: Quantity of conductors indicated; 1mm tinned-copper conductors; color-coded, low-loss PVC insulation; aluminum/Mylar shield; No. 22 AWG tinned-copper drain wire; PVC jacket.

D. PARAS BELOW SPECIFY DIFFERENT CONSTRUCTIONS OF TWISTED-PAIR CABLE. THIS CABLE IS AVAILABLE WITH OVERALL SHIELD UNDER PVC JACKET.

E. CABLE IN PARA BELOW IS ONE PAIR WITHOUT OVERALL JACKET.

F. CABLE IN PARA BELOW IS ONE OR MORE PAIRS WITH OVERALL SHIELD.

G. Twisted Pair: Quantity of twisted pairs indicated; 0.5mm tinned-copper conductors; color-coded, PVC insulation; overall aluminum/polyester shield; 0.5mm tinned-copper drain wire; PVC jacket.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

A. Install cable as indicated, according to manufacturer's written instructions.

B. Install transmission media without damaging conductors, shield, or jacket.
   1. Do not bend cable, in handling or installation, to smaller radii than minimum recommended by manufacturer.

C. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
   1. Pull cables simultaneously if more than one is being installed in same raceway.
   2. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
   3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage media or raceway.

D. Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."

F. Use splice and tap connectors compatible with cable material.
   1. Make no splices except at indicated splice points.

G. Seal around cables penetrating fire-rated elements according to Division 7 Section "Firestopping."

H. Bond shields and drain conductors to ground at only one point in each circuit.

I. Connect components to wiring system and to ground as indicated and instructed by manufacturer.

J. 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 IEC standards..

K. Identify cables according to Division 16 Section "Basic Electrical Materials and Methods."

L. SELECT PARA ABOVE OR BELOW.

M. Identify cables according to Division 16 Section "Electrical Identification."

3.3 FIELD QUALITY CONTROL

A. Copper Cable Testing Procedures: Inspect for physical damage and test cable for continuity and shorts. Use time-domain reflectometer with strip-chart recording capability and anomaly resolution to within 12 inches (300 mm) in runs up to 1000 feet (300 m) in length. Test cable segments for faulty connectors, splices, terminations, and the integrity of the cable and its component parts.

B. FIELD TESTING IS EXTREMELY IMPORTANT FOR OPTICAL FIBER CABLE. REFERENCED TESTS IN NETA STANDARD INCLUDE INSPECTION PROCEDURES TO VERIFY PHYSICAL CONDITION AND TESTS AND MEASUREMENTS TO VERIFY PROPER INSTALLATION.

C. Replace malfunctioning cables at Project site, where possible, and retest to demonstrate compliance.

SECTION 16124 — MEDIUM VOLTAGE CABLES

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 cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

B. Samples: 400-mm lengths of each type of cable indicated.

C. Qualification Data: For Installer.

D. Material Certificates: For each cable and accessory type, signed by manufacturers.

E. Source quality-control test reports.

1.5 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

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

D. Comply with IEEE C2 and NFPA 70.

E. Comply with Local Authority requirements.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cables:
      -Saudi Cables (KSA)
      -Ducab (United Arab Emirates)
      -Or approved equal.
   2. Cable Splicing and Terminating Products and Accessories:
      -Raychem Corp.
      -RTE Components; Cooper Power Systems, Inc.
      -3M; Electrical Products Division.
      - Or approved equal.

2.2 CABLES

A. MV Cable shall be insulated with chemically cross linked polyethylene

B. (XLPE) SWA armored and PVC sheathed, of the type and rating 15(18) KV.

C. MV Cable shall conform to IEC60 502.

D. Cable shall be suitable for a maximum conductor operating temperature of 90 Degrees C.

E. Each phase shall be identified. The cable designation and manufacturer's name shall be embossed on the cable over-sheath.

F. The semi-conductive layer of the cable insulation shall be capable of being removed without the use of tools to ensure that the core insulation is undamaged.

G. Cables shall be de-rated in accordance with the ambient air and ground temperatures.

H. Conductor: Copper.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
   1. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
   2. Premolded, cold-shrink-rubber, in-line splicing kit.
   3. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.4 SOLID TERMINATIONS

A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.
   1. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
   2. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.

C. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
   1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap.
   2. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.

2.6 FAULT INDICATORS

A. Indicators: Automatically reset fault indicator, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Armoring on all cables shall be fixed by armor clamps to the metalwork and earthing system.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
   1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
   2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."

F. Install direct-buried cables on leveled and tamped bed of (75-mm-thick, clean sand. Separate cables crossing other cables or piping by a minimum of 100 mm of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

G. Install "buried-cable" warning tape 305 mm above cables.

H. 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.

I. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.

J. Install separable insulated-connector components as follows:
   1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
   2. Portable Feed-Through Accessory: Three.
   3. Standoff Insulator: Three.

K. Seal around cables passing through fire-rated elements according to Division 7 Section "Through-Penetration Firestop Systems."

L. Install fault indicators on each phase where indicated.

M. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

N. Identify cables according to Division 16 Section "Electrical Identification."

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
   2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

B. Remove and replace malfunctioning units and retest as specified above.

SECTION 16139 — CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes hot dip galvanized cable trays and accessories.

1.3 SUBMITTALS

A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths and fittings.

C. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
1. Vertical and horizontal offsets and transitions.
2. Clearances for access above and to side of cable trays.
3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.

D. Field quality-control reports.

E. Operation and Maintenance Data: For cable trays to include in emergency, operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source form a single manufacturer.

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

C. Comply with NFPA 70 or with BS EN ISO1641

1.5 DELIVERY, STORAGE AND HANDLING

A. Hot dipped galvanized steel cable tray may be stored outside without cover, but shall be loosely stacked, elevated off the ground, and ventilated to prevent staining during storage.

B. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Local manufacturers are strictly prohibited subject to compliance with requirements, provide products by one of the following:
1. Wire mold (UK)
2. KSC (K.S.A.)
3. Vergokan (Belgium)
4. Thomas and Bett (USA)
5. EMI (UAE)
6. BICC (England)
7. Swifts Legrand (UK – France)

2.2 MATERIALS AND FINISHES

A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1 or BS EN ISO 1461 and BS EN 10326 and BS EN 10327.

B. Sizes and Configurations: Refer to the Cable Tray Sizes on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Minimum thickness= 1.5mm. Cable tray shall be heavy duty type, hot dip galvanized with return flange. Cable trays with 50-60cm shall have a thickness of 2.0mm.
1. Center-hanger supports may be used with approval of Engineer.

2.3 CABLE TRAY ACCESSORIES

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

B. Covers: Louvered type of same materials and finishes as cable tray.

C. Barrier Strips: Same materials and finishes as cable tray.

D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

E. Cable trays installed outdoor shall be provided with Sunshade cover

2.4 WARNING SIGNS

A. Lettering (40mm) high, black letters on yellow background with legend “Warning” NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL”

B. Materials and fastening are specified in Division 16 Section “Electrical Identification”.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Cable trays shall be used for all multicore cables surface mounted.

B. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees and crosses.

C. Remove burrs and sharp edges form cable trays.

D. Fasten cable tray supports to building structure
   1. Place supports so that spans do not exceed maximum spans recommended by supplier.
   2. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
   3. Support bus assembly to prevent twisting from eccentric loading.
   4. Manufacture center-hung support if approved and authorized by the Engineer, designed for 60 percent versus 40 percent eccentric loading conditions, with a safety factor of 3.
   5. The cable trays shall be of sufficient width to take all cables without crowding and shall allow for possible future additions to the proportions of the present requirements. Spare capacity shall be 35% minimum. Cables shall be run singly and stacking will not be permitted.
   6. Cable trays fixed to walls or flat ceilings shall be installed with the flange outwards or downwards respectively to suit and shall be fixed with an approved fixing with spacing and washers such that the tray is at least 25mm form the surface of the wall or ceiling. Earth continuity shall be maintained between each section of cable tray and total run of tray shall be effectively bonded to the nearest earth continuity conductor at both ends.
   7. Cable trays installed on roof floor or in any other floor where exposed to sun rays shall be protected with size shade covers (asbestos not approved)

E. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Supports cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.

F. Install expansion connectors where cable tray crosses buildings expansion joint

G. Make changes in direction and elevation Not cutting of tray shall be permitted.

H. Seal penetrations through fire and smoke barriers according to Section 16084 "Through-Penetration Firestop Systems."

I. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

J. Workspace: Install cable trays with enough space to permit access for installing cables.

K. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

L. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

3.2 CABLE INSTALLATION

A. Install cables only when cable tray installation has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. On vertical runs, fasten cables to tray every (45mm). Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

D. In existing construction, remove inactive or dead cables from cable tray.

E. Install covers after installation of cable is completed.

F. Wherever the cable trays are exposed to outside conditions, i.e. laid on the roof, these shall be covered with galvanized steel sheet of 20 gauge to protect from heat and rain.

3.3 CONNECTIONS

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

3.4 FIELD QUALITY CONTROL

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

Stage 1: after completion of cable tray installation

Stage 2 after completion of cables installation

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

B. Report results in writing.

3.5 PROTECTION:

A. Protect installed cable trays.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
   2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
   3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

SECTION 16145 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, to be in accordance with the requirements of section 16010 of the specification.

1.2 SUMMARY

A. This Section includes time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

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.

B. Comply with IEC, EN or NF.

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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Contactors and Relays:
      a. Merlin Gerin.
      b. Telemecanique.
      c. Moeller.
      d. Siemens Energy and Automation, Inc.
      e. ABB.
      f. Cutler-Hammer Products; Eaton Corporation.
      g. GE Lighting Controls.
      h. Square D Co.; Power Management Organization.

   2. Time Switches:
      a. Merlin Gerin.
      b. Telemecanique.
      c. Moeller.
      d. Siemens.
      e. Legrand.
      f. Grasslin Controls Corp.

   3. Photoelectric Relays:
      a. Merlin Gerin.
      b. Legrand.
      c. Allen-Bradley/Rockwell Automation.
      d. Grasslin Controls, Corp.

   4. Occupancy Sensors:
      a. Bryant Electric.
      b. Legrand
      c. Honeywell, Inc.; Home and Building Controls.

2.2 GENERAL LIGHTING CONTROL DEVICE REQUIREMENTS

A. Line-Voltage Surge Protection: Include in all 220 V solid-state equipment. Comply with IEC or NF for each category.

2.3 TIME SWITCHES

A. Description: Solid-state programmable units with alphanumeric display complying with IEC or NFC.
   1. Digital dial.
   2. Two contacts, rated 30 A at 240-V ac, unless otherwise indicated.
   3. Two pilot-duty contacts, rated 2 A at 240-V ac, unless otherwise indicated.
   4. Eight-day program uniquely programmable for each weekday and holidays.
   5. Skip-day mode.
   6. Battery backup for 100 hours.

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, and complying with IEC or NF.

B. Light-Level Monitoring Range: 0 to 3500 fc (0 to 37 673 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.

2.5 OCCUPANCY SENSORS

A. Ceiling-Mounting Units: Unit receives 24-V dc power from a remote source and, on sensing occupancy, closes contacts that provide signal input to a remote microprocessor-based lighting control system.

B. Switch-Box-Mounting Units: Unit receives power directly from switch leg of the 220V ac circuit it controls and operates integral power switching contacts rated 220V ac, minimum.

C. Operation: Changes its dry contact state 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 or ON 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.

D. 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.

E. 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, and complying with IEC or NF.
   1. Current Rating for Switching: IEC or NF listing or rating 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.
   3. Contactors shall have a built-in local by-pass for locking contactor in On or OFF positions.

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 of "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 "Conductors and Cables" for low-voltage connections and "Voice and Data Systems" for digital circuits. Always terminate on terminal boards (WAGO or similar).

B. Wiring Method: Install all wiring in raceway as specified in Division 16 Section "Raceways and Boxes," unless run in accessible ceiling space and gypsum board partitions.

C. Bundle, train, and support wiring in enclosures.

D. Ground equipment.

E. Connections: Tighten electrical connectors and terminals according to manufaturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section "Basic Electrical Materials and Methods."

B. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."

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. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.

D. Verify settings of photoelectric devices with photometer calibrated within previous six months.

E. 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.

F. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

G. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

H. 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. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
   1. Train Owner's maintenance personnel on troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of three hours' training.
   2. Training Aid: Use the approved final version of maintenance manuals as a training aid.
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

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.

SECTION 16275 — MEDIUM VOLTAGE DRY TRANSFORMER

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Indoor ventilated dry-type secondary substation transformers.

1.2 REFERENCES

The ventilated dry-type transformers and protection devices shall be manufactured according to latest revision of the following standards (unless otherwise noted).

BSEN 50541-1

IEC 60076-1 to 60076-5

IEC 60076-11 (2004)

IEC 60905

CENELEC (European Committee for Electro-technical standardization) harmonization Document EN 60076-1,-2,-3,-5, HD 538-2 S1:1995, EN60076-11 Concerning dry type transformer

1.3 SYSTEM DESCRIPTION

A. Transformers shall be (indoor) secondary unit substation type with IP31 protective metal enclosure from incoming line terminals to outgoing feeder terminals.

B. Primary terminations shall be cable connections in air-filled terminal chambers.

C. Secondary terminations shall be busway or cable connections in air-filled terminal chambers as indicated on drawings.

D. All necessary interfaces for BMS or remote monitoring shall be provided.

1.4 SUBMITTALS

A. Manufacturer shall provide copies of following documents to owner for review and evaluation.
   1. Product data and spare parts list;
   2. Outline, nameplate, connection diagrams and other shop drawings on transformer;
   3. Installation and operating instructions, maintenance, troubleshooting and repair procedures and technical literature pertaining to all components or instruments provided.
   4. A certified test report containing minimum information per IEEE C57.12.91 Appendix.

1.5 OPERATION AND MAINTENANCE DATA

A. Manufacturer shall provide copies of installation, operation and maintenance procedures to owner.

B. Submit operation and maintenance data based on factory and field testing, operation and maintenance of specified product.

1.6 QUALITY ASSURANCE (QUALIFICATIONS)

A. Manufacturer shall have specialized in the manufacture and assembly of ventilated dry-type secondary substation transformers for (20) years.

B. Manufacturers: Firms regularly engaged in manufacture of dry type transformer of types and ratings required, whose products have been in satisfactory use in similar service for not less than 10 years. Preference shall be given to local manufacturers and agents/suppliers.

C. Installer: Firms regularly engaged and qualified with at least 10 years of successful installation experience on projects with electrical installation work similar to that required for the project.

D. Installer's Qualification:
   1. The contractor shall be responsible for obtaining the latest version of SEC specification for Power Distribution Transformers and shall be responsible for obtaining SEC approval.
   2. A contractor who is currently approved by SEC must carry out installation. The written approval of SEC for the contractor to carry out the work must be forwarded to the Engineer, and be acknowledged by him, before any installation works commences.

1.7 PROJECT CONDITIONS

A. Follow (standards) service conditions before, during and after transformer installation.

B. Indoor ventilated dry-type transformers shall be located in well-ventilated areas, free from excess humidity, dust and dirt and away room hazardous materials. Ambient temperature of area will be between minus 10 and plus (45) degrees C.

1.8 WARRANTY

A. Manufacturer warrants equipment to be free from defects in materials and workmanship for 1 year from date of handing over the Project.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Available Manufacturers : Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include , but not limited to the following :
   1. Schneider Electric / France Transfo (France).
   2. ABB (Sweden/Germany).
   3. Holec/Eaton Corp (Holland).
   4. Siemens (Germany).
   5. Zucchini (France/Italy).

2.2 DRY TYPE CAST RESIN POWER TRANSFORMER

A. Type: 3-phase, indoor type, two winding, low loss, solventless cast epoxy resin, copper windings, with minimum class F insulation for LV and MV windings, rated for continuous operation under worst site ambient conditions at full load, and complying with IEC 60726. Winding temperature rise is not to exceed 80 deg C over an ambient temperature of 40deg. C for class F insulation.

B. Insulation and Encapsulation: Humidity resistant, explosion and fire-resistant, self-extinguishing, tropicalized, giving non-toxic gases in the event of fire. To fulfill environmental, climate and fire classes of E2, C2 and FI respectively to CENELEC HD 464 SI/DIN 42523.

C. Winding current densities at rated normal and short circuit conditions are to be submitted for approval. Normal densities are to be within 2 A/mm2 for Copper, unless otherwise submitted by manufacturer and approved by engineer.

D. Tapping is to be provided on MV side by means of re-connectable links (off-circuit), giving +/-2.5% and +1-5% tapping on transformers for each primary voltage rating.

E. Rubber sound isolation pads are to be provided between core and coil assemblies, and between base and housing.

F. Cooling fans, are to permit 35% increase in rated power.

G. No load and load losses shall be minimum for efficient operation.

H. 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.

I. Temperature monitoring is to be provided by externally mounted tripping units giving alarm and trip at two stages with adjustable 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. Temperature monitoring system is to be microprocessor based digital type and equipped with temperature indicator to display winding temperature values in degrees Celsius.

J. Terminals: Arranged as specified and/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. Earthing busbars are to be provided on LV and MV sides of housing.

L. Housing: Sheet steel construction, IP 21 with provision of fans for indoor installation.

M. Noise Level: A weighted sound power (LWA)/pressure (LPA) level measured at lm in any direction from transformer (with fans off) is to be less than the following limits:

Transformer (kVA)	dB
1000	73/58
1250	74/58
1600	76/60
2000	78/62

N. Noise level for transformers with fans: the sound power/pressure level with all fans in operation is not to exceed 6 dB additional to the values above.

O. Characteristics:
1. Rated Power (net without fans) : as shown on drawings
2. Frequency : 60 Hz.
3. Rated Voltage:
   a. LV Side (primary): 13.8 kV.
   b. LV Side (secondary): 400 V.
4. Winding Connections: Dyl 1 neutral insulated and brought out.
5. Impedance Voltage at Rated Current: 5% for up to 1250 KVA transformers and 6% for 1600 KVA transformers.
6. Highest voltage for equipment (HV/LV): 20/1.1 kV.
7. Rated short duration induced and separate: Source AC with stand voltage (HV/LV): 50/3 kV
8. Separate source AC withstand voltage duration test time: 60 seconds.
9. Short duration test time: 60 seconds for any test frequency up to and including twice the rated frequency, or according to requirements of IEC 60076-3 for higher test frequency.
10. Lightning Impulse Withstand-Voltage: 95 kV.
11. Short-Circuit Apparent Power of the System at Location: 500 MVA.
12. Duration of Short-Circuit-Withstand: 2 seconds.
13. Terminal Connection System:
    a. MV Side: open bolted terminals with cable sealing ends (epoxy joints) for cables from below.
    b. LV Side: fully enclosed terminal box with cable sealing ends and removable non metallic plates for cables from above.

P. Accessories are to include the following:
1. Four re-orientable roller rim wheels and attachment accessories.
2. Digital protective unit for transformer monitoring and protection against winding temperature and fan operation with thermometer for indication of winding temperature values, 2 N.O. contacts for winding temperature alarm and trip, along with necessary winding temperature sensors (at least one 3-wire PT100 or equivalent per phase) and interface with fan control and protection system.

2.3 TESTING

A. Each transformer shall receive the following standard commercial test with test results available by transformer serial number upon request.
1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project.
2. Ratio tests on the rated voltage connection and on all tap connections.

3. Polarity and phase-relation tests on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Applied potential test.
7. Induced potential tests.

B. The following special tests shall be performed on each transformer.
1. Impulse test on the high voltage winding.
2. Temperature test at self-cooled rating.
3. Temperature test at maximum cooled rating.
4. Sound level test at self-cooled rating.
5. Insulation Resistance (megger) test.
6. Partial Discharge test.

C. All the tests shall be as per the IEC 60076-1, 2,-3,-5,-6,-7.

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 16 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 transformers and install warning signs according to Division 16 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.
   4. Duration of Each Test: 10 minutes.
   5. Temperature Correction: Correct results for test temperature deviation from 20 deg C standard.
   6. 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.
   7. Winding Resistance: Measure for windings at nominal tap setting. Measured resistance, deviating more than 1 percent, from that of adjacent windings, is not acceptable.
   8. Functional test of all protective devices.

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 16 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.

SECTION 16289 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER & LOW CURRENT CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 16010 of Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and extra low voltage (low current) equipment.

B. Related Requirements:
   1. Section 16115 "Main Distribution Boards" for factory-installed SPDs.
   2. Section 16116 “DISTRIBUTION, SUBDISTRIBUTION AND FINAL BRANCH CIRCUIT PANELBOARDS " for factory-installed SPDs.

1.3 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.4 TYPES

A. Furnish and install a complete internal lightning protection system including lightning & overvoltage arresters. As follows:

B. Lightning current arresters (Class I): For protection of installations against lightning current due to direct or close lightning strikes to be installed at main distribution panel(s)

C. Surge arresters (Class II): For protection of equipment against distant lightning strikes to be installed at secondary distribution panel(s)

D. Surge Arresters (Class III): For protection of equipment against the effects of induced magnetic fields & switching overvoltage to be installed as close as possible to the equipment to be protected

E. Class I and II arresters shall be energy coordinated with Class III arresters and terminal equipment to assure proper protection.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

1.9 APPROVED MANUFACTURERS

A. DEHN (Germany)

B. Furse (England)

C. Schneider Electric (France)

D. Siemens (Germany)

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

E. EN 61643-11

F. IEC 61643-1/-11

All supplied equipment shall be approved and certified by a third party laboratory as KEMA, UL, VDE or GOST.

2.2 LIGHTNING CURRENT ARRESTERS – CLASS I

A. Lightning current arresters should be of the combined type “Lightning current and surge arrester” being:

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

C. Energy-coordinated with surge arresters, Class II and III without additional Decoupling coils as well as energy coordinated with terminal equipment

D. Low voltage protection level

E. Double terminals for all conductor connections as well as output multifunctional terminal for conductors and bus bars

F. Ready for TT or TNS installations with the following technical specifications:

1.	Type 1+2	
2.	Continuous operating voltage	255V/50-60Hz
3.	Follow current extinguishing capability	25KArms
4.	Lightning Impulse Current (10/350)	25/100KA
5.	Voltage protection level at Iimp	<1.5KV
6.	Response Time	<100ns
7.	Back Up fuse	125A serial connection 315A parallel connection
8.	TOV Voltage [L-N]	Ut= 440V for 120minutes
9.	TOV Voltage [N-PE]	Ut= 1200V for 200ms

G. With built in remote signaling with full monitoring including N/PE arrester

H. Enclosure material Thermoplastic UL94-V0

I. Approved by KEMA

J. Only combined arresters with spark gap technology shall be accepted. MOV based combined arresters shall not be approved.

K. Combined Lightning current arresters shall be installed inside each main distribution panel(s) (MDB). TT installation configuration with N/PE arrester (3+1 circuit).

L. Where space saving inside MDB is required, Combined arrester with built in fuse shall be installed.

2.3 OVERVOLTAGE ARRESTERS – CLASS II (C)

A. Class II (C) arresters: To be installed at the power secondary distribution panel (SDB) with the following specifications:
1. Nominal Discharge current In = 20KA (8/20)
2. Max Discharge current Imax = 40KA (8/20) / pole
3. Lightning impulse current (10/350) Iimp 12KA(10/350)
4. Uc = 275V [L-N], 255V [N-PE]
5. Voltage protection level at In Up < 1.25KV
6. Voltage protection level [L-N] for 5 KA Up < 1KV
7. TOV Voltage [L-N] Ut= 335V for 5s
8. TOV Voltage [N-PE] Ut= 1200V for 200ms
9. Response time <25ns
10. Operating State: Green / Red
11. Degree of protection IP = 20
12. Enclosure materials – red thermoplastic UL 94 V-0
13. Max. mains-side over-current protection: 125A Gg/Gl
14. Short Circuit withstand capability at max. mains-side over-current protection = 50KArms

B. With built in remote signaling with full monitoring including N/PE arrester

C. Ready for installation in TT (TNS) installation without additional wiring includes Thermodynamic disconnection circuit for disconnecting in case of fault

D. Class II arrester should be KEMA approved.

E. Where space saving inside SDB is required, Class II arrester with built in fuse shall be installed.

2.4 OVERVOLTAGE ARRESTERS – CLASS III (D)

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

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

7. With remote signaling capability

2.5 SPD FOR DATA NETWORK AND INSTRUMENTATION

A. All data cables shall be protected with surge arresters with the following specifications:
   1. SPD Class: Type 2/ P1
   2. Nominal Voltage Un: 48V
   3. Maximum continuous operating voltage Uc: 48V
   4. Nominal Current IL: 1A
   5. Nominal Discharge current (8/20µs) per line-line In: 150A
   6. Total Nominal discharge current (8/20µs) line to Pg In: 10KA
   7. Nominal discharge current (8/20µs) line to Pg In: 2.5KA
   8. Voltage protection level line-line for In Up: <190V
   9. Voltage protection level line-Pg for In Up: <600V
   10. Insertion loss at 250Mhz: ≤2dB
   11. DIN Rail mountable
   12. Test Standard: IEC 61643-21
   13. Approved / Certified by: Cat. 6 acc. to ISO/IEC 11801, GOST

2.6 SPD FOR CCTV SYSTEM

A. CCTV cameras and Digital video recorders should also be protected using surge arresters specifically design to protect CCTV cameras and with residual voltage inferior to the system immunity against surges.

B. Surge arresters shall be used to protect both power, video signal or IP interface for IP cameras, and control cables of each camera whereas the video signal at each DVR input shall also be protected.

C. Video signal shall be protected with SPD with the following specifications:
   1. SPD Class: Type 2 / P1
   2. Nominal Voltage Un: 5V
   3. Maximum continuous operating voltage Uc: 8V
   4. Nominal Discharge current (8/20µs) per line In: 2.5KA
   5. Nominal discharge current (8/20µs) per shield-Pg In: 10KA
   6. Voltage protection Level Up line-shield for In: <25V
   7. Voltage protection Level Up line-shield at 1KV/µs: <15V
   8. Cut off frequency Fq: 300Mhz
   9. Test Standard: IEC 61643-21
   10. Approved by: GOST

D. For IP cameras, SPD should have the following specifications:
   1. SPD Class: Type 2/ P1
   2. Nominal Voltage Un: 48V
   3. Maximum continuous operating voltage Uc: 48V
   4. Nominal Current IL: 1A
   5. Nominal Discharge current (8/20µs) per line-line In: 150A
   6. Total Nominal discharge current (8/20µs) line to Pg In: 10KA
   7. Nominal discharge current (8/20µs) line to Pg In: 2.5KA
   8. Voltage protection level line-line for In Up: <190V
   9. Voltage protection level line-Pg for In Up: <600V
   10. Insertion loss at 250Mhz: ≤2dB
   11. DIN Rail mountable
   12. Test Standard: IEC 61643-21
   13. Approved / Certified by: Cat. 6 acc. to ISO/IEC 11801, GOST

2.7 SPD FOR PABX SYSTEM

A. Telephone lines shall be protected also with surge arresters using coarse and fine arresters to reduce the residual voltage to an acceptable level. Arresters with only Gas discharge tubes are not accepted.

B. Arresters shall have the following specifications:
1. Variable protection for 1 to 10 pairs in LSA systems of type 2/10
2. Modular system of lightning current and surge arresters
3. includes visual fault indicator.

C. Coarse arrester:
1. SPD Type:1
2. Fault indication: visually by colour change
3. Nominal voltage UN: 180 V
4. Max. continuous operating d.c. voltage UC: 180 V
5. Max. continuous operating a.c. voltage UC: 127 V
6. Nominal current IL: 0.4 A
7. D1 Total lightning impulse current (10/350 s) Iimp: 5 kA
8. D1 Lightning impulse current (10/350 s) per line Iimp: 2.5 kA
9. C2 Total nominal discharge current (8/20 s) In: 10 kA
10. C2 Nominal discharge current (8/20 s) per line In: 5 kA
11. Voltage protection level line-line for Iimp D1 Up: ≤500 V
12. Voltage protection level line-PG for Iimp D1 Up: ≤ 500 V
13. Voltage protection level line-line at 1 kV/ s C3 Up: ≤500 V
14. Voltage protection level line-PG at 1 kV/ s C3 Up: ≤ 450 V
15. Series impedance per line: ≤ 0.005 ohms
16. Capacitance line-line C: ≤5 pF
17. Capacitance line-PG C: ≤5 pF
18. Fail-safe function: gas discharge tube with spring contacts
19. Operating temperature range: -40°C...+80°C
20. Degree of protection: IP 10
21. Pluggable into: LSA disconnection block 2/10
22. Earthing via: mounting frame
23. Enclosure material: polyamide PA 6.6
24. Test standards: IEC 61643-21
25. Approvals, Certifications: VDS, GOST

D. Fine arrester:

For installation in conformity with the lightning protection zones concept at the boundaries from 1-2 and higher with the following specifications:
1. SPD Type: 3/P1
2. Nominal voltage UN: 180 V
3. Max. continuous operating d.c. voltage UC: 180 V
4. Max. continuous operating a.c. voltage UC: 127 V
5. Nominal current (IL): 0.1 A
6. D1 Total lightning impulse current (10/350 s)
   in combination with DRL 10 B... Iimp: 5 kA
7. D1 Lightning impulse current (10/350 s) per line
   in combination with DRL 10 B... Iimp: 2.5 kA
8. C2 Total nominal discharge current (8/20 s)
   in combination with DRL 10 B... In: 10 kA
9. C2 Nominal discharge current (8/20 s) per line
   in combination with DRL 10 B... In: 5 kA
10. Voltage protection level line-PG for Iimp D1
    in combination with DRL 10 B... Up: ≤280 V
11. Voltage protection level line-line at 1 kV/ s C3 Up: ≤500 V
12. Voltage protection level line-PG at 1 kV/ s C3 Up: ≤270 V
13. Series impedance per line: 4.7 ohms

14. Cut-off frequency line-PG Fg: 42 MHz
15. Capacitance line-line C: ≤50 pF
16. Capacitance line-PG C: ≤80 pF
17. Operating temperature range: -40°C...+80°C
18. Degree of protection: IP 20 (when plugged in)
19. Earthing via: earthing frame
20. Enclosure material: polyamide PA 6.6
21. Test standards: IEC 61643-21
22. Approvals, Certifications: VDS, GOST

2.8 SPD FOR SMATV SYSTEM

A. SPD shall be installed at the input of each coaxial cable such as of CATV and satellite reception systems with the following specifications:
   1. Class 3 / P1
   2. Include measuring output for dB loss Testing
   3. Combined lightning current and surge arrester for high discharge capacity & low voltage protection level
   4. Iimp = 0.2KA (10/350)
   5. In = 1.5KA (8/20)
   6. Uc = 24V
   7. In = 2A
   8. Frequency range: DC, 5-3000Mhz
   9. Insertion Loss 5-862Mhz = 1.2dB
   10. Insertion loss 862-2400Mhz = 1.4dB
   11. Insertion loss 2400-3000Mhz = 2dB
   12. Return Loss (5..47Mhz) ≥ 14dB
   13. Return Loss (47..3000Mhz) ≥18dB
   14. Response time <1ns
   15. Connection (input/output): F connector
   16. Degree of Protection : IP30
   17. Test Standard: IEC 61643-21
   18. Approved by: GOST

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with IEC 60364.

B. Install an OCPD or disconnect as required to comply with IEC standard.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:

1. Power Wiring: Comply with wiring methods in Section 16120 "Conductors and Cables."
2. Controls: Comply with wiring methods in Section 16120 "Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to operate and maintain SPDs.

SECTION 16320 — MV SWITCHGEAR (METAL ENCLOSED)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Medium Voltage (17.5 kV) switchgear and associated equipment including, but not limited to, the following:
   1. MV (17.5kV) metal enclosed switchgear.
   2. DC battery and charger.
   3. Cable glands.
   4. Accessories.

1.2 REFERENCES

A.	IEC 60099	Surge Arrestors
B.	IEC 60376	Sulphur Hexafluoride
C.	IEC 60185	Current Transformer.
D.	IEC 60186	Voltage Transformer.
E.	IEC 60255	Electrical Relays.
F.	IEC 60529	Degrees of Protection of Enclosures.
G.	IEC60071	Insulation Coordination
H.	IEC62271-200	Metal enclosed switchgear
I.	IEC 60265-1	High voltage switches for rated voltages of 52kV and above.
J.	IEC 62271-105	High voltage alternative current switch-fuse combinations.
K.	IEC 62271-100	High voltage alternating current circuit breakers.
L.	IEC 62271-102	High voltage alternating current disconnectors and earthing switches.

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. locations of protective gear (relays, metering instruments, CTs, VTs) etc.
   4. Schematic and elementary diagrams of control circuits.
   5. Block diagrams for BMS and SCADA interface points
   6. Foundation details, grouting holes and installation details.
   7. Physical arrangement of incoming and outgoing feeders, instrument transformers, busbars, connections etc.
   8. Dimensions and weights of control power supply and other auxiliary equipment or components.

C. Point-wise compliance statement to the specifications, duly signed by the manufacturer /manufacturer's authorized representative and the contractor.

D. Calculation of current and voltage transformers characteristics to verify their suitability for proper unsaturated operation under site fault condition and their adequacy for relay /wires/metering requirements

E. 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.

F. 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.

G. 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.

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 specified in Division 1.

K. Coordination Study: Submit protection coordination study, 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 based on coordination curves of protective devices used and specific calculated prospective short circuit currents at various points.

1.4 WARRANTY

A. Manufacturer warrants equipment to be free from defects in materials and workmanship for 1 year from date of handing over the project.

1.5 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.

1.6 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.
   2. Complete set of main contacts of each rating.
   3. Complete set of breaker/switch auxiliary contacts.
   4. Complete mechanism of breaker/switch of each type.
   5. Drive motor of each type

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.

1.7 QUALITY ASSURANCE (QUALIFICATIONS)

A. Manufacturer shall have specialized in the manufacture and assembly of MV Switchgear for (20) years.

B. Manufacturers: Firms regularly engaged in manufacture of MV Switchgear with ratings required, whose products have been in satisfactory use in similar service for not less than 10 years. Preference shall be given to local manufacturers and agents/suppliers.

C. Installer: Firms regularly engaged and qualified with at least 10 years of successful installation experience on projects with electrical installation work similar to that required for the project.

D. Installer's Qualification:
   1. The contractor shall be responsible for obtaining the latest version of SEC specification for 13.8 kV Switchgear and shall be responsible for obtaining QGEWC approval.
   2. A contractor who is currently approved by SEC must carry out installation. The written approval of SEC for the contractor to carry out the work must be forwarded to the Engineer, and be acknowledged by him, before any installation work commences.

PART 2 - PRODUCTS

2.1 GENERAL

A. All material is used in the manufacture and installation of MV switchgear shall be of high quality and of proven suitability for the functions they will perform and the conditions they will meet in service.

B. For remote monitoring / controls, comply with the requirements.

2.2 MV (17.5 kV) SWITCHGEAR

A. Parameters

The MV switchgear shall be constructed based on following system parameters or as required by KAUST/SEC

1.	Voltage	: 17.5kV, 3 phase.
2.	Frequency	: 60Hz
3.	Basic Impulse Level (BIL)	: 95kV
4.	Symmetrical Fault Level	: 25kA RMS (1 second)
5.	Neutral	: Resistance earthed.

2.3 INDOOR FIXED METAL-ENCLOSED SWITCHGEAR

A. Type: For installation indoor categorized, three compartments with insulated or metallic partitions, comprising Single busbar, floor mounted, free standing switchgear of modular construction, forming a continuous integral structure extendable at either end, with withdrawable mounted circuit breakers, fixed breaker-switch disconnector combination, isolating disconnectors, and/or switch-disconnector-fuse combination, as specified or shown on the Drawings.

B. Switchgear is to have a degree of protection, against contact with live parts and against external effects, of IP3X for enclosures and IP 2X for partitions according to IEC 62271-1 and IEC 60529, when in the connected position.

C. Circuit breakers are to be frame mounted and bolted into position. Frame is to have wheels for handling during installation or maintenance.

Busbars: high conductivity, electrolytic copper, modular, design 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 fibreglass reinforced epoxy to approved standards.

D. Busbars: are to be insulated, either with epoxy insulation applied by the fluid-dip process or heat shrinkable insulating sleeves. Busbar connections are to be insulated with easily installed, preformed vinyl boots, secured by nylon hardware.

E. Single air-break /SF6 isolator is to be provided, on busbar side of circuit breaker, interlocked with circuit breaker operation such that isolation or connection of circuit breaker is not possible while circuit breaker is closed. Isolators are to be padlockable in the off and earth positions.

F. Compartementation is to be provided by insulated partitions between switching devices, busbars, cable terminations and LV equipment.

G. Mechanical interlock between the door and the switch disconnector's "Earth Position" is to be provided.

H. Control and monitoring of each unit is to be provided on front panel and is to include mimic diagram, operating handles of main device and earthing switches, position indicators, close and trip push buttons, potential indicators, identification and instruction plates, protective devices, metering and indicating instruments, key and padlockable devices, as specified and shown on the Drawings.

I. Access to LV wiring is to be from front of cubicle for control, protection, test terminal blocks and associated LV power connections. Multi-pin, disconnectable, lock-in type plug and socket arrangement is to be provided between circuit breaker and stationary part of cubicle.

J. 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.

K. K. 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.

L. 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.

M. <u>Labeling</u>

The labeling on various components of MV switchgear snail shall be provided such that no ambiguity is found during operation according to the following guidelines:

1. Blank circuit labels shall be fixed on the front and back panels of the switchgear. Labels shall be of a laminated material to enable the engraving of black letters on a white background.
2. "Spring charged" and "Spring discharged" shall be indicated by these words with black lettering on white and yellow background respectively.
3. Semaphore indication of the circuit breaker condition shall be labeled ON in white letters on a red background and OFF in white letters on a green background.
4. The circuit shutters shall be painted yellow and have "CABLE" painted on them in white lettering. The busbar shutter shall be painted red and have the word "BUSBAR" painted on it in white colour.
5. The two busbar shutters on the bus-section shall be painted red and, in addition to the word "BUSBAR" painted on in white, an arrow pointing in the direction of the respective busbar.
6. The push buttons used for opening and closing the circuit breaker shall be labelled "Push for ON" and "Push for OFF" in white letters on blue background. Safety interlocks in MV switchgear shall be provided to prevent the following situations:

a. Moving the breaker unit from the "disconnected" position to the service position without all auxiliary supplies being connected.
b. Uncoupling the auxiliary supplies while the breaker unit is in the "service" position.
c. Withdrawing the breaker unit past the "disconnected" position before auxiliary supply plugs and sockets have been uncoupled.
d. Moving the breaker unit from the service or disconnected position while the circuit breaker is closed.
e. Closing of the circuit breaker when the breaker unit is between the disconnected and service position.
f. Moving the breaker from the disconnected position to the service position while the earthing switch is closed.
g. Closing the earthing switch when the breaker unit is in service position or between the service and disconnected position.
h. Paralleling of the two incoming services with the bus section breaker closed.

N. Busbars:

1. The busbar system of the MV switchgear shall be suitable to withstand mechanical stress for rated short circuit currents. The busbars, connections and their insulated supports shall be of approved construction and mechanically strong with moulded insulation completely encasing each busbar and connections.
2. Compensation for expansion and contraction of the busbar and enclosure arrangement due to temperature changes shall be provided.

O. Bus Section Unit:

The bus section unit of MV switchgear shall be provided with circuit breakers, earthing switch, CTs, relays, indication lamps, etc

1. The Circuit Breaker shall be of 3 pole type rated for an ambient temperature of 50 °C and shall conform to the following requirements:
   a. System Nominal Voltage : 17.5kV
   b. Basic Impulse Level (BIL) : 95kV
   c. Power Frequency Withstand Voltage : 38kV
   d. Frequency : 60Hz
   e. Rated Normal Current at 50°C : 630Amps
   -Rated Normal Current: As shown on Drawings.
   -Rated Short-Circuit Breaking Current at Nominal Service Voltage and
   -Percentage -D.C. Component in Accordance with IEC 62271: 25 kA.
   -Rated Short-Circuit Making Current (peak): 50 kA.
   -Rated Duty Operating Sequence: O - 3 min - CO-3 min - CO.
   f. Control Voltage : 48Volts, DC
   g. Spring Charge Voltage : 48Volts, DC

2. 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.

3. SF6 breakers, are 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.

4. A busbar earthing switch shall be provided beside the bus-section circuit breaker so that each section of busbar can be earthed.

5. Current transformers shall be provided with 3 x 630/5 CTs each side of the bus section circuit breaker to give three zones of stuck breaker protection.

6. Relays shall be flush mounted on the front panel.

7. A three position, trip / normal / close switch for local tripping and closing of the circuit breaker shall be provided.

8. Provide lamp test switch (to check healthy lamp condition for all indication lamps) with positions normal and test. The switch shall have spring return to normal position.

9. Suitably rated long life low burden 48 Volts DC indication lamps shall be Provided to indicate the status of circuit breaker and earth switch as follows:-
   a. Green Lamp: Circuit Breaker OFF.
   b. Red Lamp: Circuit Breaker ON.
   c. Orange Lamp: Earth Switch ON.

10. Terminals shall be provided in an external cable connection box at the rear of the panel. Sufficient terminals shall be provided to terminate 2 x 12 core 2.5 mm2 PVC / SWA / PVC cables. (Incoming control supplies 48 Volts DC and 380 Volts AC 3 phase 60 Hz). Termination for 2 x 4 core cables associated with the stuck breaker protection shall also be provided for. The control supplies shall be wired from the connection box terminals to terminals in the front panel and from there bussed to adjacent panels.

11. Main Bus:
    1. The main bus shall be tin plated copper and rated as indicated in drawings. Bus bars shall have a continuous current rating based on temperature rise and documented by design tests. All joints will be in plated with at least 2 bolts per joint. Bus bars will be braced to withstand magnetic stresses developed by currents equal to main power circuit breaker close, carry, and interrupt ratings. Access to bus bars shall be through removable front panels. Bus bars shall have fluidized bed epoxy flamed retardant and non-hydroscopic insulation with a continuous current rating.
    2. A ground bus (1/4 by 2 inch copper) shall extend throughout assembly with connections to each breaker grounding contact and cable compartment ground terminal. Joints shall be made up as indicated in drawings. Station ground connection points shall be located in each end section.

12. The incoming unit of MV switchgear shall comprise circuit breaker, incoming cable earthing, current and voltage transformers, protection and control relays, meters and instrumentation and shall conform to the requirements as detailed hereunder:
    1. The circuit breaker and earthing switch shall be provided according to the requirements given above for bus-section unit.
    2. Current transformers shall be of epoxy resin encapsulated design and be capable of 20% overload and shall have 5 Amps secondary. Shrouded CT test links shall be provided on the front panel. All CTs shall be fully rated in accordance with the data given for the circuit breaker. All CT wiring shall be terminated in the rear mounted multi-core cable box. CTs shall be delivered short circuited.
    3. Voltage transformers shall be of electromagnetic epoxy encapsulated dry type design and rated as follows:

       a. Vector Group: Y-Y
       b. Rated Voltage Factor: 1.9
       c. Primary Voltage: 13.8kV, 3 phase, 60Hz.
       d. Secondary Voltage: 400 or 231V, 60Hz.

       The secondary windings of voltage transformers shall be wired to fuse and links in the front panel 3 x 5A fuses are required for two phases (E10, E50) and 3 links for the other phase (E30). The links should be solidly earthed, mounted in the circuit breaker control compartment.
    4. Protection and control relays shall be provided for IDMT over-current, earth fault and differential protection in accordance with SEC standards. Protection relays shall be flush mounted on the front of the MV Switchgear. The tripping circuit of the circuit breaker shall be extended to the rear mounted multi-core termination box to facilitate the connection of a trip signal from the remote protection relays if required in the future. Integrated protective relaying

systems similar to SEPAM (Schneider) or approved equal from Siemens are recommended.

5. All meters and instruments shall be flush mounted on the front of switch panel. One voltmeter with switch is to be provided to read R-Y, Y-B, B-Y (phase to phase) volts. An OFF position shall be provided. The full scale deflection shall be 20kV with a red line marked at 13.8kV. The voltmeter shall be connected to the voltage transformer. One Ammeter with selector switch or three individual ammeters shall be provided to read R, Y, B scaled to the maximum expected current range to measure phase currents. The ammeters shall be connected to the current transformers.
6. Cable boxes shall be provided with sufficient terminals to terminate 3 x 12 cores and 1x4 core 2.0mm2 PVC/SWA/PVC multi-core cables.

P. The feeder unit(s) of MV switchgear shall comprise circuit breaker, cable earthing switch, current transformers, protection and control relays, meters and instrumentation and shall conform to the requirements as detailed hereunder:

1. The circuit breaker, earthing switch and current transformers for instrumentation and protection shall be provided according to the requirements given above for bus-section unit.
2. Protection and control relays shall be flush mounted on the front panel. As a minimum, relays shall be provided for IDMT over-current and earth fault protection.
3. All meters and instruments shall be flush mounted on the front of switch panel. One ammeter (flush fitting) with selector switch for phase currents and one thermal maximum " "demand indicator meter (30 minutes time lag) full scale deflection to 600 or 400 Amps or as required to suit the site installations, shall be provided. These ammeters shall be connected to the CTs.
4. Cable boxes shall be provided with sufficient terminals to terminate 1 x 12 cores 2.5 mm2 PVC / SWA / PVC multi-core cable.

Q. The standard method of cable termination shall be compression terminal lugs and heat shrink insulation.

R. All panel wiring shall have a minimum cross section of 2.5 mm2 for current circuits and 1.5 mm2 for potential circuits. Conductors shall have a minimum of 3 strands per conductor. Wiring numbering shall be in accordance with the drawings attached to the Specifications.

S. In addition to the contacts already specified and required for various operations, 2 spare normally open and 2 spare normally closed contacts shall be provided for each MV circuit breaker.

2.4 DC BATTERY AND CHARGER

A. The DC battery and charger equipment shall be supplied for the control and protection of MV switchgear and manufactured according to the latest provisions of the applicable IEC standards.

B. The DC battery and charger equipment shall be suitable for the climatic conditions.

C. The charger unit shall be housed in a self-contained, floor or wall mounted sheet metal enclosure to IP41. The battery shall be mounted on a separate steel frame for ease of maintenance. Adequate ventilation of the battery shall be provided.

D. The battery shall provide sufficient power at 48 Volts DC (or any other voltage as indicated on the drawings) to close or trip all the breakers in MV switchgear simultaneously and maintain other loads in the switchgear. Any future breakers shall be taken into consideration when sizing the battery and charger.

E. The battery shall comprise required number of nickel-cadmium cells at 1.2 Volts / cell with potassium hydroxide electrolyte. Each cell shall be constructed in a semitransparent plastic container. The battery shall have a nominal output voltage of 48 Volts DC or any other voltage as indicated on drawings. The calculations for the capacity of the battery shall be submitted for approval of supervising Engineer. The electrolyte level of all cells shall be visible.

F. The charger unit shall be automatic constant voltage float / boost type, with solid state electronics employing silicon voltage reference diodes and rated as follows:

1.	Input Voltage	230 Volts, 60 Hz.
2.	Output Voltage	48 Volts DC (or as per drawings).
3.	Charging Current	Adjustable 10% to 105%.
4.	Stability	Float Voltage ±1%; for mains variations ± 10%.
5.	Smoothing	Approximately 2% RMS.
6.	Recharge Float Voltage	1.44 Volts / Cell.
7.	Boost Voltage	1.68 Volts / Cell.

The mains input of the DC battery and charger shall be connected via a suitably rated circuit breaker. Circuit breakers shall also be provided for battery isolation and isolation to the DC distribution panel. An electronic current limit shall be provided at 105% of the rated output current.

A high-low voltage output relay shall provide an alarm when the output voltage falls to 80% or rises to 120%. An AC failure and DC failure alarm shall also be provided. All these alarms shall be provided locally as well as at a remote location, where 24 hour attendance is available as approved by the supervising Engineer.

The meters, switches and indications shall be provided at the front of the charger unit according to NEC. These shall include, but not be limited to, the following:

1. Moving coil DC voltmeter and ammeter for battery.
2. A float / boost switch.
3. Green neon to indicate that the charger is operating on FLOAT.
4. Red neon to indicate that the charger is operating on BOOST.

The battery shall be delivered empty of electrolyte. Sufficient quantities of distilled water and electrolyte in crystalline form shall be delivered for the first filling of the battery.

2.5 CABLE GLANDS

A. Provide cable glands for the termination of MV XLPE cables at MV switchgear. Cable glands shall provide an adequate, corrosion resistant earth bond for the metallic cable armour together with means of sealing the cable sheath terminations.

B. The cable glands shall be designed to accommodate MV XLPE cables of all sizes specified under the Contract and main incoming supply cable by PEEGT or other. The particular option regarding cable dimensions are summarized in the table below:

Cable Size (mm2)	**Diameter underneath the Armour (mm)**	**Diameter of Armour Wires (mm)**
300	70	2.5
240	67	2.3
185,150	64	2.0
50	57	1.6

C. The cable glands shall allow enough space inside the switchgear cable box to allow cross core connection and easy interchange of phase.

D. Contact between armor and cable gland shall be ensured by two worm drive clips. This contact should be designed to withstand 20 kA for 3 seconds.

E. A PVC shroud and stud (M10) shall be provided with the cable gland to connect an earthing cable. Adequate nuts and washers shall be provided as required on site.

2.6 ACCESSORIES

A. Include as part of the main tender price, all necessary equipment and accessories required to assemble individual units to form complete MV switchgear. These shall include all necessary small wiring, fuses, foundation fixing details, labels, cable termination facilities, sole-plates, busbar interconnections, terminal boards and all necessary sundries.

B. A wall mounted encapsulated single line schematic diagram showing the operational positions of the unit shall be provided, which shall be black on a white or silver background.

C. Supply MV switchgear complete with all accessories necessary to form a complete installation including, but not be limited to, the following operation and safety accessories:
1. 2 Circuit breaker raise / lower or driving handles.
2. 1 set of high voltage test bushings.
3. 2 Sets ofjumper connections.
4. Circuit breaker manual charging handle.
5. Set of special tools including circuit breaker trolley for removal and insertion of 17.5 kV circuit breakers.
6. 2 pairs of insulating gloves.
7. Notice / safety instructions and first aid chart for electric shock.
8. 1 rubber mat 35 mm thick, 1 m wide, extending full length of MV switchgear. The mat shall have corrugated surface with a dielectric strength of 40 kV minimum with 3000 volts to ground.
9. Sufficient padlocks with 6 mm shackles having 24 mm clearance.

D. The supplier shall provide a complete set of drawings for MV switchgear(s) The drawings shall include:
1. General arrangement of circuit breaker.
2. Schematic diagram for each type of breaker.
3. Wiring diagram for each type of breaker.
4. Multi-core cable schedules.

Six paper print copies of these drawing sets shall be provided and one complete set of transparency copies.

E. In English language 6 copies of a combined operating and instruction manual, describing the modes of equipment operation and the necessary on-site maintenance of all items provided. Submission of these manuals should be before shipment of the equipment.

F. Testing:

a. The switchgear equipment and circuit breakers shall receive factory production test as listed below and shall be as per the IEC 598 Standards:
1. Equipment
   a. Low frequency dielectric test.
   b. Grounding of instrument cased.
   c. Control wiring and device functional test.
   d. Polarity verification.
   e. Sequence test.
   f. Low frequency withstand voltage test on major insulation components.
   g. Low frequency withstand test on secondary control wiring.

2. Breakers:
   a. Coil check test.
   b. Clearance and mechanical adjustment.
   c. 300 Electrical and mechanical operation test.
   d. Timing test.
   e. Conductivity of current path test.
   f. Hi-potential testing of breaker.
   g. Vacuum bottle integrity test.

b. Manufacturer shall provide to the Engineer documents verifying completion of factory production tests.

G. Finish:

1. All steel surfaces shall be chemically cleaned and given an iron phosphatecorrosion resistant treatment providing a strong bond for paint adhesion. All parts shall be immersed in paint applying 0.7-0.8 mils of cathodic epoxy paint electrically bonded to all surfaces for maximum adhesion. The finish shall be cured in an oven at to insure maximum toughness and prolong service in severe environments.

H. **DIGITAL PROTECTIVE RELAYS**

1. General

a) The Protection and Control unit shall include a display unit for User Machine Interface (UMI) that indicates: measurement values, operating messages, and device maintenance messages. The display indication shall be visible from at least two meters distance. The display unit shall have, as a minimum, 4 lines for clear annunciation of alarm conditions.

b) The Protection and Control unit shall include a keypad to select the following operations: display of metering and operating data, alarm messages, clearing of alarms and resetting, acknowledgement, and access to protection and other relay settings.

c) Access to Protection setting mode shall be protected by a personal customized password of at least 4 characters; access to Parameter setting mode by a second password of 4 characters.

d) All functions and displays of the UMI shall be remotely accessible (from the most advantageous location for operation and monitoring).

e) The unit shall have screw terminals for connection of wires using ring terminal lugs for all CT inputs and trip outputs.

f) Appropriate software (using standard Windows NT operating system) shall allow the collection of:

(1) All metering and operating data, alarm messages

(2) Fault recording: single or multi curve display, 2 pointers for differential measurement, zooming, printing.

(3) Breaker diagnostics data (cumulative tripping current, operations counter...).

(3) Protection and parameter settings;

(4) Logic status of inputs, outputs, and signals LED's. (Download to/from the relay)

g) The Protection and Control unit shall have at least four logic outputs. Extension of the number of logic inputs and outputs shall be possible up to 10 inputs and 8 outputs.

h) One analog output and eight temperature sensor inputs shall be available as an extension to the Protection and Control unit (Transformer and motor applications).

i) The Protection and Control unit shall meet the applicable IEEE/ IEC design standards.

j) The operating temperature range shall be at least -25°C to + 70°C.

k) The Protection and Control unit range shall be designed to accommodate a wide range of control power supply voltages: 48, 125, and 250 Vdc, & 120, 240 Vac. (24Vdc is optional control voltage)

l) l) The design and manufacturing process shall be ISO 9001 certified.

m) The output relays shall be capable of withstanding steady state current of 8 A at the rated control voltage.

n) The Relay shall be a Schneider Electric SEPAM Series 20 or approved equal from Siemens.

2. Protection

a) The Protection and Control Unit shall contain all the necessary protection functions for the specific application:

(1) Substation/Feeder protection: (50/51) Three Phase overcurrent, (50N/51N) Ground fault (or neutral) with selectable second harmonic restraint, (46) Unbalance / negative sequence overcurrent, and (79) Recloser (4 steps);

(2) Transformer protection: same overcurrent elements as Substation/Feeder protection plus (49 RMS) thermal overload, (49/63) Thermostat / Buchholz (gas detection/pressure), and optional (49) Temperature (RTD) monitoring;

(3) Voltage network protection (busbar): (27D/47) Positive sequence undervoltage, (27R) Remnant undervoltage, (27) Phase to Phase undervoltage, (27S) Phase to Neutral undervoltage, (59) Phase to phase overvoltage, (59N) neutral voltage displacement, (81H) Overfrequency, (81L) Underfrequency.

(4) Loss of mains protection (busbar): same voltage and frequency elements as Voltage network protection (busbar) plus (81R) Rate of Change of frequency

b) Each overcurrent protection device shall have a wide range of time overcurrent protection curve settings, providing a choice of curve types:

(1) IEEE Moderately/Very/Extremely Inverse time;

(2) IEC Standard (SIT))/Very (VIT)/Long Time (LTI)/Extremely (EIT) Inverse Time;

(3) IAC Inverse (I)/ Very Inverse (VI)/ Extremely Inverse (EI) time;

(4) Standard (SIT)/Very(VIT)/Long Time(LTI)/Extremely(EIT) /Rapid (RI) Inverse time

(5) Ultra Inverse Time (UIT) - for better fuse co-ordination.

(6) Definite time (DT) with time delay settings from Instantaneous (50 ms) to 300 s.

c) Overload protection will be based on true RMS current value (up to a minimum 17th harmonic).

d) Overcurrent setting shall be made by the direct input of actual primary current values.

e) The unit shall allow for the use of zone-selective protection via logic I/O and settings.

f) The relay shall allow fast change in protection scheme: 2 groups of 50/51/50N/51N settings shall be available with provision for shifting from one group of settings to the other by a digital input.

3. Measurement

a) Each Protection and Control unit shall perform the measurements needed for operation and commissioning, i.e. at least the following - for feeder, transformer and motor applications:

(1) Phase current measurement

(2) Maximum phase current demand

(3) Measurement of fault current in each phase

(4) Additional measurements such as residual current, PhaseRMS current.

b) The unit shall include voltage, frequency and energy measurements or may be combined with an external Metering device to allow power management features:

(1) Real time readings: Amps. Volts, kW, kVAR, kVA

(2) Energy readings: kWh, kVARh, kVAh, Accumulated energy

(3) Demand, Minimum/maximum readings

(4) Frequency for each phase of current/voltage

(5) Date/time stamping

(6) On-Board Data Logging

4. Diagnostics

a) An LED and text indicating the cause of the fault shall be located on the front of the device. Nine signal LED's shall be available for alarms and status including breaker position (open/close), relay self-test, phase fault and ground fault alarms. It shall be possible to customize the assignment of the signal LED's.

b) Fault recording within the Protection and Control unit shall:

(1) Be triggered automatically on event, or manually via communications or from the Protection and Control Unit front panel;

(2) Have each record store data for at least 80 cycles, 12 samples per cycle, with a selectable number of cycles before the event configurable

(3) Include on each record, as a minimum, the date, channel characteristics, 4 current channels (I1, I2, I3, I0) and the change of status of the digital inputs

(4) Be capable of recording a minimum of 2 faults.

c) The unit shall provide time tagging of at least 60 events within an accuracy of 1ms.

d) The Protection and Control unit shall include:

(1) An internal function self-monitoring mechanism, which activates one fail-safe watchdog changeover contact

(2) An automatic device for switching to the fail-safe mode, disabling output controls when a major internal failure is detected

(3) Indication of self-test status of the device by LED and text.

5. Control

a) The Protection and Control unit shall include the logic inputs and outputs resources required for control of the interrupting devices (circuit-breaker or contactor) and for interfacing with the monitoring or logic process:

(1) CB open and close control, whatever the type of shunt trip or undervoltage release coil control

(2) ANSI 69 / Inhibit closing

(3) Remote tripping

(4) As an option, monitoring of the circuit breaker for maintenance statistics purpose: operating time, charging time, trip circuit supervision (covering power supply, wiring and coil) cumulative total of tripping currents for 5 current ranges, operation counter, pressure (for SF6 circuit breakers)

(5) As an option, monitoring the temperature via RTDs (motors, transformers)

(6) Retention of stored information (even during control power supply outages).

6. Communications

a) The Protection and Control unit shall be supplied with Communication interface options of the 2-wire/4-wire RS 485 type, up to 38,400-baud speed, Modbus Protocol. The Protection and Control unit shall communicate the metering data, enable the remote reading of the protection settings, and the transfer of the fault recorded data. The unit shall be compatible with the Software used for central management of the electrical power system.

b) The response time for control commands shall be less than 15 ms (time from order sent to the unit until order acknowledgement).

c) A RS232 connection port shall be available in the front of the relay, allowing communicating between the relay and a PC with the appropriate software.

PART 3 - EXECUTION

3.1 INSPECTION

A. The civil works for foundations must be compatible with equipment and all sizes and details must be as per manufacturer recommendations.

3.2 INSTALLATION

A. The installation of MV switchgear shall be in accordance with the manufacturer's written instructions and shall comply fully with the requirements of IEC and SEC.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed.

B. Dielectric strength or insulation resistance test of completely assembled MV switchgear after installation shall be performed.

C. Inspect installed switchgear or anchoring, alignment, grounding and physical damage.

D. Check tightness of all accessible electrical connections with a calibrated torque wrench. Minimum acceptable values are specified in manufacturer's instructions.

E. Megger and record phase to phase and phase to ground insulation resistance of each bus section. Megger for 1 minute for each measurement at minimum voltage of 1000VDC. Measured insulation resistance shall be at least 1 megohm(s).

F. Test each key interlock system for proper functioning.

G. Perform tests to prove the operation of all MV circuit breakers, simulate fault on protective relays and devices.

H. Current injection test of all protective relays and devices shall be carried out.

I. Perform ratio tests and other field tests of all current and voltage transformers.

J. Complete functional and trip testing of battery and charger unit including battery discharge test, float and boast charging functions, etc.

3.4 ADJUSTMENTS

A. Adjust protective relays and devices to provide adequate over current protection and selective tripping with downstream devices according to short circuit and protection coordination study and after proper co-ordination with protection settings of Electricity Supply Authority/KAUST.

SECTION 16331 - GENERAL LIGHTING INSTALLATION

PART 1 - GENERAL

1.1 **ELECTRICAL WORK GENERALLY** is to be in accordance with the requirements of Sections 16010 of the Specification and requirements to achieve LEED Silver Certification. All ASHRAE mandatory requirements shall be accomplished plus all credits stated for this project in this regard.

1.2 **DESCRIPTION OF WORK**: complete indoor and outdoor lighting installations including fixtures, control gear, mounting provisions, accessories and connection to circuit wiring and to corresponding lighting control equipment.

1.3 **FIXTURE DESIGN AND STANDARDS**: the Specification and the Drawings are a guide to the selection of lighting characteristics and lighting fixtures, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, fixtures are to be manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the Schedule of Lighting Fixtures and complying with IEC 598 and CISPR 15.

1.4 **DESIGN LAYOUT:** fixture layout has been determined from photometric data of specified fixtures to achieve desired level and uniformity of illumination. Reflected ceiling plans are to be checked to ensure exact positions of fixtures with respect to structural members, ducts pipes, other installations and ceiling panels/tiles, where required. Certain fixtures are shown in provisional positions, pending preparation of final equipment layout drawings. Such fixtures are to be located in coordination with final equipment layout so that illumination is as intended by the design.

1.5 **EQUIPMENT DATA:** submit data for approval including, but not limited to, the followings:

A. Detailed literature on each fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principals.

B. Details of changes to standard fixtures for adaptation to condition of installation and to the Specification.

C. Photometric data for lighting calculations including polar light distribution curves, coefficient of utilization, glare classification, efficiency, depreciation factors etc.

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

A. Exact position of each fixture on reflected ceiling plans, with indication of ceiling features, structural members, ducts, pipes and other fittings, as applicable and pertinent to the installation.

B. Installation details including suspension and mounting provisions

C. Purpose made fixtures or lighting assemblies with full details

D. Wiring details, circuit and panelboard references, special lighting control arrangements etc.

1.7 **SAMPLES:** Submit fully equipped sample of each fixture type, modified if required, together with colour and texture samples of each fixture.

PART 2 - PRODUCTS AND SYSTEMS

2.1 COMPONENTS AND ACCESSORIES

2.1.1. LIGHTING FIXTURE CONSTRUCTION-GENERAL

A. GENERALLY: construction and wiring of fixtures are to comply with the Regulations and Standards. Fixtures are to be fabricated, assembled and wired entirely at factory. Manufacturer's name, factory inspection stamp and official quality label are to be fixed to each fixture supplied.

B. LIGHTING FIXTURES (LUMINAIRES): to be manufacturer's standard, as given in Lighting Fixture Schedules shown on the Drawings, or equal.

C. SHEET STEEL HOUSINGS: to be not less than 0.6 mm thick, and thicker when required by the Specification or the Standards.

D. SHEET STEEL REFLECTORS: to be not less than 0.5 mm thick.

E. ALUMINUM REFLECTORS: to be not less than 0.7 mm thick, unless otherwise approved.

F. FABRICATION: metalwork is to be mitred, welded and ground smooth without tool marks or burrs. Flat metal parts are to be stiffened by forming grooves and edges during fabrication. Metal parts are to have finish free from irregularities.

G. RUST-PROOF FERROUS BASE: ferrous metal parts are to be bonderized (treated with corrosion resistant phosphate solution) and given an approved rust-inhibiting prime coat before application of final finish.

H. FINISH FOR NON-REFLECTING METAL SURFACES: approved baked enamel paint. Paint colour on fixture frames and trims is to be as specified or as selected by the Engineer.

I. FINISH FOR LIGHT REFLECTING SURFACES: white baked enamel paint having reflection factor not less than 85%. Mirror reflectors, where specified, are to be highly polished, anodized aluminum with reflection factors not less than 97%.

J. MECHANICAL RESISTANCE OF FINISH: after finish has been applied on steel surfaces and cured, it is to withstand a 6 mm radius bend without showing signs of cracking, peeling or loosening from base metal.

K. RESISTANCE OF FINISH TO ULTRA-VIOLET: finish is to withstand 72 hours exposure to an ultra-violet RS lamp placed 100 mm from surface without discolouring, hardening or warping, and is to retain the same reflection factor after exposure.

L. HEAT RESISTANCE: finishes, wire and components inside fixtures are to be certified materials to resist the temperatures or other conditions encountered in the fixtures.

M. WIRING INSIDE FIXTURES: to be not less than 1.5 mm2, and insulated for 240 V application. Insulation is to have acceptable characteristics to resist maximum temperatures

inside fixtures. Wiring is to be terminated on screw type and fixed. For security lighting fixture wiring shall resist 960°C.

N. HINGES: fixtures with visible frames and hinged diffusers are to have concealed hinges and catches, and stainless steel retaining clips. Other alternative equally durable products may be submitted for approval.

O. SUSPENSION ALIGNERS: to be provided for pendent fixtures for axial, vertical and horizontal alignment. Vertical adjustment is to be minimum 25 mm.

P. RECESSED FIXTURE: to be constructed to fit into suspended ceilings without distorting fixture or ceiling. Plaster rings are to be provided for plaster or concrete ceilings.

Q. OUTDOOR FIXTURES: to be non-ferrous metal or specially moulded material for outdoor use.

R. REMOVAL OF PARTS for maintenance is to be possible without removing fixture housing.

2.1.2. FLUORESCENT FIXTURES

A. LAMP HOLDERS GENERALLY: to IEC 400, heavy duty, moulded white plastic with non-corroding spring contacts.

B. LAMP HOLDERS FOR INDUSTRIAL FITTINGS: spring loaded turret type, heavy duty, dust protected.

C. BALLASTS GENERALLY: to IEC 82. Only single (36 W) or two-lamp (18 W) ballasts are to be used in any one fixture. Two-lamp ballasts are to be lead-lag, series type. Equipment is to be enclosed in sheet steel casing with corrosion resistant finish.

D. BALLAST THERMOSETTING COMPOUND is not to soften, liquify or support combustion under any operating condition or upon ballast failure, and is to fill ballast enclosure and dampen vibrations. Temperature rise, under normal operating conditions, is not to exceed 55 deg. C above maximum ambient temperature of 40 deg. C.

E. BALLAST PROTECTION: each ballast is to have one-time external fuse and fuse holder rated in accordance with manufacturer's instructions.

F. BALLAST TYPE: electronic or electronic high frequency dimmable type, as stated in fixture description and as shown on the drawings, power factor corrected to above 0.9, having manufacturer's lowest case temperature. Sound rating is not to exceed level given in the Standards. Harmonics to IEC EN 60929, radio interference suppression to IEC EN 55015 and immunity to IEC EN 61547. The ballast shall operate at a frequency not less than 30kHz.

G. BALLAST RATING: ballast is to be manufactured and certified for the specific lamp it controls and for operation from nominal power supply, with voltage and frequency equal to nominal voltage and frequency of distribution network.

H. CAPACITORS: to IEC 566, having snap-type connectors and fastening, bolt type M8, for fixing to fixture.

I. STARTERS, if required, are to comply with IEC 155, and are to be selected in conjunction with respective ballast and lamp.

2.1.3. INCANDESCENT LAMP FIXTURES

A. INCANDESCENT LAMP SOCKETS: to IEC 61 and IEC 238, high grade porcelain; E27 (ES) screw sockets for lamps not exceeding 200 W and E40 (GES) screw sockets for lamps 300 W and over.

2.1.4. HIGH INTENSITY DISCHARGE LAMP FIXTURES

A. TYPE: fixture are to be complete units including integral ballasts (and ignitors for HPS lamps where indicated) and lamps of required number and type, and are to have lighting distribution characteristics equivalent to model and manufacturer indicated in the fixture description.

B. ACCESSORIES: fixture are to have mounting accessories, such as suspension rods or chains, rails or brackets, and protective glass covers with gaskets for protection against dust and humidity or type of corrosive atmosphere predominant in the location.

C. BALLASTS AND IGNITION DEVICES are to be power factor compensated to at least 0.9 lagging, and type specially selected for lamp type and size used. Lamp is to be able to start with at least +/-10% variation from nominal line voltage and continue in normal operation with dips attaining 20% for four seconds. Compensation is to ensure there is no great increase in operating current during starting and that gear losses do not exceed 10% of normal wattage. RF suppression circuit is to be provided.

2.2 LAMPS

A. Lamps are not limited to the following; special lamps shall be subject to lighting fixture manufacturer recommendations and supervising consultant approval.

B. RATED VOLTAGE of incandescent and PL lamps is to be equal to nominal voltage of distribution network. Lamps with different rated voltages are not acceptable.

C. INCANDESCENT LAMPS FOR GENERAL LIGHTING SERVICE (GLS): to have screw base type ES for lamps 200 W and below and type GES for lamps 300 W and above. Inside frosted (IF) lamps are to be used unless otherwise specified. Guaranteed rated life is to be above 800 hours and luminous output above the followings
1. 950 lumens for 75 W lamps.
2. 1350 lumens for 100 W lamps.

D. TUNGSTEN-HALOGEN LAMPS: tubular, quartz, resistant to high temperatures. Guaranteed rated life is to be above 2000 hours and luminous output above the following:
1. 9500 lumens for 500 W lamps

E. STRAIGHT TUBULAR FLUORESCENT LAMPS (T5): to IEC 81 (SSA 138 and 139) and, unless otherwise specified, are to be switch start type, bi-pin, rated as indicated in the fixture description and with improved fluorescent internal coating. Colour of light is to be superb quality white equal to Philips Nb 84 unless otherwise specified. Lamps are to be low energy type with tube diameter 26 mm. Guaranteed rated life is to be above 8000 hours and luminous output above the followings:
1. 1350 lumens for 18 W lamps (600 mm long); 1B colour rendering index.
2. 3350 lumens for 36 W lamps (1200 mm long); 1B colour rendering index.
3. 5200 lumens for 58 W lamps (1500 mm long); 1B colour rendering index.

F. STRAIGHT TUBULAR (T5) FLUORESCENT LAMPS: to IEC 81 (SSA 138 and 139) and, unless otherwise specified, are to be switch start type, bi-pin, rated as indicated in the fixture description and with improved fluorescent internal coating. Colour of light is to be superb

quality white equal to Philips Nb 84 unless otherwise specified. Lamps are to be low energy type with tube diameter 16 mm. Guaranteed rated life is to be above 16000 hours and luminous output above the followings:

1. 1200 lumens for 14 W lamps (549 mm long); 1B colour rendering index.
2. 1900 lumens for 21 W lamps (849 mm long); 1B colour rendering index.
3. 2600 lumens for 28 W lamps (1149 mm long); 1B colour rendering index.
4. 3300 lumens for 35 W lamps (1449 mm long); 1B colour rendering index.

G. PL-C COMPACT LAMPS: single ended, compact-miniature lamp, consisting of four narrow fluorescent tubes welded together, with integral instant starter and capacitor and with special two-pin plug-in base and socket. Guaranteed rated life is to be above 5000 hours and luminous output above the following:

1. 600 lumens for 10 W lamps (80 mm long)
2. 900 lumens for 13 W lamps (90 mm long)
3. 1200 lumens for 18 W lamps (100 mm long)
4. 1800 lumens for 26 W lamps (115 mm long).

H. Lamps are to be type PLC as manufactured by Osram, Philips or other equal and approved, with warm colour impression.

I. LED LAMPS: LED lamps shall be chip on board (COB) and shall follow latest technology by the time of execution, shall be of high luminous flux of not less than 100 lumens/watt and up to 160 lumens/watt where required to meet LEED requirements, rendering index of 1B and 2700-4000K color temperature. LED lamps shall have 50,000 hrs minimum rated life with L80B10 degradation and mortality ratios. Binning of LED lights shall have Standard Deviation Color Matching (SDCM) of 2 or less. LED lamps shall have appropriate optical system for projection of emitted light to the aiming design angle with a high output ratio. Constructional measures shall ensure that the LED modules operate within their ideal thermal range to achieve output for the specified power throughout their operational life. Control gear associated with LED lamps shall be fully compatible, and dimmable where required using leading/trailing edge phase control technology to guarantee a flicker free dimming.

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

1. 19000 lumens for 250 W lamps
2. 32500 lumens for 400 W lamps
3. 90000 lumens for 1000 W lamps
4. 190000 lumens for 2000 W lamps

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

2.3 EXIT SIGNS

A. Description: Comply with EN 60598-2-22; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
   a. Battery: Sealed, maintenance-free, nickel-cadmium type.
   b. Charger: Fully automatic, solid-state type with sealed transfer relay.

c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.4 EMERGENCY LIGHTING UNITS

A. Emergency lighting levels to meet NFPA 101 chapter 7.

B. Description: Self-contained units complying with EN 60598-2-22.
1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audiblealarm and flashing red LED.

2.5 EMERGENCY FLUORESCENT POWER UNITS

A. Emergency lighting levels to meet NFPA 101 chapter 7.

B. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924 or EN 61347-2-7.
1. Emergency Connection: Operate 1 fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Night-Light Connection: Operate one fluorescent lamp continuously.
3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge: bright glow indicates charging at end of discharge cycle.

4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggerssimulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audiblealarm and flashing red LED.

C. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from lighting fixture. Comply with UL 924 or EN 61347-2-7.

1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Night-Light Connection: Operate one fluorescent lamp in a remote fixture continuously.
3. Battery: Sealed, maintenance-free, nickel-cadmium type.
4. Charger: Fully automatic, solid-state, constant-current type.
5. Housing: NEMA 250, Type 1 enclosure or equivalent.
6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggerssimulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

PART 3 - FIELD AND INSTALLATION WORK

3.1 INSTALLATION

A. GENERALLY: install fixture level, aligned and parallel or square to building lines and at uniform heights as shown on the Drawings or as approved by the Engineer. Make final height adjustment after installations.

B. FIXTURE SUPPORT: provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. And method of fastening for approval. Rigidly secure fixture mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.

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

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

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

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

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

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

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

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

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

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

3.2 INSPECTION AND TESTS ON SITE

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

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

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

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

PART 4 – ANNEX

9.4 Mandatory Provisions

9.4.1 Lighting Control

9.4.1.1 Automatic Lighting Shutoff

Interior lighting in buildings larger than 465 m2 shall be controlled with an automatic control device to shut off building lighting in all spaces. This automatic control device shall function on either:

a. a scheduled basis using a time-of-day operated control device that turns lighting off at specific programmed times—an independent program schedule shall be provided for areas of no more than 2323 m 2 but not more than one floor—or
b. an occupant sensor that shall turn lighting off within30 minutes of an occupant leaving a space or
c. a signal from another control or alarm system that indicates the area is unoccupied.

Exceptions: The following shall not require an automatic control device:

a. Lighting intended for 24-hour operation.
b. Lighting in spaces where patient care is rendered.
c. Lighting in spaces where an automatic shutoff would endanger the safety or security of the room or building occupant(s).

9.4.1.2 Space Control.

Each space enclosed by ceiling height partitions shall have at least one control device to independently control the general lighting within the space. Each manual device shall be readily accessible and located so the occupants can see the controlled lighting:

a. A control device shall be installed that automatically turns lighting off within 30 minutes of all occupants leaving a space, except spaces with multi-scene control, in
   1. classrooms (not including shop classrooms, laboratory classrooms, and preschool through 12th grade classrooms),
   2. conference/meeting rooms, and
   3. employee lunch and break rooms.

These spaces are not required to be connected to other automatic lighting shutoff controls.

b. For all other spaces, each control device shall be activated either manually by an occupant or automatically by sensing an occupant. Each control device shall control a maximum of 232 m 2 area for a space 929 m 2 or less and a maximum of 929 m2 area for a space greater than 929 m 2 and be capable of overriding any time-of-day scheduled shut off control for no more than four hours.

   Exception: Remote location shall be permitted for reasons of safety or security when the remote control device has an indicator pilot light as part of or next to the control device and the light is clearly labeled to identify the controlled lighting.

9.4.1.3 Exterior Lighting Control.

Lighting for all exterior applications not exempted in Section 9.1 shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours. Lighting not designated for dusk-to-dawn operation shall be controlled by either

a. a combination of a photosensor and a time switch or
b. an astronomical time switch.

Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least ten hours.
Exception: Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.

9.4.1.4 Additional Control

a. Display/Accent Lighting —display or accent lighting shall have a separate control device.
b. Case Lighting—lighting in cases used for display purposes shall have a separate control device.
c. Hotel and Motel Guest Room Lighting—hotel and motel guest rooms and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.
d. Task Lighting—supplemental task lighting, including permanently installed under shelf or under cabinet lighting,
shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device is readily accessible and located so that the occupant can see the controlled lighting.
e. Nonvisual Lighting—lighting for nonvisual applications, such as plant growth and food warming, shall have a separate control device.
f. Demonstration Lighting—lighting equipment that is for sale or for demonstrations in lighting education shall have a separate control device.

9.4.2 Tandem Wiring.

Luminaires designed for use with one or three linear fluorescent lamps greater than 30 W each shall use two-lamp tandem-wired ballasts in place of single lamp ballasts when two or more luminaires are in the same space and on the same control device.
Exceptions:
a. Recessed luminaires more than 3 m apart measured center to center.
b. Surface-mounted or pendant luminaires that are not continuous.
c. Luminaires using single-lamp high-frequency electronic ballasts.
d. Luminaires using three-lamp high-frequency electronic or three-lamp electromagnetic ballasts.
e. Luminaires on emergency circuits.
f. Luminaires with no available pair.

9.4.3 Exit Signs.

Internally illuminated exit signs shall not exceed 5 W per face.

9.4.4 Exterior Building Grounds Lighting.

All exterior building grounds luminaires that operate at greater than 100 W shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section 9.1.1 or 9.4.5.

9.4.5 Exterior Building Lighting Power.

The total exterior lighting power allowance for all exterior building applications is the sum of the individual lighting power densities permitted in Table 9.4.5 for these applications plus an additional unrestricted allowance of 5% of that sum. Trade-offs are allowed only among exterior lighting applications listed in the Table 9.4.5 “Tradable Surfaces” section.
Exceptions: Lighting used for the following exterior applications is exempt when equipped with a control device
independent of the control of the nonexempt lighting:
a. Specialized signal, directional, and marker lighting associated with transportation.
b. Advertising signage or directional signage.

TABLE 9.4.5 Lighting Power Densities for Building Exteriors

Tradable Surfaces (*LPDs* for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded.)	**Uncovered parking areas**	
	Parking lots and drives	**1.0** W/m^2
	Building grounds	
	Walkways less than 3 m wide	**3.3** W/linear meter
	Walkways 3 m wide or greater	
	Plaza areas	**2.2** W/m^2
	Special feature areas	
	Stairways	**10.8** W/m^2
	Building entrances and exits	
	Main entrice	**98** W/linear meter of door width
	Other doors	**66** W/linear meter of door width
	Canopies and overhangs	
	Canopies (free standing and attached and overhangs)	**13.5** W/m^2
	Outdoor sales	
	Open areas (including vehicle sales lots)	**5.4** W/m^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	**66** W/linear meter
Nontradable Surfaces (*LPD* calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	**Building facades**	**2.2** W/m^2 for each illuminated wall or surface or **16.4** W/linear meter for each illuminated wall or surface length
	Automated teller machines and night depositories	**270** W per location plus **90** W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	**13.5** W/m^2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles	**5.4** W/m^2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Drive-through windows at fast food restaurants	**400** W per drive-through
	Parking near 24-hour retail entrances	**800** W per main entry

c. Lighting integral to equipment or instrumentation and installed by its manufacturer.
d. Lighting for theatrical purposes, including performance, stage, film production, and video production.
e. Lighting for athletic playing areas.
f. Temporary lighting.
g. Lighting for industrial production, material handling, transportation sites, and associated storage areas.
h. Theme elements in theme/amusement parks.
i. Lighting used to highlight features of public monuments and registered historic landmark structures or buildings.

9.5 Building Area Method Compliance Path

9.5.1 Building Area Method of Calculating Interior

Lighting Power Allowance. Use the following steps to determine the interior lighting power allowance by the Building
Area Method:

a. Determine the appropriate building area type from Table 9.5.1 and the allowed LPD (watts per unit area)

from the “Building Area Method” column. For building area types not listed, selection of a reasonably equivalent type shall be permitted.

b. Determine the gross lighted floor area (square meters) of the building area type.
c. Multiply the gross lighted floor areas of the building area type(s) times the LPD.
d. The interior lighting power allowance for the building is the sum of the lighting power allowances of all building area types. Trade-offs among building area types are permitted provided that the total installed interior lighting power does not exceed the interior lighting power allowance.

9.6 Alternative Compliance Path: Space-by-Space Method

9.6.1 Space-by-Space Method of Calculating Interior

Lighting Power Allowance. Use the following steps to determine
the interior lighting power allowance by the Space-by Space Method:

a. Determine the appropriate building type from Table 9.6.1.
For building types not listed, selection of a reasonably equivalent type shall be permitted.
b. For each space enclosed by partitions 80% or greater than ceiling height, determine the gross interior floor area by measuring to the center of the partition wall. Include the floor area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.
c. Determine the interior lighting power allowance by using the columns designated Space-by-Space Method
in Table 9.6.1. Multiply the floor area(s) of the space(s) times the allowed LPD for the space type that most
closely represents the proposed use of the space(s). The product is the lighting power allowance for the space(s). For space types not listed, selection of a reasonable equivalent category shall be permitted.
d. The interior lighting power allowance is the sum of lighting power allowances of all spaces. Trade-offs among spaces are permitted provided that the total installed interior lighting power does not exceed the interior lighting power allowance.

9.6.2 Additional Interior Lighting Power.

When using the Space-by-Space Method, an increase in the interior lighting power allowance is allowed for specific lighting functions.
Additional power shall be allowed only if the specified lighting is installed and automatically controlled, separately
from the general lighting, to be turned off during nonbusiness hours. This additional power shall be used only for the specified luminaires and shall not be used for any other purpose.
An increase in the interior lighting power allowance is permitted in the following cases:

a. For spaces in which lighting is specified to be installed in addition to the general lighting for the purpose of decorative appearance, such as chandelier-type luminaries or sconces or for highlighting art or exhibits, provided that the additional lighting power shall not exceed 10.8 W/m2 of such spaces.
b. For lighting equipment installed in sales areas and specifically designed and directed to highlight merchandise, calculate the additional lighting power as follows:
Additional Interior Lighting Power Allowance =
1000 watts + (Retail Area 1 × 11 W/m 2) + (Retail Area 2 × 18 W/m2) + (Retail Area 3 × 28 W/m2) + (Retail Area 4 × 45 W/m 2) , where Retail Area 1 = the floor area for all products not listed in Retail Areas 2, 3, or 4;
Retail Area 2 = the floor area used for the sale of vehicles sporting goods, and small electronics;
Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics, and artwork; and
Retail Area 4 = the floor area used for the sale of jewelry,
crystal, and china.
Exception: Other merchandise categories may be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the authority having jurisdiction.

SECTION 16441 - WIRING DEVICES AND DISCONNECTS

PART 1 - GENERAL

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

1.2. DESCRIPTION OF WORK: wiring devices, lighting switches, socket outlets, cord outlets, automatic and manual lighting control equipment, dimmers, outlet boxes and plates, disconnect switches etc.

1.3. STANDARDS: components are to be standard manufactured items, uniform and modular, complying with one set of approved Standards.

1.4. EQUIPMENT 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.

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

A. Exact indication of position of each item and outlet box and fitting on layout drawings, with box and equipment types and sizes.

B. Installation details of special items including LV transformers, isolating switches, fans etc.

C. Wiring diagrams of special items.

1.6. SAMPLES: submit samples of each type of device for approval, unless otherwise agreed in writing by the Engineer.

PART 2 - PRODUCT AND SYSTEMS

2.1. FITTINGS

2.1.1 WIRING DEVICES: Obtain wiring devices as follows or other equal and approved by architect:

A. NOBLE AND DECORATIVE AREAS: finish to selection of architect in 2x2 modules and 2x3 modules configuration.

B. NON-DECORATIVE AREAS: **Legrand Arteor - White** (finish to the selection of architect)

C. TECHNICAL AND PARKING AREAS: **Legrand Plexo IP55**

2.2.1. OUTLET BOXES AND PLATES GENERALLY

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 compatible standards as switches, socket outlets 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. BLANK PLATES: blank plates are to be installed on outlet boxes on which no apparatus is installed or where apparatus installed does not have suitable cover for box. Blanks plates for wall outlets are to be attached by a bridge with slots for horizontal and vertical adjustment.

D. FLOOR OUTLETS AND PLATES are to be water-tight and impact resistant.

2.2.2. 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: 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. 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.

F. MANUFACTURERS: obtain metallic outlet boxes from same manufacturer as conduit or other approved, and to the satisfaction of the Engineer.

2.2.3. 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.

C. MANUFACTURERS: obtain moulded plastic outlet boxes from:

1. Egatube (England)
2. M.K. (England)
3. Legrand (France)
4. B Tichino (Italy)

or other equal and approved.

2.2.4. 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 moulded plastic, white colour, for general use:

D. CABLE/ CORD 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.

2.2.5. <u>SWITCHES</u>

A. GENERALLY: quick- make, quick- break type with silver alloy contacts in arc resisting moulded 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: 10 A 220 V a.c., rocker operated, grid- switch with plastic plate, for indoor installations in general, unless otherwise indicated.

1. Man: Legrand or other equal and approved.

D. PUSH BUTTON SWITCH, Ref unless otherwise mentioned on drawings:

E. MANUAL SWITCH: 2 pole, for fractional single and three phase motors and appliances, to interrupt motor and induction loads, rated 20 A at 415 V a.c., toggle operated, with positive indication of on/off position of contacts.

2.2.6. SOCKET OUTLETS

A. General purpose Socket Outlets:
1. to BS 1363
2. 3 rectangular pin (2P+E) shuttered, with combined switch, rated 13A, 250V.

B. 15A Socket Outlet:
1. to BS 546:1950
2. 3 round pin (2 P + E) shuttered switched pattern complete with plugs.
   a. Neon indicator lamp, unless specified otherwise in the Project Documentation.

C. Weather proof Sockets:
1. 13A Sockets: to BS 1363
2. 3 rectangular pins, Un-switched type to be complete with weather proof plugs
3. Plugs: 13 Amps

4. Sockets: fused type with single pole cartridge fuse link of same rating as plug
5. Sockets and plugs:
6. To have minimum IP 55 grade protection
7. Housing parts: brass or pressure die-cast finished in grey hammered stove enamel
8. Plugs:
    a. Cable grips shall have rubber compression rings
    b. There shall be rubber gasket between plug and socket to ensure weather tightness.
9. Sockets shall have screw on caps that close tight on socket when plugs are not inserted.

D. Weatherproof Sockets Used in Apartments:
1. 13A Sockets: to BS 1363
2. 3 rectangular pins, Un-switched type
3. To be watertight IP 56 or as indicated in the Project Documentation
4. To be made of poly-carbonate
5. Shall not discolour, crack or fade in UV light

E. Shuttered Sockets:
1. The Shutters shall effectively screen & isolate the line & neutral socket outlets to exclude dust & interference & shall only be operable when the interlocked earth pin in the associated plug top has been inserted.

2.2.7. 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.

2.2.8. SWITCH DISCONNECTOR (DISCONNECTING SWITCH)

A. RATING: 690 V, 2,3 or 4 pole, load break, short- circuit make, in accordance with IEC 947-3, utilization category 22 for heating and lighting loads, category 23 for motor circuits, and with ampere rating shown on the Drawings.

B. DESIGN: non- fusible, air- break switch disconnector, 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 door unless switch is in open position. Switch disconnector 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 IK 08, unless otherwise required or shown on the Drawings. Locking of operating handle is to be possible in open and closed positions.

E. MANUFACTURERS: obtain switch disconnector from one of the following of the following or other equal and approved:
1. BILL Switchgear Ltd. (England)
2. G.E. (U.S.A.)
3. G.E.C. - Henley Ltd (England)
4. M.E.M. (England)
5. Siemens (Germany)
6. Westinghouse (U.S.A.)
7. Socomec (France)

8. Merlin-Gerin (France)
9. ABB (Germany)

2.2 SPECIAL DEVICES

2.2.1. LIGHTING CONTACTORS

A. TYPE: unless otherwise indicated single pole for single phase and neutral circuits, and three pole for three phase circuits, mechanically held electrically operated or with local built-in bypass for locking in OFF or ON positions, rated 500 V, of current ratings shown on the Drawings, and complying with IEC- 1059 category AC7a.

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

C. AUXILIARY CONTACTS: as required to provide specified interlocks and signals as shown on the Drawings.

D. ENCLOSURE: unless forming part of system housed in sheet steel panel, contractor is to be provided with IP 42 enclosure for indoor use or IP 65 enclosure for outdoor use.

E. CONTROL: each contractor whether part of a system or separately enclosed is to have on/off pilot lights and set of on/off/ automatic toggle switch mounted on cover.

2.2.2. DIMMERS FOR INCANDESCENT OR FLUORESCENT LAMPS (If Applicable)

A. 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.

B. VARIATION OF LUMINOUS INTENSITY: to be smooth over continuous dimming range from 1% for incandescent and fluorescent lamps, and from 10% for compact fluorescent lamps, up to 100% intensity or full normal brightness.

C. 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.

E. MANUFACTURERS: obtain dimmers from:
1. Man: Lutron Dynalite, Crestron, Electronic.or other equal and approved.

2.3 KNX System

2.3.1. General

A. KNX System shall be of International Standard (ISO/IEC 14543-3) as well as an European Standard (CENELEC EN 50090 and CEN EN 13321-1)

B. All products used within the system being specified shall be certified by the KNX Association and bear the KNX Logo. Manufacturers include:
1. Gira
2. ABB
3. Berker
4. JUNG
5. AMX
6. Basalte
7. Busch & Jaeger
8. Daikin
9. Crestron

10. Honeywell
11. Siemens
12. Schneider

C. KEYPADS: **ABB** Future Linear (Aluminum Silver) or equivalent to architect's approval.

D. KNX Bus Protocol: The KNX control system shall use distributed intelligence where individual units update their status across the network. The system shall be capable of providing constant feedback on the operational status of inputs and outputs and be capable of interrogating the status of specific devices.

E. KNX Network Topology: The network topology of the KNX control system shall be flexible and allow devices to be connected in a star, tree, daisy chain or combination of star, tree and daisy chain configuration. The network topology is made up of Lines, Main Lines and Areas.

1. Line: A Line is a local network that supports 64 bus devices and 255 addresses. It requires a power supply. It is connected up-stream by either Line couples or IP Routers.
2. Main Line: A main line will connect up to 12 Lines together via Line Couplers. The Main Line also supports up to 64 bus devices. Each Main Line must have its own power supply. A group of Lines connected to a Main Line is known as an Area.
3. Multiple Areas: Multiple Areas can be linked together using a Backbone Coupler on each Mail Line. Up to 15 Area can be linked together on one Backbone.
4. IP Connectivity: An IP Router can be used to in place of either Line Couplers or Backbone Couplers to create a fully IP router KNX network with support for over 14,000 bus devices.

F. The cabling of KNX system shall be as follows:

1. Installation bus 2-wire, event-controlled, multi-master system
2. Transmission type serial, with distributed bus access procedure CSMA-CA
3. Transmission speed 9.6 kbaud
4. System voltage 30 V DC
5. KNX control cable: PYCYM 2 x 2 x 0.8 mm (4 kV).

G. KNX System Programming: Individual components of the KNX control system shall be configurable across the network using PC software with a Windows® operating system. Each unit that communicates on the network shall be given an address unique to the specific network, and have a serial number which may be retrieved by the configuration software. All units shall provide feedback across the network as to their status.

H. The KNX control system shall have the option of comprehensive head end control software. The software shall be multi user with user access control via passwords. The software shall reside on a PC and connect via Ethernet. The system shall provide a graphical representation of the system with indictors showing the status of the inputs and outputs. Should communications with a connected device fail a colored indicator will be displayed, an alert will be raised and record of the event will be stored.

I. High Level 3rd Party Integration: The KNX control system shall be capable of integrating with third party systems including DALI, DSI, HVAC, Audio/Visual and Building Management Systems (BMS) via various mediums and protocols including Ethernet, RS-232, OPC, BACnet and LON.

J. Low Level 3rd Party Integration: The KNX control system shall be capable of integrating with 3rd party systems by initiating and detecting the closure of voltage free contacts using relays or universal interface input devices.

K. The KNX control system shall have the ability to have batteries connected directly to it enabling the Line to remain operational should a power failure occur. The batteries shall be integrated into the system and be DIN mounted next to the Line power supply. The system shall provide alerting if the backup batteries are being used.

2.3.2 CONTROL DEVICES AND SENSORS:

A. Multiple Push-buttons:

1. Multiple KNX Push-buttons (2, 4, 8 or 16 gangs) shall be able to be used for On/Off switching, Dimming, Shutter/Blinds control, Scene recall...
2. The multiple KNX Push-buttons shall be connected via the bus line to other KNX devices with no need for external power. A permanent 'Green' Led shall indicate that the push-button device is operational. The multiple KNX Push-buttons shall have indication for 'On' and 'Off' status with 'Red' Led color for each gang with a possibility to reverse them via software. In the case of circuits switched in parallel from multiple locations, the Led shall display the true status of the circuit based on the latest signal sent to the particular circuit. It shall be possible to control any circuit in the system from any of the switch channels to ensure all channels are available for entire control of the system.
3. Master On/Off switching shall be possible from any switch located anywhere in the system
4. Where necessary, a combination of several KNX push-buttons can be grouped together in one single location to provide all the required control.
5. Each gang of the KNX multiple push-button shall be programmed individually according to the request (switching, dimming or shutter control) independently from the other gangs.
6. Light Scenes Can be recalled using a dedicated light scenes multiple push-button. Each light scene dimming level shall be preset using the KNX software.
7. KNX keypads with thermostat shall have a built in temperature sensor, LCD display, ON/OFF button, fan speed button, temperature control and winter/summer mode control button.

B. Touch Screen Devices

1. Programmable IP/KNX touch display for room comprehensive control, infotainment and entertainment centre
2. With a closed capacitative glass surface and a design strip made of stainless steel (brushed)
3. With integrated camera
4. Easy control using intuitive navigation concept
5. House control: Switching, dimming, blinds, RTC, scene/sequences, timed controls
6. Entertainment: Multimedia, remote control RC5 and B&O
7. Infotainment: IP telephony, RSS reader, intercom with picture, e-mail, voice and graphic memo, consumption data monitoring
8. Door communication: Indoor station for the ABB Welcome system in combination with IP Gateway 83341.
9. Safety: Video surveillance with IP cameras, alarm function, message function, presence simulation
10. Representation from individual floor plans, room images and operation pages
11. 23 cm (9") (or 31 cm/12.1") touch display with 800 x 480 pixels (or 1,280 x 800 pixels)
12. Maintenance via remote control over IP
13. Control with smartphones and tablets via the ComfortTouch App (Apple iOS /Google Android from Version 4)
14. Connection:
15. Inputs: RJ 45 (LAN)
16. Control element: Freely programmable touch surfaces
17. Display elements: Capacitive touchdisplay 480 x 800 pixel
18. Type of protection: IP 20, IEC/EN 60 529
19. Temperature range: 0 °C to 45 °C
20. Dimensions (L x W x D): 210 mm x 315 mm x 29 mm (or 270 mm x 400 mm x 29 mm)
21. Position for installation: Horizontal
22. Mounting depth: 60 mm
23. Manufacturer: ABB Comfort Touch

C. Constant light control:

1. There shall be constant lighting control in (where indicated on drawings, BOQ or elsewhere in the specifications) via a light sensor mounted in a standard flush box in the ceiling. The light sensor shall be connected with corresponding light controller suitable for the application, thus providing closed loop control for constant lighting,
2. Constant light control shall be achieved by dimming lights up/down in a particular space according to the ambient brightness in that area. Total cable length connecting the sensor and controller shall not exceed 100 m. mounting position for the light sensor shall be coordinated by contractor in such a way that to avoid direct light (windows, luminaries, mirrored surfaces) and installing the light sensor into the room as much as possible (away from the window).

D. Motion detectors:

1. Motion detectors shall be used for automatic switching or dimming of a certain light circuit where required for the purpose of energy saving (such as inside corridors, staircases, guest w/c,..)
2. The KNX motion detector shall be connected via the bus line to other KNX devices with no need for external power. The sensitivity of the sensor, the duration of the switching, and the behavior in case of a bus voltage failure and recovery shall all be adjustable.
3. It shall be possible to use the motion detector in double mode: either normal switching mode, or alarm mode to trigger an alarm in case of movement detection.

E. Other sensors:

1. The system shall be able to have other types of sensors such as rain sensor, humidity sensor, wind sensor, brightness sensor... connected to the bus system in order to provide a certain action (such as light switching or shutter lowering) in case of a preset threshold value is reached.

2.3.3 ACTUATORS & PANEL MODULES

A. Actuators for On/Off switching shall be:

1. DIN rail mounted consisting of four (4), six (6) , eight (8) or sixteen (16) individually programmable integral relays (contactors) with local manual bypass switches (one per relay).
2. Each of these contactors shall be rated 16 A/AC1. Additional contactors shall not be used to control any of the lighting circuits.
3. The output states of each of these relays shall be displayed on the front. Each of these relays shall be latch-on type with manual operation (override) possible even without the presence of the bus voltage & without having to remove the cover of the KNX panel.
4. In the event of power failure or bus wiring failure or control module failure, each of the relays shall attain a pre-programmed fail-safe position ('ON', 'OFF' or 'as it is Last status') at the time of commissioning.
5. The actuators shall be capable of being programmed with different applications to suit site requirements for e.g. staircase lighting function that switches 'OFF' the relays after a preprogrammed time from the time it has switched 'On'. The application for which a relay has been programmed shall apply irrespective of the signal from which it is controlled.
6. Each of the relays shall be capable of being programmed with its own 'ON' and 'OFF' delays that shall be applicable irrespective of the signal from which the relays are controlled.
7. Each of the actuators shall have its own individual address and shall be capable of being programmed from the central PC for the purpose of changing parameters without the need to access the module locally.

B. Dimming actuators shall be:

1. Dimming actuators for filament type light fittings (such as Incandescent, Low voltage halogen, Halogen, xenon, LED...etc.):
    a. The dimming actuators shall directly dim any type of filament type fittings (such as Incandescent, Low voltage halogen, Halogen, xenon...etc.).

b. The dimming actuators shall be plug-in type DIN rail-mounted self-contained, filters and related circuitry providing noise free dimming with compliancy with the latest IEC and EN standards and directives related to EMC and harmonic pollution. The dimming actuator shall have proper heat dissipation and shall be installed inside a closed KNX panel without the necessity of installing a fan for heat dissipation.
c. Each of the dimming modules shall be designed to operate the load as per the consultant approved load schedule.
d. It shall be possible to customize and correct the dimming characteristic curve of the lamp to suite the sensitivity of the human eye and to extend the service life of the connected lamps.
e. The dimming circuits shall be able to be switched on with preprogrammed value from 0 to 100%, additionally dimming shall be also possible between preprogrammed minimum and maximum values.
f. The dimming controller shall be capable of being programmed to attain a fail-safe position in the event of power failure. On power restoration after a power loss to the system, the control system shall automatically revert back to the particular setting (scene) selected in each individual area prior to the power loss.
g. Mixed loads (Conventional Transformers and Electronic Transformers) shall not be connected within the same individual load block due to the different behavior and characteristics between conventional and electronic transformers.
h. Dimmer actuators shall have a standard load of 210VA, 300VA or 500VA and shall be able to handle all types of loads (R, LC). Additional power amplifier shall be added to the dimmer actuator to reach the required lighting circuit load, but without the need to pull more than one cable from the lighting fixtures circuit to the KNX Panel for each dimming channel.

2. Dimming actuators for fluorescent light fittings:
   a. The dimming actuators shall be plug-in type DIN rail-mounted comprising of a 1-6A AC1 switching channels (latch-on type relay) and a passive 1-10 VDC channels for the high frequency dimmable ballasts.
   b. Each of the dimming modules shall be designed to operate the load as per the consultant approved load schedule.
   c. Each of the switching channels shall be used to switch the light fittings ON/OFF while the corresponding 1-10 VDC channel will provide the control (dimming) for the high frequency dimmable ballasts. Dimmers without latch-on type relay switching channel shall not be acceptable.
   d. Each of the channels shall be individually programmed to control a circuit irrespective of the other channel-controlled circuit.
   e. Dimming circuits shall be able to be switched on with preprogrammed value from 0 - 100%, additionally dimming shall be also possible between preprogrammed minimum and maximum values.
   f. Dimming actuator shall be capable of being programmed to attain a failsafe position in the event of power failure. On power restoration after a power loss to the system, the control system shall automatically revert back to the particular setting for each channel prior to the power loss.
   g. Fluorescent & Cold Cathode type light fittings shall be equipped with High Frequency Dimmable Ballasts accepting 0-10 VDC signal. These High Frequency dimmable ballasts should be an integral part of the light fittings and supplied by the light-fitting manufacturer in coordination with the KNX system supplier for any compatibility issues.
3. Dimming actuators for LED light fittings:
   a. The dimming actuators shall be plug-in type DIN rail-mounted comprising of a 1-6A AC1 switching channels (latch-on type relay) and a passive 1-10 VDC channels for the LED dimmable power supply.
   b. Each of the dimming modules shall be designed to operate the load as per the consultant approved load schedule.
   c. Each of the switching channels shall be used to switch the light fittings ON/OFF while the corresponding 1-10 VDC channel will provide the control (dimming) for the LED dimmable power supply. Dimmers without latch-on type relay switching channel shall not be acceptable.

d. Each of the channels shall be individually programmed to control a circuit irrespective of the other channel-controlled circuit.
e. Dimming circuits shall be able to be switched on with preprogrammed value from 0 - 100%, additionally dimming shall be also possible between preprogrammed minimum and maximum values.
f. Dimming actuator shall be capable of being programmed to attain a failsafe position in the event of power failure. On power restoration after a power loss to the system, the control system shall automatically revert back to the particular setting for each channel prior to the power loss.
g. LED type light fittings, where shown dimmable on drawings or schedules, shall be equipped with LED Dimmable Power supplies accepting 0-10 VDC signal. These LED dimmable power supplies should be an integral part of the light fittings and supplied by the light-fitting manufacturer in coordination with the KNX system supplier for any compatibility issues.

C. Blinds / Rolling Shutter Control actuators shall be:
1. Plug-in type DIN rail-mounted suitable for controlling up to four (4) or eight (8) independent 230 VAC or 24 VDC drive mechanisms.
2. Shutter actuators shall have up to four (4) or eight (8) independent channels, each with 2 switch contacts for up/down control.
3. Each channel contact shall be rated at 6 A per switch contact.
4. The control module shall have a safety feature that avoids any possible damage to the drive mechanism due to sudden changes in direction. Mechanism protecting shall be via identifying a fixed time base for determining the pause between changes in direction.
5. Shutter actuators shall have manual operation (override) possible even without the presence of the bus voltage & without having to remove the cover of the KNX panel.
6. Each shutter actuator channel shall be individually equipped fuse for locked motor or instantaneous magnetic protection.

2.3.4 OTHER DEVICES

A. Interface with BMS System:
1. Bidirectional communication between KNX and BMS (TCP/IP or BACNET).

PART 3 - DRY TYPE TRANSFORMERS

The Contractor shall furnish and install where indicated on the Electrical Drawings dry-type transformers as manufactured by Legrand or approved equal. KVA ratings shall be as indicated on the electrical plans.

Transformers shall have a 220 V primary and a 110 V 24 V, 12 V secondary. Transformers shall be supplied with 2-2 1/2% full capacity taps above and 4-2 1/2% full capacity taps below primary voltage.

Transformer coil must be vacuum impregnated with non-hygroscopic thermosetting varnish. Each layer shall have end fillers or tie down to provide maximum mechanical strength. No splicing acceptable.

Materials incorporated must have at least a minimum off one year of proven field usage, accelerated laboratory tests not acceptable in lieu of this field usage.

Transformer coils shall have a final wrap of electrical insulating material designed to prevent injury to the magnet wire. Transformers having coils with magnet wire visible will not be acceptable.

The core and coil unit shall be completely isolated from the enclosure by means of vibration absorbing mounts. There shall be no metal to metal contact between the core and coil and the enclosure.

Transformers shall be provided in a ventilated enclosure.

Transformers shall be suitable for wall mounting.

The maximum top of case temperature, shall not exceed 35° C, above ambient. The entire transformer enclosure shall by degreased, cleaned, phosphatized, primed and finished with baked enamel. Air dry finishes will not be accepted as being equal.

The core and coils shall be visibly grounded to the frame of the transformer cubicle by means of a flexible grounding strap of adequate size.

Sound levels shall be guaranteed by the manufacturer and substantiated by certified tests on each unit furnished. The sound levels are not to exceed the following values: 0 to 9 dB.

Suppliers asking consideration as an approved equal shall submit full guaranteed performance data on similar units in service for one more years.

PART 4 - FIELD AND INSTALLATION WORK

4.1. INSTALLATION

A. LOCATIONS: the 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 finishings, window trim, panelling and other architectural 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 the 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. SINGLE POLE SWITCHES are to switch the phase wire. Do not run neutral wire through switches having neutral shunt or bridge.

D. ADDITIONAL OUTLETS to those shown on the Drawings are to be provided as required by equipment manufacturers for control or other wiring.

E. EXPOSED OUTLET BOXES: securely fasten to wall with machine screws to permanent inserts or lead anchors.

F. RECESSED OUTLET BOXES: make neat openings, to the satisfaction of the Engineer, allowing for thickness of finishings and use extension rings if required. Repair damaged finishings to original condition before installation of fittings or plates.

G. 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.

H. GROUPED OUTLETS: arrange neatly so that use of fittings is convenient and clear.

I. WATERPROOF AND EXPLOSION- PROOF FITTINGS: follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.

J. DAMAGED FITTINGS: reject damaged fittings or plates with damaged finish. Protect fittings and plates against damage after installation and handed over.

K. CONNECTION OF APPLIANCE:

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 connecting wiring in flexible conduit firmly fixed to outlet box cover plate and to terminal box on appliance.

4.1.1. INSPECTION AND TEST ON SITE

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.

SECTION 16481 - MOTORS & STARTERS

1. GENERAL

The Contractor shall supply and install the motors and the starters under other sections when so mentioned, as shown on the Drawings and as herein specified.

Motor starting method and corresponding furnished starter shall be concordant.

2. RATING OF MOTORS

Motors shall be suitable for operation on 220/230 volt single phase or 380/400 volt 3-phase, 3-wire, 60 Hz system and shall be dripproof fan cooled to IEC 34-6 induction motor type unless otherwise indicated or specified. All motors shall have a service factor of 1.15, and a power factor of 0.85 as a minimum.

Motors of ratings smaller than 1 HP shall be single phase and those of ratings 1 HP and larger shall be three phase, unless otherwise indicated or approved.

Motors of rating larger than seven horsepower shall be star-delta closed transition starting type, unless otherwise required by the Local Authorities.

Motors of rating seven horse power and smaller shall be direct on line starting type.

Every motor shall be of sufficient capacity to operate the driven equipment under all load and operating conditions without exceeding its rated name-plate current or power or its specified temperature limit. The horsepower ratings for motors shown on the Drawings must be considered as an indication only. For the use of motors other than that specified, the Contractor shall assume the cost of, and responsibility for satisfactory accomplishing all changes (including engineering costs of redesign by the Engineer) in the work as indicated and specified. All derating resulting from site conditions shall be allowed for in the design.

Motor performances shall comply with the requirements of IEC 34-1.

3. TYPES OF MOTORS

All motors shall be of a type approved for starting characteristics and ruggedness as may be required under the actual conditions of operation.

All motors shall have class F insulation as a minimum requirement.

The motors shall be designed so that the maximum temperature rise at continuous run under full load and operation conditions shall be in accordance with IEC Standards for Motors and Generators and based on the local ambient temperature.

4. GENERAL DESIGN OF MOTORS

Motor windings shall be braced to withstand successfully the stresses resulting from the method of starting. The windings shall be treated thoroughly with approved insulating compound suitable for protection against moisture and slightly acid or alkaline conditions.

Bearings shall be of the self-lubricating type, designed to ensure proper alignment of rotor and shaft, and to prevent leakage of lubricant.

Bearings for open motors shall be of the sleeve or ball type, as specified under respective items of mechanical equipment.

Indoor motors located in relatively clean surrounding, free from any abrasive or conducting dust or chemical fumes, shall be enclosed ventilated dripproof type. Otherwise motors shall be totally enclosed fan cooled type.

Vertical motors if any shall be provided with thrust bearings adequate for all thrusts to which they can be subjected in operation.

Vertical motors of open type shall be provided with drip hoods of approved shape and construction. When the drip hood is too heavy to be easily removed, provision shall be made for access for testing.

5. MOTOR TERMINAL BOXES AND LEADS

Motors shall be furnished with oversized conduit terminal boxes to provide for making and housing the connections and with flexible leads of sufficient length to extend for a distance of not less than 10 cm beyond the face of the box. The size of cable terminals and conduit terminal box holes shall be as approved by the Engineer. An approved type of solderless lug shall be supplied. Totally enclosed motors shall have cast iron terminal boxes.

6. MOTOR SHOP TESTS

Motor shop tests shall be made in accordance with IEC Test Code or approved equal. Complete tests of each motor supplied shall be made and certified shop test data sheets shall be submitted, unless witness shop tests are required by the Detail Specifications pertaining to the equipment. Each motor shall be tested for efficiency and power factor at 50,75 and 100 percent of its rated horsepower, for temperature rise, torque, starting current and dielectric strength; and for compliance with all specified performance requirements.

7. MOTOR STARTERS

Motor Starters shall be built and sized in accordance with IEC Standard 158-1 and IEC 947-4-1coordination type 2, BS 775 and IEC 292-1&2, or approved equal. Starters shall be non-reversing, magnetic type unless otherwise indicated or specified.

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

The starter shall be provided with auxiliary contacts for the connection of signaling, interlocking and other circuits as required for the controls.

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

Starters shall have horsepower ratings at least equal to ratings of motors they serve following IEC 947-4-1coordination type 2.

Voltage of control circuit shall not exceed 240 volts for starters in motor control centers or panels. Individually mounted starters or combination starters may have their control voltage on 380 volts provided local regulations or local inspectors do not forbid the use of same. The Contractor when utilising such voltage for control shall provide the use of same. The contractor when utilising such voltage for control shall provide a clear warning of existence of such voltage within the station. If

220 volts are required by the local regulations or local inspectors, a neutral conductor shall be brought within the feeder of the starter of approved cross section, at no extra charge.

Starters shall be electrically held in, providing inherent under voltage release.
Starters when not part of a motor control center and are located indoors shall be encased in an IP 42 dust-proof enclosure, unless otherwise indicated.

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

The protective and control device for motor protection, have to be type-2 co-ordinated to IEC 947-4.1.

“Star-Delta” Starters shall provide closed transition.

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

8. VARIABLE SPEED PUMPING SET (If Required)

A. The variable speed pumping set control system shall include as, a minimum:

1. The programmable logic pump controller.
2. Adjustable frequency drive(s).
3. Automatic bypass.
4. Additional equipment as specified or as required to properly execute the sequence of operation including remote sensor/transmitters.

B. Pump Logic Controller:

1. The controller shall be specifically designed for variable speed pumping applications.
2. The controller shall function to a proven program that safeguards against damaging hydraulic conditions including motor overload, pump flow surges, hunting,end of curve.
3. The pump logic controller shall capable of accepting up to 4 analog inputs from zone sensor/transmitters indicated on the plans. The controller shall scan each analog input a minimum of once every 500 milliseconds. It will then select the analog signal that has deviated the greatest amount from its setpoint. This selected signal will be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value.
4. The pump controller shall be capable of controlling 6 pumps in parallel.
5. The controller shall be field expandable to control up to 6 pumps in parallel and accept up to 16 analog inputs. This modification shall consist of nothing more than the addition of analog input modules and shall not require the use of special tools or factory reprogramming.
6. The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral and derivative values shall be user adjustable over an infinite range.
7. The pump logic controller shall be self prompting. All messages shall be displayed in plain English. The operator interface shall have the following features:
   a. Multi-fault memory and recall
   b. On-screen help functions
   c. LED pilot lights and switches
   d. Soft-touch membrane keypad switches.

8. The readout shall be two lines of forty 0.50" brightly lit fluorescent characters capable of displaying the following values:
   a. Differential pressure in PSIG

b. Pressure in PSIG
c. Flow in GPM
d. Kilowatt consumption
e. Wire to water efficiency calculation

9. The following communication features shall be provided to the BMS :
   a. Remote system start / stop
   b. Failure of any system component
   c. Process variable
   d. AFD speed

C. Adjustable Frequency Drive (AFD)

1. The adjustable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
2. Enclosure shall be IP55 ventilated for installation as a wall mounted or free-standing unit, depending on the amp rating. A hand-off-automatic switch and speed potentiometer shall be mounted on the front of the enclosure.
3. AFD shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC voltage. Power factor shall remain above 0.95 regardless of speed or load. AFDs employing power factor correction capacitors shall not be acceptable.
4. Insulated gate bipolar transistors shall be used in theinverter section to convert the fixed DC voltage to a three phase, adjustable frequency, AC output. A DC line reactor shall be provided to minimize harmonic and current distortion of the input power line.
5. The following customer modifiable adjustments shall be provided:
   a. Accel time: 0.1 to 1800 seconds
   b. Decel time: 0.1 to 1800 seconds
   c. Minimum frequency: 0.5 HZ
   d. Maximum frequency: 320 HZ
   e. Analog input filter: 0.1 to 10 seconds
   f. Analog outputs: 10 to 1 gain
   g. Volts / Hertz ratio

6. Speed reference signal shall be customer selectable for 0-10 VDC or 4-20 mA.
7. The AFD shall be suitable for elevations to 3300 feet above sea level without derating. Maximum operating ambient temperature shall not be less than 104 degrees F. AFD shall be suitable for operation in environments up to 95% non-condensing humidity.
8. The AFD shall be capable of displaying the following information in plain English via a 40 character alphanumeric display:
   a. Frequency
   b. Voltage
   c. Current
   d. Kilowatts per hour
   e. Fault identification
   f. Percent torque
   g. Percent power
   h. RPM
9. All AFDs shall be warranted for a period of 24 months after shipment. This warranty shall cover parts and labor.

D. Automatic AFD Bypass

1. Variable speed pumping system shall be equipped with an automatic bypass.
2. Bypass shall consist of a main power disconnect, a pair of interlocked contactors and a motor overload relay.
3. Automatic bypass shall operate as described in the sequence of operation.

E. Sensor / Transmitters (For Pressure Boosting Applications)

1. Provide 1 field mounted single point pressure sensor transmitter(s) as indicated on the plans. Unit shall transmit an isolated 4-20 mA DC signal indicative of process variable to the pump logic controller via standard two wire 24 VDC system. Unit shall have stainless steel wetted parts with one 0.25" male NPT process connection. It shall be protected against radio frequency interference and shall have a watertight, NEMA 4 electrical enclosure with a 0.5" NPT conduit connection. Accuracy shall be within 0.25% of full span.

F. Sequence of Operation

1. The system shall consist of a pump logic controller, multiple pump/AFD sets with manual and automatic alternation and pump staging with across the line bypasses for each pump.
2. The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position.
3. Sensor/transmitters shall be provided as indicated on the plans.
4. Each sensor/transmitter shall send a 4-20mA signal to the pump logic controller, indicative of process variable condition.
5. The pump logic controller shall compare each signal to the independent, engineer/user determined set points.
6. When all set points are satisfied by the process variable, the pump speed shall remain constant at the optimum energy consumption level.
7. The Technologic pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone.
8. If the set point cannot be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of events to stage a lag pump.
9. The lag pump shall accelerate resulting in the lead pump(s) decelerating until they equalize in speed.
10. Further change in process variable shall cause the pumps to change speed together.
11. When the set point criteria can be safely satisfied with fewer pumps, the Technologic pump logic controller shall initiate a timed destage sequence and continue variable speed operation.
12. As the worst case zone deviates from set point, the pump logic controller shall send the appropriate analog signal to the AFD to speed up or slow down the pump/motor.
13. The operation of the pumps in the failure mode shall be started through the pump logic controller and an across the line bypass.
14. When in the "AUTOMATIC" mode, the pump(s) shall operate through the AFD(s) being controlled by a signal generated by the pump logic controller.
15. In the event of a system differential pressure failure, due to a pump, AFD, overload fault, the pump logic controller shall automatically initiate a timed sequence of events to start the remaining pump/AFD set(s) in the variable speed mode. A message on the display shall indicate the fault, pump/motor, or AFD. Subsequent failures shall initiate a timed sequence of events to the variable speed mode as available.
16. In the event of all AFD faults, all pumps shall be automatically started across the line.
17. When in the "BYPASS" mode, the selected pump(s) shall be able to be operated across the line at constant speed with motor overload protection. A solid red light shall signal this condition. All pumps shall be locked out of the variable speed mode.
18. In the event of an overload fault while in the "BYPASS" mode, the selected pump shall be locked out.
19. In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan/compare program. Alternative zone sensor/transmitters, if available, shall remain in the scan/compare program for control.
20. The zone number corresponding to the failed sensor/transmitter shall be displayed on the operator interface of the pump logic controller.
21. In the event of failure to receive all zone process variable signals, the AFD shall maintain 100% speed, reset shall be automatic upon correction of the zone failure.
22. PUMP, AFD, OVERLOAD fault shall be continuously scrolled through the display on the operator interface of pump logic controller until the fault has been corrected and the controller has been manually reset.

SECTION 16482 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes motor-control centers for use on AC circuits rated 600 V and less.

1.3 SUBMITTALS

A. Product Data: For products specified in this Section. Include dimensions, ratings, and data on features and components.

B. Shop Drawings: For each motor-control center 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. Schedule of features, characteristics, ratings, and factory settings of individual motor-control center units.
   2. Wiring Diagrams: Interconnecting-wiring diagrams pertinent to class and type specified for motor-control center. Schematic diagram of each type of controller unit indicated.

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

D. Maintenance Data: For products to include in the maintenance manuals specified in Division 1.

E. Load-Current and Overload-Relay List: Compile after motors have been installed and arrange to demonstrate that selection of protections suits actual motor nameplate full-load currents.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer.

C. Comply with IEC EN 61439 & IEC 364 for construction form as indicated on drawings comply with IEC 947-4-1, coordination **type 2** for all motor drives.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor-control centers, including clearances between motor-control centers and adjacent surfaces and items, and are based on types and models indicated. Other manufacturers' motor-control centers with equal performance characteristics and complying with indicated maximum dimensions may be considered.

1.5 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, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers." Use factory-installed lifting provisions.

1.6 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. The protections shall follow IEC 947-4-1, coordination type 2.

PART 2 - PRODUCTS

A. Enclosures: Free standing cabinets as indicated. Unless otherwise indicated to meet environmental conditions at installed location. Motor control centers shall be FORM 2B to IEC EN 61439-1&2.

1. Ingress Protection: IP55 (provide anti-condensation heaters and submit thermal study to justify the panel's cooling method.
2. Compartments: Modular; individual doors have concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units require disconnect means in off position before door can be opened or closed, except by consciously operating a permissive release device.
3. Interchangeability: Compartments are constructed to remove functional units without disturbing adjacent elements, disconnecting adjacent compartments, or disturbing the operation of other units in control center. Compartments are constructed to permit ready rearrangement of units, such as replacing 3 single units with a unit requiring 3 spaces, without cutting or welding.
4. Wiring Spaces: Each vertical section of structure with horizontal and vertical wiring has spaces for wiring to each unit compartment in each section, with supports holding wiring in place.

B. Short-Circuit Current Rating for Each Section: 30 % greater than indicated available fault current in symmetrical amperes at motor-control center location for 1 second minimum.

2.2 BUSES

A. Material: Tin Plated copper.

B. Ampacity Ratings: As indicated for horizontal and vertical main buses.

C. Neutral Buses: Full size, insulated and isolated from cabinet.

D. Equipment Ground Bus: Non-insulated, horizontal copper bus (50 by 6 mm), minimum as required by IEC standards.

E. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or approved equivalent.

F. Short-Circuit Withstand Rating: Same as short-circuit current rating of section for 1 second minimum.

2.3 FUNCTIONAL FEATURES

A. Description: Modular arrangement of motor controllers, control devices, overcurrent protective devices, transformers, panel boards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center as indicated.

B. Motor-Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.
1. Units have short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.

C. Overcurrent Protective Devices: Types of devices with features, ratings, and circuit assignments indicated.

D. Transient Voltage Surge Suppressors: Connected to motor-control center bus.

E. Spaces and Blank Units: Compartments fully bused and equipped, ready for insertion of units.

F. Spare Units: Type, sizes, and ratings as indicated, and installed in compartments indicated "spare."

2.4 MAGNETIC MOTOR CONTROLLERS

A. Description: full voltage, nonreversing, across the line, unless otherwise indicated.

B. Control Circuit: 220 V; obtained from integral control isolation power transformer, unless otherwise indicated. Include a control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Combination Controller: Factory-assembled combination controller and disconnect switch with overcurrent protection.
   1. Moulded case nonfusible Disconnect: heavy-duty, nonfusible switch.
   2. Moulded case circuit-Breaker Disconnect: motor-circuit protector (magnetic trip only) with field-adjustable short-circuit trip coordinated with motor locked-rotor amperes.

D. Overload Relay: Ambient-compensated type with inverse-time-current characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect, and with appropriate adjustment for duty cycle.

E. Star-Delta Controller: closed transition with adjustable time delay and overload protection.

F. Part-Winding Controller: closed transition with separate overload relays for starting and running sequences.

G. Contactor: To IEC standards 947-4-1, AC-3 or AC-4 rated as required by the application, in coordination type 2 with motor circuit breaker, thermal relay and motor nameplate data.

H. Solid-State, Reduced-Voltage Controller: Suitable for use with polyphase, medium induction motors.

   It shall comply with IEC 801-2, level 3 and IEC 801-4 level 4 for immunity to interference and directive 89/336/EEC for EMC requirements and IEC 664 for clearances and creepage distances.

   1. Adjustable acceleration rate control uses voltage or current ramp, and adjustable starting torque control has up to 500 percent current limitation for 20 seconds.
   2. Surge suppressor in solid-state power circuits provides 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   3. LED indicators show 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 operates automatically when full voltage is applied to motor.

2.5 VARIABLE-SPEED PUMPING SET (If Required)

A. Description: Variable speed drive controller, listed and labeled as a complete unit and arranged to provide soft starting of a recognized standard, induction motor by adjusting output voltage and frequency.

It shall comply with IEC 801-2, level 3 and IEC 801-4 level 4 for immunity to interference and directive 89/336/EEC for EMC requirements and IEC 664 for clearances and creepage distances.

B. Design and Rating: Match type pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Isolation Transformer: Match transformer voltage ratings and capacity to system and motor voltages; and controller, motor, drive, and load characteristics.

D. Output Rating: 3-phase, 0.5 to 320 Hz, with torque constant as speed changes.

E. Starting Torque: 100 percent of rated torque or as indicated.

F. Speed Regulation: Plus or minus one percent.

G. Ambient Temperature: 0 to 40 deg C.

H. Efficiency: 95 percent minimum at full load and 320 Hz.

I. Isolated control interface allows controller to follow 1 of the following over an 11:1 speed range:

1. Electrical Signal: 4 to 20 mA at 24 V.

J. Internal Adjustability: Include the following internal adjustment capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to 22 seconds.
4. Deceleration: 2 to 22 seconds.
5. Current Limit: 50 to 110 percent of maximum rating.

K. Self-protection and reliability features include the following:

1. Input transient protection by means of surge suppressors.
2. Snubber networks to protect against malfunction due to system voltage transients.
3. Motor Overload Relay: Adjustable and capable of NEMA 250, Class 10 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous overcurrent trip.
6. Loss of phase protection.
7. Reverse phase protection.
8. Under- and overvoltage trips.
9. Overtemperature trip.
10. Short-circuit protection.

L. Automatic Reset/Restart: Attempt 3 restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Restarting during deceleration will not damage controller, motor, or load.

M. Power-Interruption Protection: Prevents motor from reenergizing after a power interruption until motor has stopped.

N. Status Lights: Door-mounted LED indicators to indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

O. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate controller output current, voltage, and frequency.

Q. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch indicator lights set and indicate mode selection.

R. Integral disconnect.

S. Isolating Switch: Non-load-break switch arranged to isolate variable-frequency controller and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

T. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.6 VARIABLE-SPEED DRIVES (fractional horse-power to and including 15 kW)

A. GENERAL REQUIREMENTS

1. Scope: requirements for pulse-width modulated (PWM) Adjustable Frequency Drives, herein referred to as AC Drives, for use with NEMA design AC motors, or standard IEC motors.

2. The AC Drive is a system for controlling the rotational speed of an AC motor and providing on demand the right torque to the pump & fan application.

3. The same drive must be able to manage both asynchronous and synchronous motor.

4. The fitting of the drive to the motor is the key factor to ensure an optimized motor control energy efficiency wise. Consequently the AC Drive must have the capabil-ity to measure automatically the parameters of the motor to fine tune the control.

5. Shortening the downtime increases the operational performance of any facility and reduces the operating expenditures. Maintenance and monitoring tools such as fault history, parameters upload/download, scope and keypad emulation are built-in in the drive and used for trouble shooting. Moreover an additional user-friendly PC software must encompass the configuration management and com-missioning functionalities without additional investment.

B. APPLICABLE STANDARDS

1. The VSD is qualified to address all the major economic area standards.

2. The AC Drives shall be :

   a. CE marked, conforming to European Low Voltage (2006/95/EC modified from 73/23/EEC and 93/68/EEC and EMC (2004/108/EC modified from 89/336/EEC) Directives, and Machinery directive N0 98/37/EC modified by 98/79/EC.

   b. UL marked according to UL 508C.

3. Moreover it shall comply with National and International standards and the recommendations for electrical industrial control devices (IEC, EN, UL, NFC, VDE) listed below:

Standard	**Title**
IEC 60068-2-3 IEC 60068-2-6 IEC 60068-2-27	Environmental testing; Part 2-3: Tests - Test Ca: Damp heat, steady state Part 2-6: Tests - Test Fc: Vibration (sinusoidal) Part 2-27: Tests - Test Ea and guidance: Shock
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 61800-3 IEC 61800-5-1	Adjustable speed Electrical Power Drive Systems; Part 3: EMC requirements and specific test methods Part 5-1: Safety requirements - Electrical, thermal and energy

C. SPECIFIC REQUIREMENTS

1. PROTECTION

   a. The following function shall be available to prevent the risks of equipment destruction from component's failures.

   b. The AC Drive shall be protected against short circuits, between output phases and to ground.

   c. The AC Drive shall have under-voltage power-loss ride through performance.

   d. The AC Drive shall integrate a protection against IGBT chips over temperature in addition to the heat sink overheat protection.

   e. The output frequency shall be software enabled to fold back when the motor is overloaded.

   f. Upon loss of the analog process follower reference signal, the AC Drive shall be programmable to display a fault.

   g. Three skip frequency ranges that can be programmed to a bandwidth of 30Hz.

2. COMMISSIONING

   a. A keypad display interface shall offer the modification of AC Drive adjustments through a touch keypad. All electrical values, configuration parameters, I/O assignments, faults, local control, and adjustment storage, and di-agnostics shall be accessible.

   b. The built-in graphic keypad display interface must have the Run/Stop command buttons for quick local running feature. For security reasons the keypad must not be removable from the drive.

c. The optional remote display is mandatory and must have the three following press keys:
   i. Local / Remote to switch the drive command locally or remotely
   ii. RUN to run the drive
   iii. STOP to stop the drive.

d. A red led will lit on the front panel to indicate the energizing status of the drive DC bus.

e. The hereafter parameters; Speed reference, Motor current, Drive rated current, Drive thermal state, Output power must be displayed on the graphic terminal.

f. The motor should be able to operate after the wiring without any parameter settings. Thus allows short lead-time for connection checking to speed up the commissioning.

3. HARMONICS MANAGEMENT

a. The DC power link capacitor technology must be compliant to a life expectancy of 14 years as minimum duration.

b. To mitigate the oversizing of the transformer and power cables the rectifier bridge technology must guarantee a VSD THDI (Total Harmonic Current Distortion IEC/EN 61000-3-12 standard) below 35% without additional parts such as fixed or swinging DC chokes, line inductances, harmonic fil-ters.

c. Displacement Power Factor (cosφ): cosφ ~ 1 almost no reactive current on the power supply.

d. True Power Factor: The true power factor is defined as the ratio between the fundamental current, I1 (the current at 60Hz), and the RMS current, I RMS (current including all harmonics). A high true power factor (close to one) shall be an indication of good harmonic suppression

4. CONTROL CONNECTIONS

a. The control power for the digital inputs and outputs shall be 24Vdc. The in-put logic type (positive logic) or sink (negative logic) is configured by an hardware switch.

b. The internal power supply shall incorporate automatic current fold-back that protects the internal power supply if incorrectly connected or shorted. The transistor logic outputs will be current limited and will not be damaged if shorted.

c. Removable terminal strips shall be used on all logic and analog signal connections in the power converter

d. Two voltage-free relay output contacts will be provided. One of the contacts will indicate AC Drive fault status. The other contact shall indicate a drive run status. These relays shall be configurable for other status indicators.

5. SERIAL COMMUNICATION

a. The AC drive shall have an integrated RJ45 port for Modbus.

b. The following HVAC building protocols; LonWorks, BACnet shall be provid-ed where the drive it indicated to be interfaced with the BMS or automation and control system. plug-in board.

D. OPERATION

1. RATINGS

a. The AC Drive shall be designed to operate at the input line voltage and power rating range indicated in the table below:

Voltage	**Phases**	**Power rating**
380V -15% to 480V +10%	three-phase	0.75 kW to 75 kW

b. The AC Drive shall operate from an input frequency range of 50Hz - 5% to 60Hz + 5%.

c. The efficiency of the AC Drive at 100% speed, 100% load, and 35% THDI shall not be less than 97%.

d. The requested AC Drive over-torque capacity is 120% of the nominal torque for one minute.

2. ENVIRONMENTAL RATINGS

Operating ambient Temperature	-10°C up to 50 °C without derating in side by side mounting. -up to 60 °C with derating
Maximum operating altitude	1000 m without derating 1000…3000m: current derating of 1% per addi-tional 100 m.
Max. Relative Humidity (IEC 60068-2-3)	5…95 %, without condensation and dripping wa-ter

a. The AC drive must operate with a switching frequency of 10 kHz to die down the motor noise at 40°C without derating.

b. The AC Drive shall be able to give a 100 % output current continuously in the above specified conditions. The derating factor must not have an impact on the lifetime of the AC Drive, the unit's performance, overload capability included, and the reliability of the AC Drive.

c. The EMC Plate must be included in the standard drive in order to conform with EMC best practices.

d. A built-it Class B EMC (EN55011) filter shall be provided for all drives irre-spective of the IP rating. That corresponds to IEC 61800-3 Cat C1.

e. The top of the standard drive must comply to IP21 or IP41 to prevent from any objects dropping in the drive and damaging it.

f. The product shall be available in two versions, IP20 and IP54. When using IP54 class B EMC filter must embedded in the enclosure.

g. An accessory shall be available to achieve UL type 1 compliancy. The Type 1 products shall additionally be recognized as plenum rated and comply with the

applicable requirements for installation in a compartment handling conditioned air.

E. MAINTENANCE

1. BUILT-IN FUNCTIONALITY

a. Upon power-up, the AC Drive shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, DC-to-DC power supply, control power and pre-charge circuit.

b. An user-friendly PC software workshop is used as a commissioning, configuration set-up and troubleshooting tool.

2. MANUFACTURER

a. The AC Drive Manufacturer must have a minimum of 30 years experience in world-class drive design and manufacturing. The installed base product quantity must be large enough to be credible in its capability to be an edge company continuously enhancing its product management process.

3. 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. The support team must be able to attend to site problems on site within 24 to 48 hours with fair notice from customer.

b. The most critical spare parts like fuses, IGBTs, cooling fans as well as main control- and I/O-boards shall be available on site or within 8-12 hours after the positive identification was made of the spare part that is required to repair the drive.

c. The more rarely used spare parts should be available in maximum 10 days on site.

4. WARRANTY and AFTER-SALES

a. A factory test report shall be delivered by the AC Drive Manufacturer on request.

b. A 24-month parts warranty shall be provided on materials and workman-ship from the date of purchase.

c. Services are provided (spare part and repairing) for 10 years after the end of commercialization.

F. SUSTAINABLE DEVELOPMENT

1. The manufacturer of the AC Drive shall be a qualified ISO 14001 facility.

2. The materials used in the AC Drive shall be recyclable, non-toxic and flame retardant. The AC Drive shall comply with the European directive RoHS (Restriction Of Hazardous Substances) 2002/95/EC.

3. The Product Environmental Profile (PEP) analysis must be performed in conformi-ty with standard ISO 1404 .

2.7 FEEDER OVERCURRENT PROTECTION

A. Molded-Case Circuit Breaker: MCCB, handle lockable as mentioned and specified in main distribution board.

2.8 MCC CIRCUIT BREAKERS: MCCB below 800 Ampers and Air Circuit Breaker above 800 Ampers, both with utilization category “B” and electronic trip unit as indicated in section 16115 (Main Distribution Boards).

2.9 ACCESSORIES

A. Devices are factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break push-button station with a factory-applied hasp arranged so a padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Elapsed Time Meters: Heavy duty with digital readout in hours.

F. Meters: Power meter as indicated in section 16115 (main Distribution Boards).

G. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

H. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay.

I. Transient Voltage Surge Suppressors: IEC 60364, IEC 61643-11, IEC 664-1 and IEC 1643-1, selected to meet requirements for a high-exposure category.

J. Impulse sparkover voltage coordinated with system circuit voltage.

K. Factory mounted with a Recognized Testing Laboratory listed and labeled mounting device.

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 accepted and 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.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs according to Division 16 Section "Basic Electrical Materials and Methods."

B. Identify field-installed wiring and components and provide warning .

C. 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.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Division 16 Section "Wires and Cables."

B. Bundle, train, and support wiring in enclosures.

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 CONNECTIONS

A. Tighten motor-control center bus joint, electrical connector, and terminal bolts according to manufacturer's published torque-tightening values. Such that system is Tested Assemblis to IEC EN 61439-1&2.

3.6 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 each visual and mechanical inspection and electrical test stated in correspond IEC standards. Certify compliance with test parameters.
2. Remove and replace malfunctioning units with new units, and retest.

3.7 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.

3.8 DEMONSTRATION

A. Training: Engage a factory-authorized service representative to demonstrate solid-state and variable-speed controllers and motor-control centers, and train Owner's maintenance personnel.

1. Conduct a minimum of 4 hours of training in operation and maintenance. Include training relating to equipment operation and maintenance procedures.
2. Schedule training with at least 7 days' advance notice.

SECTION 16521 – EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 16010 of the Specification and requirements to achieve LEED Silver Certification. All ASHRAE mandatory requirements shall be accomplished plus all credits stated for this project in this regard.

1.2 SUMMARY

A. This Section includes the following:
   1. Exterior luminaires with lamps and ballasts.
   2. Luminaire-mounted photoelectric relays.
   3. Poles and accessories.
   4. Luminaire lowering devices.

B. Related Sections include the following:
   1. Division Section 16331 "General Lighting Installations" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

A. CRI: Color-rendering index.

B. HTD: High-intensity discharge.

C. Luminaire: Complete lighting fixture, including ballast housing if provided.

D. Pole: Luminaire support structure, including tower used for large area illumination.

E. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.

B. Live Load: Single load of 500 ibf (2224 N), distributed as stated in AASHTO LTS-4.

C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
   1. Wind speed for calculating wind load for poles in height is 120 km/h.

1.5 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
   2. Details of attaching luminaires and accessories.
   3. Details of installation and construction.
   4. Luminaire materials.
   5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
      a. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
      b. Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
   6. Photoelectric relays.
   7. Ballasts, including energy-efficiency data.
   8. Lamps, including life, output, and energy-efficiency data.
   9. Materials, dimensions, and finishes of poles.
   10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
   11. Anchor bolts for poles.
   12. Manufactured pole foundations.

B. Shop Drawings:
   1. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
   2. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
   3. Wiring Diagrams: Power and control wiring.

C. Samples for Verification: For products designated for sample submission in Exterior Lighting Device Schedule. Each sample shall include lamps and ballasts.

D. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying load imposed by luminaire has been included in design.

E. Qualification Data: For agencies providing photometric data for lighting fixtures.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For luminaires, poles and luminaire lowering devices to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited in Europe.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent European agency, with the experience and capability to conduct the testing indicated.

C. Electrical Components, Devices, and Accessories: Listed and labeled by a testing agency acceptable to authorities having jurisdiction, and marked for intendeduse.

D. Comply with IEEE C2, "National Electrical Safety Code."

E. Comply with NFPA 70.

F. All outdoor lighting fixtures shall be chromium plated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 300mm above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetalhc finishes, handle with web fabric straps.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
   1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
   2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
   3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
   4. Warranty Period for Lamps: Replace lamps and fuses that fail within 12 months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.
   5. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Ballasts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   4. Globes and Guards: 10 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

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

3. Basis of Design Product: The design of each item of exterior luminaire and its support is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LUMINAIRES, GENERAL REQUIREMENTS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

C. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide falter/breather for enclosed luminaires.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames. lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

E. Exposed Hardware Material: Stainless steel.

F. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat and UV radiation.

G. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent
   3. Diffusing Specular Surfaces: 75 percent

I. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

J. Lumiuaire Finish: Manufacturer’s standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

K. Factory-Applied Finish for Steel Luminaires:
1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants mat could impair paint bond. Grind welds and polishsurfaces to a smooth, even finish. Remove mill scale and rust if present, from uncoated steel.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   a. Color: As selected from manufacturer's standard catalog of colors.
   b. Color: Match Architect's sample of manufacturer's standard color.
   c. Color: As selected by Architect from manufacturer's full range.

L. Factory-Applied Finish for Aluminum Luminaires:
1. Natural Satin Finish: Provide fine, directional, medium satin polish and seal aluminum surfaces with clear, hard-coat wax.
2. Class I, Clear Anodic Finish: Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: clear coating 0.018 mm or thicker.
3. Class I, Color Anodic Finish: (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electronically deposited color coating 0.018 mm or thicker.
   a. Color: as indicated in Schedules.

2.3 **FLUORESCENT BALLASTS AND** LAMPS refer to General Lighting Installations Section 16331.

A. Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) minus 0 deg.

2.4 **BALLASTS FOR HID** LAMPS refer to General lighting Installations Section 16331.

A. Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) minus 0 deg.

2.5 **HIP LAMP:** refer to General Lighting Installations Section 16331.

2.6 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics:
1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping hi steady winds of speed indicated in Part 1 with a gust factor of 1.3.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."

E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M: andwith top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptableto authorities having jurisdiction.

2.7 STEEL POLES

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46.000 psig (317 MPa); 1-piece construction up to 40 feet < 12 m} in height with access handhole in pole wall.
   1. Shape: Round.
   2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

B. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate Material and finish same as pole.

C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
   1. Adapter fitting welded to pole and bracket, then bolted together with stainless steel bolts.
   2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
   3. Match pole material and finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

E. Steps: Fixed steel, with nonslip treads, positioned for (38l-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 3 m above finished grade.

F. Intermediate Handhole and Cable Support: Weathertight, 26-by-127-mm handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.

G. Grounding and Bonding Lugs: Welded 13-mm threaded lug, complying with requirements in Division 16 Section "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

I. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.

J. Prime-Coat Finish: Manufacturer’s standard prime-coat finish ready for field painting.

K. Galvanized Finish: After fabrication, hot-dip galvanized complying with ASTM A 123/A 123M.

L. Factory-Painted Finish:

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   a. Color: As selected by Owners from manufacturer's full range.

2.8 DECORATIVE POLES

A. Pole material: Stainless steel, or Aluminium as shown on schedules.

B. Mounting Provisions: Bolted to concrete slab.

C. Fixture Brackets: Cast aluminium or as indicated on schedule.

D. Pole Finish (as per I.D).

2.9 2.10 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

B. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept (ballast).

2.10 REQUIREMENTS FOR INVIDUAL EXTERIOR LIGHTING DEVICES

A. Exterior lighting Device Type
   1. Basis-of-Design Product: Insert manufacture's name; product name or designing or a comparable product by one of the following:
   2. Voltage: 220Vac
   3. Nominal Dimensions
   4. Lamps
   5. Ballast Types and Features.
   6. Photoelectric Control: Integrally mounted.
   7. Lens
   8. Reflector
   9. Focusing and Aiming Provisions.
   10. Cutoff Category
   11. Nominal Beam Spread for Floodlights
   12. Internal Light Shield
   13. Photometric Performance of Installed Units:
      a. Spot Intensity: Minimum initial horizontal illumination at grade.
      b. Average Intensity: Minimum average initial horizontal illumination at grade
      c. Uniformity.
      d. Ballast Factor.
      e. Minimum Luminaire Efficacy Rating.
      f. Pole Description.
   14. Ballast Factor.
   15. Minimum Luminare Efficacy Rating.
   16. Pole Description.
      a. Material or Type.
      b. Luminaire Support Components and Accessories:
      c. Mounting Provisions.

d. Luminaire Mounting Height above finished grade.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Faster luminaire to indicated structural supports.

C. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

D. Adjust luminaries that require field adjustment or aiming.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum alignment of luminaries and their mounting provisions on the pole.

B. Install on concrete base with top 100mm above finished grade or surface at bollard location Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3 Section "Cast-in-Place Concrete."

3.3 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top (100mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3 Section "Cast-in-Place Concrete."

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 16 Section "Raceways and Boxes." In concrete foundations, wrap conduit with 0.010-inch- (0.254mm) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 GROUNDING

A. Ground metal poles and support structures according to Division 16 Section "Grounding and Bonding".
   1. Install grounding electrode for each pole, unless otherwise indicated.
   2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Division 16 Section "Grounding and Bonding."
   1. Install grounding electrode for each pole.
   2. Install grounding conductor and conductor protector.

3. Ground metallic components of pole accessories and foundations.

3.6 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
   1. Verify operation of photoelectric controls.

C. Illumination Tests:
   1. Measure light intensities at night with photometric.

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustment

SECTION 16551 — LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements.

1.2 **DESCRIPTION OF WORK:** air termination network, down conductors, earth termination network, bonding to prevent side flashing and accessories.

1.3 **STANDARDS:** The following standards are referred to in this part:

NFPA 780 Lightning protection system.

Alternative Standard:
BS 62305 Code of practice for protection of structures against lightning.

1.4 **TECHNICAL DATA:** submit data for approval including manufacturer's illustrated catalogues with description and specification of component parts for Protective termination network, conductors, fasteners, testing joints (test links), earth rods, connectors, wall inserts and bolts and any accessories forming part of the lightning protective system.

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

A. Exact location and routing of roof and down conductors with indication of sleeves and types of fixings.

B. Exact location of earth pits and routing of interconnecting ring.

C. Typical details of jointing and bonding.

1.6 **AS- BUILT DRAWINGS:** provide as- built drawings and indicate nature of soil, special earthing arrangements, date and particulars of salting if used, test conditions and results obtained.

1.7 **MANUFACTURERS:** obtain equipment, manufactured specifically for lightning protection, from one of the following:

A. Copperweld (USA)

B. Thompson Lightning Protection (USA)

C. ERICO (USA)

D. Furse (UK)

E. Wallis (UK)

PART 2 - PRODUCTS AND SYSTEMS - COMPONENTS AND ACCESSORIES

2.1 MATERIALS

A. Generally:

(a) Products used in the lightning protection system shall be copper or an approved copper alloy, unless otherwise specified, and specifically manufactured for the purpose.

(b) Comply with UL96 and NFPA 780

B. Air Termination Conductors and Down Conductors:

(a) Lightning air terminals and down conductors for lightning shall be provided as indicated on the drawings. Where vertical air terminations are used, they shall be min of 15 mm diameter tinned copper (air termination rod) 0.8 meter long with top spike, unless otherwise specified in the Project Documentation

(b) Air Terminals More than 600 mm Long shall be with brace attached to the terminal at not less than half the height of the terminal.

(c) Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in roofing Sections.

(d) Generally, roof conductors and down conductors shall be of 3 x 25 mm (minimum) copper tape.

(e) Air termination rods shall be securely anchored and welded.

(f) Down conductors shall be run along the outer surface of the wall or column of the building.

(g) Down conductors shall be as short as possible, protected and directly connected to earthing system through test links.

(h) Anchoring bolts shall be used to hold roof conductors and down conductors in firm position.

(i) Lightning conductor connectors shall be provided for conductor splice connections and conductor terminal connections

(j) The connectors shall be heavy duty, cast metal and shall have hex-head screws in the bodies and holes in the tongues for bolts

(k) TV antenna, HVAC equipment, handrails and structures in the vicinity of the lightning protection system, if any, shall be bonded to the system by 3x25 sq. mm (minimum) PVC sheathed copper tape.

C. Main Earth Loops:

(a) 25 x 3 mm tinned copper tape, unless otherwise indicated on the Project Drawings or Specification.

D. Earth Electrodes:

(a) Shall be the earth rod electrode type, unless impracticable to drive deep into the particular soil and shall be driven at least to the depth 2 m below water table in summer time

(b) Earth rod electrodes: 19 mm diameter steel core copper jacketed type, comprising a high strength steel alloy core with a molten welded copper covering, minimum 0.25 mm thick

(c) To be not less than 3.0 m long, in sections coupled by strong bronze couplers.

E. Plate Electrodes

(a) To be either:

(i) Copper.

(ii) Cast iron where artificial treatment of soil is necessary because of high soil

resistivity.

F. Earth Connectors:
   (a) Connection of rod electrodes: bolted type.

G. Removable Earth Links:
   (a) To comprise a bolted copper link fixed on porcelain insulators and complete with studs, nuts and washers to take the earth tape and a bolted lug adequately sized for the final connection of the earth electrode.

H. Bolts, Washers and Nuts in Bolted Connections:
   (a) High copper alloy or silicone bronze. Ferrous hardware is not acceptable.

I. Earth Pit Cover
   (a) Shall be of heavy duty cast iron cover
   (b) Shall have a recessed lifting hook
   (c) Shall have a brass plate, engraved “Electrical Earth Below”.

PART 3 - FIELD AND INSTALLATION WORK

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.

C. Conceal the following conductors:
   (a) System conductors.
   (b) Down conductors.
   (c) Interior conductors.
   (d) Conductors within normal view of exterior locations at grade within 60 m of building.

D. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

E. Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
   (a) Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.

F. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer’s written instructions.

G. Bond extremities of vertical metal bodies exceeding 18 m in length to lightning protection components.

H. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure.
   (a) Bury ground ring not less than 600 mm from building foundation.
   (b) Bond ground terminals to the ground loop.
   (c) Bond grounded building systems to the ground loop conductor within 3.6 m of grade level.

I. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 18-m intervals.

J. Removable Earth Links

(a) Fix in every main earth lead to enable the electrode system to be disconnected for testing.
(b) Install in an accessible position, above ground as close as possible to the earth electrode.

K. Bolted Connections:
(a) Multiple bolt type
(b) Where bare copper is bolted in connections contact surfaces shall be silver electroplated.

L. Brazed Connections:
(a) Where earthing terminal connections are to be brazed to equipment, thoroughly clean metal prior to brazing and repaint impaired surfaces to prevent corrosion.

M. Connections Between Dissimilar Metals:
(a) Protect by:
(i) Painting with a moisture resistant bituminous paint or compound, or
(ii) Wrapping with protective tape to exclude moisture.

N. Earth Rod Electrodes:
(a) Drive extensible rods of the same diameter into the ground, either manually or by power driven hammer, to a suitable depth to obtain low resistivity in the particular soil.
(b) Weld earth connectors to the top of the rods, in sufficient number to make connection with all incoming cables.

O. Earth Plate Electrodes:
(a) Use where:
(i) Ground resistivity is low but increases with depth;
(ii) It is not possible to go deep into soil.
(b) Protect terminations against corrosion.

P. Earth Pit:
(a) Construct a small concrete pit complete with removable heavy gauge cast iron cover with recessed lifting hook, at the head of the earth rod, to protect the rod and allow access to connections for testing.

3.2 TESTS ON SITE AND RECORDS

A. RESISTANCE TO EARTH of each termination electrode and the network and of the complete bonded installation is to be measured during the dry season and checked against specified resistance.

B. ELECTRICAL CONTINUITY of conductors, a bond etc… is to be checked.

C. RECORDS: submit the following:
1. Actual layout and specification of components of the system.
2. Nature of soil and characteristics and any special earthing arrangement.
3. Test conditions and results.

SECTION 16610 - UNINTERRUPTIBLE POWER SUPPLY SYSTEM (U.P.S.)

PART 1 - PART 1- GENERAL

1.1 SUMMARY

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

B. Work Included: The work shall include, but not be limited to, the following:
1. Solid state rectifiers/chargers.
2. Inverter.
3. Static bypass.
4. Batteries.
5. Accessories.
6. Furnishing load banks and test instruments during field testing.

C. Related Work Specified Elsewhere
1. Basic Electrical Requirements - Section 16010.

1.2 QUALITY ASSURANCE

A. Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.
1. Code Compliance: Comply with the applicable electrical code as applicable to installation and construction of electrical equipment.
2. IEC Standards: Comply with IEC standards 146 and 439.

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

1.3 APPLICABLE STANDARDS

A. The UPS shall be designed in accordance with the applicable sections of the current revision of the following documents. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.

1. Safety:
   a. IEC 62040-1 or EN 62040-1
   b. IEC 60950-1 or EN 60950-1
2. Emission and Immunity:
   a. IEC 62040 (International Electrotechnical Commission) – Uninterruptible power systems (UPS) – Part 2: Electromagnetic Compatibility (EMC) Requirements.
   b. EN61000-4-2,-3,-4,-5
   c. Slow high energy surges in input/output lines:
   d. 1 kV line/earth, 0.5 kV line/line (IEC 61000-4-5)
   e. Fast low energy transients in power lines:
   f. 2 kV line/earth (IEC 61000-4-4)
   g. Fast low energy transients (burst) in control and signal lines:
   h. 1 kV line/earth (IEC 61000-4-4)

i. Electrostatic discharge (ESD):
j. 8 kV air discharge, 6 kV contact discharge (IEC 61000-4-2)
k. Electromagnetic field: IEC 61000-4-3 level 3

B. IEC 62040 (International Electrotechnical Commission) – Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements.

1.4 SUBMITTALS

A. Submit the following in accordance with Submittal Requirements specified in Section 16010.

1. Product Data: Submit manufacturer's data on uninterruptible power supply systems and components.

2. Shop Drawings: Submit dimensioned layout drawings and descriptive data of UPS systems and accessories including, but not limited to, weights, rectifiers/chargers, inverters, static transfer switches, maintenance switches, batteries and instruments, indicating accurately scaled UPS system equipment locations and their spatial relationship to associated equipment; show connections to normal and standby power supplies, elementary diagrams of protection, control and instrumentation systems, wiring and single line diagrams, time current curves of protective devices. Submit calculations to indicate compliance with battery requirements of scheduled standby use with no more than specified drop in battery voltage.

3. Maintenance Data: Submit maintenance data, parts and recommended spare parts list for each uninterruptible power supply and accessory; including "troubleshooting" maintenance guide. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Section 16010.

4. Field Test Procedure: Submit a detailed site acceptance test procedure.

5. Submit a failure mode and effects analysis and a reliability prediction based on the final design.

6. Submit a detailed factory acceptance test procedure.

7. Submit certified factory and site test data and reports, for the UPS equipment and the batteries.

8. Submit battery manufacturer name, container type, the total number of containers required per UPS module, battery and rack dimensions and weights.

1.5 DELIVERY, STORAGE AND HANDLING

A. UPS equipment and batteries shall be delivered undamaged to the site by an experienced direct carrier using appropriate air ride suspension equipment. In no case shall be UPS equipment and batteries be shipped without prior written approval of the Engineer. Premature shipment will be automatic cause for rejection.

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

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

1.6 WARRANTY AND GUARANTY

A. The UPS system warranty shall be no less than Two years after initial startup, and must include costs including repair, parts, labor, travel and living for the manufacturer's service personnel. The manufacturer shall respond to requests for and provide warranty service within 8 hours.

B. Battery: The battery provided herein shall be guaranteed by the UPS manufacturer on a pro rated basis for Two years (unless otherwise specified herein), provided that the prevailing ambient temperature of the battery area does not exceed 25°C. Batteries shall deliver a minimum of 100% of rated capacity initially and a minimum of 80% of rated capacity at the end of the battery guarantee period in accordance with IEE standard 485.

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

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer
   1. Eaton
   2. Schneider Electric
   3. Socomec
   4. Emerson

2.2 UNINTERRUPTIBLE POWER SUPPLY 20KVA (3PH IN / 3PH OUT)

A. SYSTEM DESCRIPTION

1. The UPS shall operate as a double conversion UPS with the following operations modes:
   a. Normal: During the Normal or Double Conversion Mode the rectifier shall derive power as needed from the commercial AC utility or generator source and supply filtered and regulated DC power to the on-line inverter. The inverter shall convert the DC power to highly regulated and filtered AC power for the critical loads.
   b. Battery: Upon failure of the AC input source, the critical load must continue being supplied by the inverter without any switching. The inverter must obtain its power from the battery. There must be no interruption in power to the critical load upon failure or restoration of the AC input source.
   c. Recharge: Upon restoration of the AC input source, the rectifier/battery charger must recharge the battery. The inverter shall with no interruption in power regulate the power to the critical load.
   d. Bypass: The static bypass switch has to be used for transferring the critical load to mains supply without interruption. Automatic re-transfer to normal operation must also be accomplished with no interruption in power to the critical load. The static bypass switch has to be capable of manual operation.
   e. External maintenance bypass: The external maintenance bypass switch is preferred but minimum need is the integral maintenance bypass if no such item in the system. It is used for supplying the load directly from the mains supply, while the UPS is isolated for maintenance.

2. Converter (rectifier): Incoming power shall be filtered and converted to DC by a sine-wave rectifier. The DC power is then processed by a high-frequency converter to supply power to the inverter. The Converter corrects the input power factor to 0.99 and draws sinusoidal current (with less than 5% THD) from the utility. In the event of utility failure, the converter shall be supplied power without interruption from the internal of external batteries. During normal operation, the batteries will be charged through the rectifier.
   a. Overload Capacity: The converter shall be capable of supplying up to 150% of rated load for at least 5 seconds if no bypass is available.

3. Inverter: The inverter converts the DC Power to regulated AC Power for critical loads.
   a. Output Voltage: The inverter output voltage is specified in section 2.03.
   b. Voltage Regulation: The inverter steady state voltage regulation is +/- 2% in steady state and +/- 5% for a 0 to 100% load step.
   c. Frequency Control: The inverter steady state frequency regulation is +/-0.005 Hz free running in steady state. UPS is synchronized to mains in normal operation.

4. Batteries: The batteries shall be sealed, lead acid, maintenance-free, high-rate discharge cells. They will be kept fully charged by the battery charger. They have an expected life of 200-300 complete full load discharge cycles when operated and maintained within specifications.

5. Battery Charger: The battery charger (or rectifier) is responsible for charging the battery and maintaining full battery charge when AC is applied to the UPS.

6. Automatic Bypass (Static bypass): The UPS shall provide an alternate path to the commercial AC or generator source in case of an overload, load fault or internal UPS failure. This input must match the output in voltage, frequency, and grounding in order to properly utilize this feature.

7. User Interface Panel: The UPS shall provide a user-friendly interface panel, which allows the user to: change operating modes, set system parameters, check alarm logs, etc. This LCD display should have back light and languages consisting of English and the number of optional local languages.

8. Serial (RS-232) Communication Interface: A 9-pin sub-D connector shall provide capability for communicating with manufacture-supplied software package. The UPS shall also provide signals for indication of UPS general alarm.

9. Communication card: The UPS shall include Communication card for network communication via SNMP/Web, AS400 relays, and Modus/Jbus capabilities, etc.

10. Remote Emergency Power Off (EPO) connection: The UPS shall provide a built-in landing for field connection of a Remote Emergency Power Off circuit. Upon initiation of the REPO circuit, the output will be de-energized and battery will be disconnected, preventing power from being delivered to the attached loads.

11. Disable Bypass Operation connection: If active the automatic transfer to the static bypass is prevented. Synchronization to bypass is not carried out (default).

12. ABM resting connection: If active the batteries are disconnected from the UPS unit. The discharge of batteries is not prevented but charging will not start.

13. Remote ON/OFF connection: If active the UPS output turns off regardless of mode of operation. Auxiliary power, communications and rectifier/battery charger shall remain functional.

14. External Bypass connection: If active the UPS is forced to static bypass operation regardless of the bypass status.

15. External Battery Breaker Status: If active the UPS knows that the batteries are connected.

16. Remote Go To Bypass connection: If active the UPS transfers to bypass if bypass voltage, frequency and synchronization are ok.

17. Remote Go To Normal connection: If active the UPS transfer to inverter operation if not prohibited by EPO or alarm condition.

18. UPS shall be capable for external Matching Battery Cabinets: 64 and 96 block (7 Ah 12V) for extended runtime requirements.

19. SNMP/Web Adaptor: Internal communication card providing network communication via SNMP protocol.

20. (Option) ModBus/Jbus Adaptor: Internal communication card providing network communication via Modus protocol.

21. (Option) Relay Card: Internal card providing dry contacts for operation with AS400 systems, etc.

2.3 SYSTEM RATINGS AND OPERATING CHARACTERISTICS

A. System Input

1. Input Voltage Operation Range
   a.
   b. Nominal Input Voltage range is 220-240VAC or 3x380-400VAC
   c. Maximum Input Voltage range is 176-276VAC or 3x339-484VAC

2. Input Frequency
   a. 45 to 65Hz
   b. auto sensing

3. Input Power Factor is 0.99

4. Input Current Distortion: 5% THD maximum at full linear load.

5. Inrush Current: 100% of full load input current

6. Surge Protection: EN 500091-2

B. System Output, Normal Mode

1. Nominal Output Voltage
   a. 380/220, 400/230, and 415/240 VAC with three-phase input.

2. Voltage regulation: +/-3% of selected output voltage in steady state

3. Transient Voltage Response:
   a. Voltage Transient Response: +/- 3% maximum while in Double Conversion mode with resistive step loads from 0% to 50%, 50% to 100%, 100% to 50% and 50% to 0%. Or, +/-5% maximum while in Double Conversion mode with resistive step loads from 0% to 100% or 100% to 0%.

4. Transient Recovery Time: To within 1% of steady state output voltage within 50 milliseconds

5. Voltage THD:
   a. 3% Total Harmonic Distortion (THD) maximum into a 100 percent linear load
   b. 5% THD maximum into a 100% non-linear load

6. Nominal Frequency: 50 or 60 Hz selectable

7. Frequency Regulation:
   a. Sync with line within +/-3 Hz of nominal line frequency, or
   b. Transfer to battery power with frequency at +/-0.1 Hz of the selected nominal frequency if out of +/-3 Hz specification.

8. Output Current: Maximum output current (at nominal output voltage) for the UPS shall be:
   a. 20 kVA system: 29,0 A @ 230V
   1. Current Overload Capability without bypass:

b. 150% for 5 seconds
c. 220% for 300 ms

9. Bypass:
   a. Automatic bypass shall provide an alternate path to power in the case of overload, inverter failure or other UPS failure.
   b. Standard internal or External Maintenance Bypass can be utilized with the UPS to all servicing of the UPS.
   c. Transfer time to and from any internal bypass shall be no-break.

10. Efficiency:
    a. Typical of 98% while in bypass mode
    b. Nominal 93% in Normal Mode with full resistive load and fully charged batteries

11. Autonomy:
    a. The autonomy of the UPS shall be 30 minutes at full load.

C. System Output, Battery Mode:

1. Nominal Output Voltage: This shall be the user selected output voltage.

2. Voltage Regulation: +/-3% of selected nominal voltage

3. Transient Voltage Response
   a. Voltage Transient Response: +/- 3% maximum while in Battery mode with resistive step loads from 0% to 50%, 50% to 100%, 100% to 50% and 50% to 0%. Or, +/-5% maximum while in Battery mode with resistive step loads from 0% to 100% or 100% to 0%.

4. Transient Voltage Recovery: To within 1% of steady state output voltage within 50 milliseconds

5. Voltage THD:
   a. 3% Total Harmonic Distortion (THD) maximum into a 100 percent linear load
   b. 5% THD maximum into a 100% non-linear load

6. Frequency Regulation: +/-0.005 Hz of selected nominal frequency

7. Overload Capacity:
   a. 150% for 5 seconds
   b. 220% for 300 ms

D. Mechanical Construction:

1. All materials and components making up the UPS shall be new, of current manufacture, and shall not have been in prior service except as required during factory testing. The UPS shall be constructed of replaceable subassemblies. All active electronic devices shall be solid-state.

2. The UPS unit comprised of: input rectifier/battery charger, inverter, bypass, and battery consisting of the appropriate number of sealed battery modules, shall be housed in a single freestanding enclosure. The UPS cabinet shall be cleaned, primed, and painted with the manufacturer's standard color. Casters and leveling feet shall be provided as standard.

3. Matching External Battery cabinets shall be available in different sizes.

2.4 BATTERY

A. Battery Type: Valve Regulated Lead Acid (VRLA), minimum 3 year float service life at 25 degrees C.

B. UPS Holdover Time (Runtime): Each UPS system, consisting of a minimum of one battery string (consisting of 36 battery blocks) for each power modules shall have a minimum holdover time of 5 minutes.

C. Extended Holdover Time (Runtime): Each UPS system shall have capability for addition of extra matching battery cabinets (in two cabinet sizes) to increase the total holdover time. Please refer to datasheet for a list of runtimes. The battery times listed are approximate and may vary depending on load configuration and battery charge.

D. Battery Recharge Time:

1. Base UPS System consisting of one or more battery will have a recharge time of max. 10 hours to 90% usable capacity @ nominal line after a full load discharge.

E. Bus Voltage: Nominal bus voltage is 432 VDC. This consists of 36 battery blocks with 7 Ah or 9 Ah capacity.

F. Battery Protection:

1. Short Circuit Protection: Over-current protection shall protect the batteries from all short circuit and reverse polarity fault conditions.

2. Battery Module Fusing: Internal Battery string fusing shall be provided.

3. Under-voltage Protection:
   a. Inverter cutoff voltage: Battery operation shall be terminated when the battery voltage drops to the 1.75 VPC set point.
   b. Protective shutdown voltage: Inverter shall shutdown after 1 min when the battery voltage drops below 1.75 VPC volts-per-cell typical.

4. Over-voltage Protection: If the UPS systems battery bus voltage exceeds the preset setpoint then the UPS will disable charger and alarm a high battery condition.

G. Advanced Battery Management:

1. Battery recharge: After recharging batteries to full capacity, the charger will entre the rest mode to increase the battery lifetime according the ABM cycle. Hence, continuous float charging of the battery shall not be allowed.

2. The active battery charger states are constant-current (charge mode), constant-voltage (float mode) and no-charge (rest mode).

3. Battery Runtime Monitoring: UPS shall monitor batteries and provide status to end user of battery runtime via front panel, serial communications, or both. Runtime calculations to be based on load demand and analysis of battery health.

4. Battery Health Monitoring: UPS shall periodically test&monitor battery health and provide warnings visually, audibly and/or serially when battery capacity falls below 80% of original capacity. Battery testing may also be user initiated via front panel or serial communications.

2.5 SYSTEM INPUT & OUTPUT CONNECTIONS

A. AC Input:
   1. UPS unit shall be capable of utilizing Hardwired Input.

B. AC Output:
   1. UPS unit shall be capable of utilizing Hardwired Output.

C. Extended Battery Connector: Ext. battery cabinets include cable kit to connect each battery cabinet to the UPS.

D. Remote Emergency Power Off (EPO) connection: The UPS shall provide a built-in landing for field connection of a Remote Emergency Power Off circuit. Upon initiation of the REPO circuit, the UPS shall open its input relays, and disengage the battery converter, preventing power from being delivered to the attached loads.

E. Serial (RS-232) Communication Interface: A 9-pin sub-D connector shall provide capability for communicating with manufacture-supplied software package. The UPS shall also provide signals for indication of UPS alarm status.

F. (2) Communication card slots: The UPS shall provide (2) Communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus / Jbus capabilities, etc.

G. (2) programmable Input connections: The UPS shall provide a built-in inputs for field connection (environmental input). The inputs shall be parameter programmable to suit the needs of the application. to a generator.

2.6 USER INTERFACE

A. Front Panel Display: The UPS shall include a front panel display consisting of a graphical LCD display with back light, four status LED's, and a four-key keypad.

   1. Graphical LCD display: Basic Language (English and local selectable language), display of unit function and operating parameters. It shall be used to signify the operating state of the UPS, for indicating alarms, for changing operations control parameters and set points.

   2. Four status LED's, which indicate:
      a. Alarms, with a Red LED
      b. On Battery, with a Yellow LED
      c. On Bypass, with a Yellow LED
      d. UPS ok, with a Green LED

   3. Four-Key Multifunction Keypad: UPS shall have keypad to allow user to adjust UPS parameters, view alarm and inverter logs, change UPS operational modes, turn UPS on and off.

B. Power Management Software Package: The UPS shall include serial communications interface that provides the following communication capabilities:

   1. Monitor and graphically display input and output voltage and other operating characteristics.

   2. Notify end users in the event of a power anomaly via network, E-mail or page

C. Communication Ports:

1. (2) Communication card slots: The UPS shall provide (2) Communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus/Jbus capabilities, etc.

2. Serial communications (via RS-232) with manufacturer-supplied Power Management Software package.

2.7 ENVIRONMENTAL CONDITIONS

A. The UPS shall be certified to the following safety standards:

1. EN 62040-1, IEC 62040-1, EN 60950

B. The UPS shall meet Category 2, IEC62040-2 for Emissions and IEC62040-2

C. Audible Noise: Less than 50 dBA (A weighted) at 1 meter from all sides in all system modes.

D. Ambient Temperature

1. Operating: UPS 0 deg C to +40 deg C; battery 20 deg C to 30 deg C for optimum performance.

2. Storage: UPS -40 deg C to +60 deg C; battery 0 deg C to 32 deg C

E. Relative Humidity

1. Operating: 5 to 95% non-condensing.

2. Storage: 5 to 95% non-condensing.

F. Altitude

1. Operating: To 1000 meters. Derating or reduced operating temperature range may be required for higher altitudes.

2. Storage: To 3000 meters.

G. Electrostatic Discharge: The UPS shall be able to withstand a minimum 8 kV without damage and shall not affect the critical load.

2.8 UNINTERRUPTIBLE POWER SUPPLY 80KVA (3PH IN / 3PH OUT) SYSTEM DESCRIPTION

A. UPS System Components: The UPS system shall consist of the following main components:

1. UPS module containing a Rectifier, Inverter, Battery Charger, Static Bypass, Integrated maintenance bypass available up to 80kVA and external solution up to 160kVA and associated Control and Monitor Panel.

2. Battery string(s) in Line-and-Match Battery Cabinets or racks.

3. Optional Line-and-Match cabinet(s).

B. UPS Module Modes of Operation: The UPS Module shall operate as frequency independent (class VFI-SS-111), fully automatic online system in the following modes:

1. Normal: Utilizing commercial AC power, the critical load shall be continuously supplied by the Inverter. The Inverter shall power the load while regulating both voltage and frequency. The Rectifier shall derive power from the commercial AC source and shall supply DC power to the Inverter. Simultaneously, the Battery Charger shall charge the battery.

2. Battery: Upon failure of the commercial AC power, the critical load shall continue to be supplied by the Inverter, which shall obtain power from the batteries without any operator intervention. There shall be no interruption to the critical load upon failure or restoration of the commercial AC source.

3. Recharge: Upon restoration of the AC source, the Charger shall recharge the batteries and simultaneously the Rectifier shall provide power to the Inverter. This shall be an automatic function and shall cause no interruption to the critical load.

4. Bypass: If the UPS module must be taken out of the Normal mode for overload, load fault, or internal failures, the static bypass switch shall automatically transfer the critical load to the commercial AC power. Return from Bypass mode to Normal mode of operation shall be automatic. No-break transfer to and from Bypass mode shall be capable of being initiated manually from the front panel.

5. Energy Saver Feature: The UPS shall continuously monitor the voltage and frequency of the bypass source. When the source parameters are within acceptable limits, the UPS will utilize a minimal/optimal combination of its internal subsystems to ensure acceptable power is always delivered to the critical load, at a system efficiency of 99% or greater, over the range of 10% to 100% load. The Energy Saver System shall be enabled by the user, and shall be adjustable. It shall incorporate a “High Alert Mode” to automatically (without user intervention) provide maximum power conditioning any time bypass source variation levels exceed preset, adjustable limits. When Energy Saver System is utilized, the UPS must attenuate ANSI C62.41-type line transients to within IEC and ITIC limits. The Energy Saver System shall be able to distinguish between upstream (utility) faults and downstream (load) faults, and react appropriately to protect and support the critical load, without interruption.

C. Converter (rectifier): Incoming power shall be filtered and converted to DC by a sine-wave rectifier. The DC power is then processed by a high-frequency converter to supply power to the inverter. The Converter corrects the input power factor to 0.99 and draws sinusoidal current (with less than 5% THD) from the utility. In the event of utility failure, the converter shall be supplied power without interruption from the internal of external batteries. During normal operation, the batteries will be charged through the rectifier.

1. Overload Capacity: The converter shall be capable of supplying up to 150% of rated load for at least 5 seconds if no bypass is available.

D. Inverter: The inverter converts the DC Power to regulated AC Power for critical loads.

1. Output Voltage: The inverter output voltage is specified in section 2.03.

2. Voltage Regulation: The inverter steady state voltage regulation is +/- 2% in steady state and +/- 5% for a 0 to 100% load step.

3. Frequency Control: The inverter steady state frequency regulation is +/-0.005 Hz free running in steady state. UPS is synchronized to mains in normal operation.

E. Batteries: The batteries shall be sealed, lead acid, maintenance-free, high-rate discharge cells. They will be kept fully charged by the battery charger. They have an expected life of

200-300 complete full load discharge cycles when operated and maintained within specifications.

F. Battery Charger: The battery charger (or rectifier) is responsible for charging the battery and maintaining full battery charge when AC is applied to the UPS.

G. Automatic Bypass (Static bypass): The UPS shall provide an alternate path to the commercial AC or generator source in case of an overload, load fault or internal UPS failure. This input must match the output in voltage, frequency, and grounding in order to properly utilize this feature.

H. User Interface Panel: The UPS shall provide a user-friendly interface panel, which allows the user to: change operating modes, set system parameters, check alarm logs, etc. This LCD display should have back light and languages consisting of English and the number of optional local languages.

I. Serial (RS-232) Communication Interface: A 9-pin sub-D connector shall provide capability for communicating with manufacture-supplied software package. The UPS shall also provide signals for indication of UPS general alarm.

J. (2) Communication card slots: The UPS shall provide (2) Communication card slots in the front of the UPS allowing for additional connectivity options, including SNMP/Web, AS400 relays, and Modus/Jbus capabilities, etc.

K. Remote Emergency Power Off (EPO) connection: The UPS shall provide a built-in landing for field connection of a Remote Emergency Power Off circuit. Upon initiation of the REPO circuit, the output will be de-energized and battery will be disconnected, preventing power from being delivered to the attached loads.

L. Disable Bypass Operation connection: If active the automatic transfer to the static bypass is prevented. Synchronization to bypass is not carried out (default).

M. ABM resting connection: If active the batteries are disconnected from the UPS unit. The discharge of batteries is not prevented but charging will not start.

N. Remote ON/OFF connection: If active the UPS output turns off regardless of mode of operation. Auxiliary power, communications and rectifier/battery charger shall remain functional.

O. External Bypass connection: If active the UPS is forced to static bypass operation regardless of the bypass status.

P. External Battery Breaker Status: If active the UPS knows that the batteries are connected.

Q. Remote Go To Bypass connection: If active the UPS transfers to bypass if bypass voltage, frequency and synchronization are ok.

R. Remote Go To Normal connection: If active the UPS transfer to inverter operation if not prohibited by EPO or alarm condition.

S. (Option) Isolation: The UPS can be ordered specially with output Galvanic Isolation .

T. (Option) External Matching Battery Cabinets: 64 and 96 block (7 Ah 12V) matching battery cabinets can be ordered for extended runtime requirements.

U. (Option) Wall Mounted Maintenance Bypass Cabinets: Wall Mounted Make Before Break or Break Before Make Bypass Cabinets can be ordered as needed for use with the UPS.

V. (Option) SNMP/Web Adaptor: Internal communication card providing network communication via SNMP protocol.

W. (Option) ModBus/Jbus Adaptor: Internal communication card providing network communication via Modus protocol.

X. (Option) Relay Card: Internal card providing dry contacts for operation with AS400 systems, etc.

2.9 UPS MODULE STANDARD FEATURES

The UPS module shall consist of the following standard components:

A. Rectifier/Charger: The rectifier/charger shall convert incoming AC power to regulated DC output for supplying the inverter and for charging the battery. The rectifier/charger shall be a high-frequency PWM design, using Insulated Gate Bi-polar Transistors (IGBTs). The modular design of the UPS shall permit safe and fast removal and replacement of the rectifier/charger module. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode. The rectifier/charger module shall also provide the following:

1. The rectifier shall be capable of drawing power from the utility with a power factor of 0.99 under nominal conditions.

2. The rectifier shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

B. Inverter: The inverter shall feature an IGBT pulse-width-modulation (PWM) design with high speed switching. The inverter shall also have the following features:

1. The inverter shall be capable of providing the specified quality output power while operating from any DC source voltage (rectifier or battery) within the specified DC operating range.

2. The modular design of the UPS shall permit safe and fast removal and replacement of the inverter module. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode.

3. The inverter shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

C. Static Bypass: The bypass shall serve as an alternative source of power for the critical load when performing maintenance on the UPS, or when a failure prevents operation in normal mode. The bypass shall consist of a fully rated, naturally-commutated static switch for high-speed transfers. The bypass shall feature the following transfer and operational characteristics.

1. Transfers to bypass shall be automatically initiated for the following conditions:
   a. Output overload period expired.
   b. Critical bus voltage out of limits.
   c. Over temperature period expired.
   d. Total battery discharge.
   e. UPS failure.

2. Uninterrupted automatic re-transfer shall take place whenever the inverter is capable of assuming the critical load.

3. Uninterrupted automatic re-transfers shall be inhibited for the following conditions:
   a. When transfer to bypass is activated manually or remotely.

b. In the event of multiple transfers/re-transfer operations the control circuitry shall limit “cycling” to three (3) operations in any ten minute period. The fourth transfer shall lock the critical load on the bypass source.
c. UPS failure.

4. Uninterrupted manual transfers shall be initiated from the control panel. Uninterrupted manual transfers to bypass and from bypass shall be possible with the inverter logic. During manual transfers to bypass mode, the inverter must verify proper bypass operations before transferring the critical load to the bypass.

5. All transfers to bypass shall be inhibited for the following conditions:
   a. Bypass voltage out of limits (adjustable; factory set +/- 10% of nominal)
   b. Bypass frequency out of limits, (adjustable, factory set +/- 3 Hz)
   c. Bypass out of synchronization
   d. Bypass phase rotation / installation error

6. Static transfer time: No break, complete in less than 4ms.

7. The bypass shall be manually energized using the control panel or remotely through a building alarm input.

D. Monitoring and control components: The following components shall provide monitor and control capability:

1. Control panel with status indicators.

2. Alarm and metering display.

3. Building alarm monitoring.

4. Inverter and bypass contactor monitoring.

5. Communication ports.

E. Battery management system: The UPS shall contain a battery management system which has the following features:

1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.

2. The battery management system shall automatically test the battery string(s) to ensure that the battery is capable of providing greater that 80% of it’s rated capacity. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the battery needs attention/replacement. The battery test shall be able to detect the following:
   a. Open battery string/cells
   b. Shorted battery string/cells
   c. Battery capacity (runtime) less than 80% of “new” battery capacity

3. The battery management system shall be able to test the batteries. The test shall record data used for battery life, battery failure and battery capacity analysis. This test shall provide these load ratings from 0 to 100% load on the output of the UPS system. Testing the batteries shall not jeopardize the operation of the critical load. Failure of the batteries shall be annunciated through the front panel and other communication devices.

4. An optional temperature sensor shall be available to monitor the ambient temperature internal to the battery cabinet. If the ambient temperature increases, the UPS system

charger shall automatically reduce the charging voltage to a level recommended by the battery manufacturer. If the ambient temperature is decreased the UPS shall automatically increase the battery charge voltage to that recommended by the battery manufacturer.

5. Battery life, capacity, and failure information shall be part of the UPS remote monitoring information.

F. Wiring Terminals: The neutral output compression terminal shall be sized for 200% of UPS module rated current to accommodate higher neutral currents associated with non-linear loads. The UPS module shall contain mechanical compression terminals (adequately sized to accommodate 90°C wiring) for securing user wiring to the following locations:

1. Rectifier/charger input connections (3 wires plus ground).

2. Bypass input connections (3 or 4 wires plus ground).

3. DC link connections for battery cabinets (positive and negative).

4. AC output connections (3 or 4 wires plus ground).

2.10 UPS MODULE OPTIONS AND ACCESSORIES

The UPS module shall consist of the following options and accessories:

A. SNMP Network Adapter and UPS Power Monitoring Software: SNMP adapters shall provide a communications interface between the UPS module and SNMP-compatible network management systems. This capability shall allow the unit to be monitored remotely over an Ethernet network using a standard web browser.

1. UPS Power Monitoring Software: This system shall continuously monitor critical power elements associated with the UPS, using the communications port on each module and a customer furnished PC. The system shall automatically alarm if any problems arise and notify local or remote personnel of the alarm condition via email, page, or text message.

B. Battery Cabinet: The battery cabinet shall feature valve regulated, high-rate discharge, lead-acid batteries which provide energy to the support the critical load during a momentary loss of input power to the rectifier. The batteries shall be flame retardant in accordance with UL 94V2 requirements. The battery cabinet shall have the following features:

1. The battery cabinet shall be the same depth and height as the UPS module.

2. The battery cabinet shall feature a mechanical enclosure of like appearance to the UPS module and shall feature casters. Each battery cabinet shall require front access only for installation, service and maintenance. The battery cabinet shall provide top and bottom cable entry.

3. Power wiring internal to each battery cabinet shall be factory provided. Each battery cabinet shall feature 10 battery trays which can be individually disconnected from the battery cabinet power wiring with quick disconnect devices. Each battery tray shall be firmly secured to the battery cabinet frame with fasteners. Each battery tray shall be removable from the front of the battery cabinet.

4. Each battery cabinet shall feature a DC rated circuit breaker. The circuit breaker within the battery cabinet shall only provide protection to the battery string within that battery cabinet. For battery configurations involving multiple battery cabinets, a battery string in one battery cabinet may be isolated from the DC link via its circuit breaker without removing other battery strings from the DC link and the UPS module.

5. The circuit breaker in each battery cabinet shall feature an A/B auxiliary switch. The UPS module shall be capable of monitoring and alarming an open battery cabinet circuit breaker condition.

6. The circuit breaker in each battery cabinet shall feature an undervoltage release device. The UV device shall operate to trip the battery breaker(s) for an emergency power off command or battery disable command.

7. Power and Control wiring between the battery cabinet and the UPS shall be factory provided with compression type connectors between cabinets.

8. Battery Voltage Characteristics. The UPS battery system shall have the following characteristics:
   a. UPS module will automatically adjust battery shutdown based upon loading and battery capacity.
      (1) At full load, the absolute minimum operational voltage is 1.56 V per cell (adjustable).
      (2) At all other loads, the UPS module shall automatically adjust the final discharge voltage between 1.56 and 1.75 Volts per cell based on the existing load and the rate and length of discharge.
   b. Nominal Float Voltage: 2.25 V per cell.
   c. Maximum Equalizing Voltage: 2.38 V per cell.

2.11 UNINTERRUPTIBLE POWER SUPPLY RATINGS AND OPERATING CHARACTERISTICS

A. UPS Continuous Ratings. The UPS shall be rated at:
80kVA/72kW

B. UPS Autonomy: The autonomy of the UPS shall be:
10 minutes at full load.

C. Rectifier/charger input:

1. Nominal three phase input voltage: 400 VAC:
   a. 4-wire plus ground for 4-wire plus ground output configuration

2. Operating input voltage range: + 10%, - 15% of average nominal input voltage without battery discharge. -30% of nominal voltage operated with possible battery discharge.

3. For 50Hz systems, operating input frequency range shall be 45 to 55Hz.

4. Input power factor 0.99 lagging.

5. Normal input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode:
   a. Rectifier/charger input current limit shall be adjustable from 100 to 125% of full-load input current.
   b. Battery input current limit (re-charge current) shall be adjustable.

6. On generator input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode on generator:
   a. Rectifier/charger input current limit shall be adjustable from 50% to 125%of full-load input current.

b. Battery recharge input current limit shall be adjustable from 10% to 25% of the UPS full load input current regardless of the actual load on the UPS.

7. Input current total harmonic distortion (THD) shall be less than 4.5% under linear load conditions.

8. Power walk-in: Ramp-up to full utility load adjustable from 3 seconds to 10 seconds.

D. Bypass input:

1. Synchronizing bypass voltage range shall be +/- 10% of average nominal input voltage and is adjustable.

2. Synchronizing bypass frequency range is centered on the nominal frequency.

3. Inrush current: For units with isolation or step-down transformers, typically 800% of the largest model in the series full load bypass input current.

4. Input surge withstand capability: The UPS shall be in compliance with IEEE 587 (ANSI C62.41), category A & B (6kV).

E. Rectifier/charger output:

1. Nominal DC voltage shall 480VDC for 400V input.

2. Steady state voltage regulation shall be +/- 0.5%.

3. Voltage ripple shall be less that 0.5% (peak-to-peak).

4. Capacity: The rectifier/charger shall support a fully loaded inverter and recharge the battery to 95% of its full capacity within 10 times the discharge when input current limit is set at maximum.

5. Low line operation: The rectifier/charger shall be capable of sharing the DC load with the battery when the input voltage falls below the specified operation input voltage range, the on battery indicator shall enunciate operation in this mode.

6. Battery equalize: Automatic and manual means must be provided for battery equalization.

7. DC sensing: Redundant DC voltage sensing methods shall be incorporated for providing battery over-voltage protection.

F. UPS output in normal mode

1. Nominal output voltage 400V, 3-phase, 4 wire plus ground.

2. Steady-state voltage regulation (in inverter) shall be within +/- 1% average from nominal output voltage.

3. Transient voltage response shall be < +/- 5% from nominal voltage for 100% load step, full load re-transfers and full load drop on battery.

4. Transient voltage recovery shall be 25ms to within +/- 1% of steady state.

5. Linear load harmonic distortion capability: Output voltage THD of less than 3% for 100% linear load.

6. Non-linear load harmonic distortion capability: Output voltage THD of less than 8% for 100% non-linear load when tested using the non-linear load described in IEC 62040-3 connected line to neutral.

7. Manual output voltage adjustment shall be +/- 3% from nominal.

8. Line synchronization range shall be +/- 3Hz, adjustable to +/- 5Hz.

9. Frequency regulation shall be +/- 0.01Hz free running.

10. Frequency slew rate shall be 1 Hz/second (default) and adjustable to, 7 Hz/s, 3 Hz/s, 2 Hz/s, or ±0.5 Hz/s

11. Phase angle control:
    a. Balanced linear load shall be +/- 1 degree from nominal 120 degrees
    b. Unbalanced linear loads shall be better then +/- 5degrees from average phase voltage for 100% load unbalance.

12. Phase voltage control:
    a. Balanced linear loads shall be +/- 1% from average phase voltage
    b. Unbalanced linear loads shall be better then +/- 5% for 100% load unbalanced

13. Overload current capability (with nominal line and fully charged battery): The unit shall maintain voltage regulation for up to 110% of resistive/inductive load for 10 minutes, up to 125% for 30 seconds, and up to 150% for 10 seconds.

14. Fault clearing current capability: 150% phase-to-phase for 10 cycles; 300% phase-to-neutral for up to 10 cycles

15. Static transfer time: No break, completed in less than 4ms.

G. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 65dBA at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load.

H. Electrostatic discharge (ESD): The UPS shall meet IEC 801-2 specifications. The UPS shall withstand a 2.5 kV pulse without damage and with no disturbance or adverse effect to the critical load.

I. Efficiency: The typical UPS input to output efficiency shall be 93-94,5% at full load, unity power factor (1.0) and nominal input voltage excluding any distribution or bypass voltage matching or isolation transformers.

2.12 MECHANICAL DESIGN

A. Enclosures: The UPS shall be housed in free-standing double front enclosures (safety shields behind doors) equipped with leveling feet. The enclosures shall be designed for computer room applications

B. Ventilation: The UPS shall be designed for forced-air cooling. Air inlets shall be on the front of the unit. Air outlets shall be on the top. 460 mm of clearance over the UPS outlets shall be required for proper air circulation. Air filters shall be commonly available sizes.

C. No back or side clearance or access shall be required for the system. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.

D. Cable entry: Standard cable entry for the UPS cabinet shall be through either the enclosure bottom or top. A dedicated wireway shall be provided within the UPS cabinet for routing user input and output wiring.

E. Front access: All serviceable subassemblies shall be modular and capable of being replaced from the front of the UPS (front access only required). Side or rear access for installation, service, repair or maintenance of the UPS system shall not be required.

F. Service area requirements: The system shall require no more than thirty-six inches of front service access room and shall not require side or rear access for service or installation.

2.13 CONTROLS AND INDICATORS

A. Microprocessor controlled circuitry: The UPS controls shall have the following design and operating characteristics:

1. Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled Digital Signal Processing. DSP shall eliminate variances from component tolerance or drift, and provide consistent operational responses.

2. All operating and protection parameters shall be firmware controlled, thus eliminating a need for manual adjustments. The logic shall include system test capability to facilitate maintenance and troubleshooting. Printed circuit board replacement shall be possible without requiring calibration.

3. Start-up and transfers shall be automatic functions.

B. Digital Front Panel Display: The UPS control panel shall be a digital front panel display that features a 4x80 (4 lines, 80 characters) backlit LCD display. The LCD shall display UPS status, metering, battery status, alarm/event queue, active alarms and UPS configurations. The front panel display shall show a system mimic diagram with an outlined power path, current operating mode and event logs.

C. Control Panel Indicators: The UPS control panel shall provide the following monitoring functions with indicator LED's:

1. NORMAL: This shall indicate that the commercial AC utility or generator source is supplying power to the rectifier and the inverter is supporting the critical load. A text message shall indicate if the bypass line is not within tolerance.

2. BYPASS: This shall indicate that the UPS has transferred the load to the bypass circuit.

3. BATTERY: This shall indicate that the commercial AC utility or generator source has failed and the battery is supplying power to the inverter, which is supporting the load. A text message shall indicate if the battery charge is low or if the battery is installed but disconnected.

4. ALARM: This shall indicate that the UPS detects an alarm condition, outlined in detail in the operator's manual.

D. Control Panel Controls: The UPS control panel shall provide the following functions from front panel push buttons:

1. EVENTS: Displays the list of Active System Events and a historical log of system events. Historical logs shall include a detailed time stamped list of the latest 500 events.

2. METERS: Displays performance meters for the system or critical load. When selected, the front display shall show individual screens of input parameters, output parameters or bypass parameters including; voltage, current and frequency. In addition, the battery display shall show runtime remaining.

3. CONTROLS: Displays a System Controls screen. Allows selection of operating mode, normal, bypass, charger on/off and Power Module on/off.

4. SETUP: Allows display contrast, date and time information serial communication port configuration and display of firmware revision numbers.

5. RETURN: Confirms selection or returns to previous screen.

E. Interface panel: The UPS shall be equipped with an interface panel, located behind a protective cover, which provides the following signals and communication features in a Class 2 environment:

1. Alarm contact: A dry contact for annunciating a summary alarm shall be provided for customer use. This contact shall be capable of supplying N/O or N/C states and shall be rated for operation at a minimum of 10 Amps at 240VAC or 14VDC.

2. RS232 (EIA / TIA-232) communications interface: Circuitry shall be provided for one RS232 (EIA / TIA-232) communication port for connection to automated service department diagnostic tools. This port may be used with simple (“dumb”) terminals to gain remote access to all unit operation information.

3. Building alarms: Two inputs shall be provided for monitoring the status of external dry contacts. Building alarms shall be set up through the UPS configuration mode function on the RS232 (EIA / TIA-232) port.

4. External EPO contacts: Shall be provided to connect an external remote emergency power off switch to shutdown the UPS and de-energize the critical load.

5. Battery control contacts: Contacts shall be provided to connect the battery UVR and auxiliary signals from a battery breaker or battery disconnect switch.

6. External bypass indicator connection: A connection point shall be provided to acknowledge that an external maintenance bypass has been closed around the UPS, placing the critical load on utility power.

2.14 COMMUNICATIONS

A. Communications Bay: The UPS shall be equipped with field configurable communications bays that will accommodate four (4) communication devices.

B. Monitoring:

1. The UPS shall have standard or optional communication feature to provide basic or advance UPS monitoring, notification, management, and emergency computer shutdown capabilities.

2. The UPS shall be able to be monitored locally or across a network. Monitoring of UPS status may also be performed through isolated dry contact Form C relays. Simultaneous monitoring of multiple UPSs shall be possible from one central location. Communication via modem for monitoring shall also be possible.

3. Monitoring of the UPS shall also be possible through status indicators on the UPS or elsewhere in the same facility through a device that replicates these indicators.

The UPS should be able to integrate into any industry standard Building Management System (BMS) and/or Network Management System (NMS). The UPS must also be able to be monitored and managed via any standard internet browser (i.e. Internet Explorer and Netscape), PDA or cell phone.

C. Shutdown:

1. There shall be a mechanism that provides graceful, orderly, unattended, sequential shutdown of one or multiple computers powered by one UPS. This shutdown shall be performed via in-network or out-of-network means. The order of shutdown shall be user-defined, allowing the maximization of runtime on battery for more critical systems.

2. Shutdown of AS/400 computers shall be possible through open-collector relay contacts or isolated, dry contact, Form-C relays.

3. The UPS shall also be capable of interfacing with an operating system's built-in shutdown routine, e.g. Windows NT. This shall be done through a cable connection to the optional serial port on the UPS.

D. Notification:

1. There shall be a mechanism to send alerts to key personnel via email or SNMP traps. An alarm notification may also be sent by a network message.

2. Dial-out to a computer for alarm notification may be performed. The user may respond by dialing-in to retrieve alarm history and a summary of current meter status.

3. Management: A remote battery test may be performed via an Ethernet network. The UPS shall be tested through invoking a single command.

2.15 UPS MODULE PROTECTION

A. Rectifier/Charger and Bypass protection shall be provided through individual fusing of each phase.

B. Battery protection shall be provided by thermal-magnetic molded-case circuit breakers in each battery cabinet (if standard battery pack is provided) or external protective device for an external battery.

C. Output protection shall be provided by electronic current limiting circuitry and fuses in the Inverter circuit.

D. To comply with agency safety requirements, the UPS module shall not rely upon any disconnect devices outside of the UPS module to isolate the battery cabinet from the UPS module.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

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

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

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

3.3 DEMONSTRATION

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

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

SECTION 16715 — STRUCTURAL CABLING FOR DATA AND TELECOMMUNICATION SYSTEM & MAIN TELECOM ROOM

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Supply and install a complete telecommunications cabling system based on a physical star wiring topology that is designed in accordance with and supported by a manufacturer backed certification as specified herein.

B. The cabling system shall be standards compliant and composed of the following interdependent sub-systems:

1.	(WA)	Telecommunication Outlet/Connector, associated cords and adapters.
2.	(D)	Horizontal Cabling System
	(TC, PP, VPP or DPP)	Floor/Area cross-connect system
3.	(MC/MDC)	Main/Intermediate Cross-connect System (Located in Main Cross-connect of Intermediate cross-connect Closets respectively)

1.2 QUALITY ASSURANCE

A. Qualification of Vendor:

1. The Customer shall be referred to as the Purchaser.

2. The successful bidder shall be referred to as the Vendor. The Installer shall be either employers of the Vendor or subcontractors.

3. Manufacturer refers to the company that manufacturers the components and is responsible for the design and installation guidelines used by the vendor to complete this cabling system installation. The manufacturer along with the vendor is responsible for the final warranty and certification of the application assurance.

4. The Vendor shall show proof of a contractual relationship with the manufacturer, and shall pass through the manufacturer certification to purchaser.

5. All cabling, termination hardware, and connecting cords shall be soured from the certifying manufacturer to assure quality control and validity of the manufacturer's warranty.

6. The Vendor, will accept complete responsibility for the design, installation, certification, and support of the cabling system. Vendor must show proof that vendor has the certifying manufacturer's support on all of these issues.

7. In the event that subcontractors are used for any portion of the work or technical support, the Customer will look to the Vendor for all corrective action.

8. All work shall be performed and supervised by Telecommunications technicians and Project Managers who are qualified to install voice, data, and image cabling systems and to perform related tests as required by the manufacturer in accordance with the manufacturer's methods.

9. The Telecommunications Technicians employed shall be fully trained and qualified by the manufacturer on the installation and testing of the equipment to be installed. Evidence that the vendor is a current certified installer of the manufacturer must be provided in writing prior to work commencing on the structured cabling for the building.

10. The vendor (including subcontractor(s) if any) shall have a proven track record in cabling projects. This must be shown by the inclusion of details of at least three projects involving Category 6A cabling and optical fiber, which have been completed by the vendor in the last two years. Names, addresses, and phone numbers of references for the three projects shall be included.

B. Qualification of System:

1. Acceptable proposed Systems will be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified vendor. Manufacturer shall administer a follow up program through the vendor to provide support and service to the purchaser. The first part is an assurance program which provides that the certified system will support the applications for which it is designed (including Gigabit Ethernet & 10 Gigabit Ethernet as per IEEE 802.3an for Certified Category 6 & Category 6 augmented), during the **Lifetime** of the certified system.

2. The second portion of the certification is a fifteen-year warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, and baluns).

3. In the event that the certified system ceases to support the application (So designed to run on the category of cabling installed, whether at the time of cut over, during normal use or when upgrading, the manufacturer and vendor shall commit to promptly corrective action.

4. The cabling system must conform to the current issue of industry standard ANSI/TIA/EIA 568 A & B &C. All performance requirements off this document must be followed. As well, workmanship and installation methods used shall be equal to or better than found in the BICSI (Building Industry Consulting Service International) TDM manual.

5. The cabling system shall support Power over Ethernet standard PoE 802.3af as per IEEE allowing data and power connection for PoE equipment.

6. Purchaser demands strict adherence to the performance specifications listed in ANSI/TIA/EIA 568 A & B &C.

7. Manufacturer shall maintain 9001 Quality Control certification for the facilities that manufacturer the product used in this cabling system.

8. The selected cabling system shall be able to support video over Category 6A F/UTP cabling by means of video baluns or packetized video and audio over IP.

9. New building and major renovations of telecommunications spaces and pathways should conform to EIA/TIA 569. In cases of renovations in historic or otherwise restrictive buildings, where it is impossible to follow the above stated guidelines, the exceptions must not modify the maximum distances set forth in ANSI/TIA/EIA 568 A & B & C and must not in any way affect the performance of the cabling system. Modifications to administrative issues require written approval from purchaser and certifying manufacturer.

10. The cabling system must conform to applicable Building and Electrical Safety Codes.

C. End User Responsibility

1. The vendor shall provide an End User's Manual describing the essential system elements as well as the no user's responsibility for maintaining the integrity of the cabling system over time. This Manual shall include, as a minimum, guidelines for system expansion and modification (moves, additions, changes of service) as well as labelling and record keeping.

1.3 SUBMITTALS

A. Vendor shall submit:

1. A complete telecommunications cabling system layout, including cable routing, telecommunications closet(s) and telecommunications outlet/connector designations. The layout shall detail locations of all equipment and indicate all wiring pathways.

2. Manufacturer's technical documentation on all devices used in cabling system.

3. Manufacturer supplied End User's Manual (at completion of project)

4. It is recommended that the design and engineering performed for the cabling system be approved by an accredited RCCD (Registered Communications Distribution Designer) as defined by BICSI (Building Industry Consulting Service International). As Built drawings shall be provided.

PART 2 - REQUIREMENTS BY SUB - SYSTEM

2.1 CABLE

A. Modular Line/Patch Cords: Shall consist of # 23 AWG insulated, solid conductors formed into four individually twisted pair, color-coded, enclosed in a jacket. Cords shall terminate at both ends by RJ45 connectors. Cords and connectors shall be Category 6A 10GIGA as indicated in B.O.Q and drawings. All cords must not degrade the required channel performance characteristics as per ANS/TIA/EIA 568 A & B & C. All cords shall be covered by the manufacturer's warranty and certification. All cords shall maintain the appropriate polarity. All cords shall be transferable to any channel (see diagram of channel below) without degrading channel of system performance and not be required to remain on the channel where tests were performed in order to maintain certification. Total line and patch cord lengths per channel shall not exceed 10 meters.

1. Work Area (Data outlets).
   a. Modular line cords shall be used to attach each media converter (balun) or workstation Network Interface Card (NIC) to a telecommunications outlet/connector. They shall not exceed three (3) meters in meters in length as per ANSI/TIA/EIA 568. Line cords shall be terminated with eight position modular plugs plus shield at both ends. The modular plugs shall comply with ANSI/TIA/EIA 568 A&B&C. Pin configuration shall be T568A or B (refer to property management requirements for pin assignment).
   b. NB: The Manufacturer's certification shall be Purchaser's assurance that the resultant system performance shall be true Category 6A (as required in B.O.Q and drawings) from end to end and be supported by the manufacturer's certification. Therefore, Manufacturer factory Built and tested connector zed cords shall be used.

2. Telecommunications Closets
   a. Selecting the location of a Telecom Closet in many commercial sites is a simple process. A centralised location in or near the core of the building in many cases will provide access to all of the work areas on the Floor and still meet the 90 meters instance limitation for horizontal cabling. However, the distance to all of the work areas should be calculated carefully, using the actual cable path planned or the distances may exceed the 90 meter maximum when the cable is actually run.
   b. Standards recommend that the telecom closets serve up to a maximum of 10.000 square feet. One of the reasons is that in planning a closet can reach a distance with no obstacles in the way. Once of the reason, is that in planning a closet can reach a distance with no obstacles in the way. Once HVAC or other bulky utilities are installed, the cable paths may have to change to respect the 90 meter distance. At that time, it is near impossible to rearrange or add closets. With the 900 square meters guideline used in the design stages, the possibility of this level problem is almost eliminated.
   c. Modular patch cords shall be used to patch within each cross-connect. They shall not exceed seven (7) meters in length as per ANSI/TIA/EIA 568 A&B&C (the combined length or patch cords in the cross connect and from the outlet in the work area to the equipment shall not exceed 10 meters).
   d. Patch cords shall be terminated with eight positions modular plugs plus shield.

B. Horizontal Cabling

1. The horizontal distribution system links the distribution field of the cross-connect system to the telecommunications outlet/connectors in the work areas.

2. Horizontal cables shall each consist of - # 23 AWG insulated, solid conductors, formed into four individually twisted pairs with overall Polyester shield. See Floor plans and riser diagrams provided for actual number of cable runs to each work area.

3. The horizontal cable length to the farthest workstation shall be limited to 90 m (295 ft), as specified in the ANSI/EIA/TIA 568 A & B & C standard documents. Additional telecommunications closets shall be provided on large Floor areas of a building to limit the horizontal distribution to 90 meters.

4. Dedicated four-pair 23 AWG F/UTP horizontal distribution cable shall be provided for each application or service planned, present and future. Each of the four cable pairs of each horizontal cable must be terminated on an individual eight positions modular connector with ground terminal at the telecommunications outlet/connector. Pairs within a cable shall not be split and all pairs must be terminated.

5. The splitting of pairs within a cable between different jacks is not permitted. Terminating resistors in the case of ISDN applications shall be placed external to the telecommunications outlet/connector.

6. Cable shall be provided on reels or in boxes that reel out cable properly to prevent cable chinking. Cable shall be marked decrementaly from 1000 ft to indicate both the length of a run as well as the amount of cable remaining on the reel or within the carton.

7. The installation of the horizontal cable shall follow the appropriate recommendations covered in the Manufacturer's Design Guide and the appropriate standards documents. This is done in order to ensure adequate protection from Electro - Magnetic Interference (EMI) sources and to ensure that all components and cables are in good condition after installation.

C. Intra - Building Cabling

1. The Intra - Building backbone provides for the connection between the MC (or MDC on a campus) within the building and the Telecommunications closets it serves.

2. Single mode optical fiber shall be used in the backbone. The total loss of the fiber backbone link shall not exceed 12 dB at 850 nm 11 dB at 1300 nm.

3. Outdoor Fiber optic cable shall be outdoor rated compliant to ITU-T (G.652D)

4. Indoor Fiber optic cable shall be indoor rated compliant with ITU-T (G.652A1 and G.652D)

5. A minimum of 24 fibers per TC, DPP or PP shall be installed to ensure support of new services and redundancy.

6. Backbone cabling shall be placed through shafts (other than circular holes are difficult and expensive to fire stop), conduit, raceways or Floor penetrations and supported according to the manufacturer's recommendations. The TCs, VPP, DPP or PP shall be vertically aligned where possible if not possible; the provision to house non-plenum backbone cable may be required.

7. The mechanical and environmental specifications for optical fiber cable shall be in accordance with ANSI/EIA/TIA 568 A&B (section 12.3)

8. Single mode optical fibres cables shall be OS2, non-armoured, tight buffered, suitable for use in ducts, buried, or fastened to trays or ladders, compatible with standard MCT's, and designed for direct connector termination. They shall be compliant with ITU-T G.652, and shall be supplied according to the following minimal specifications:
   a. Number of fibres: 12, 24 or 48 cores as specified,

b. Operating wavelengths: 1310nm and 1550nm,
c. Core diameter: 9.1µm ± 0.5µm,
d. Cladding diameter: 125µm ± 1.0µm,
e. Attenuation: Less than 0.38dB/km at 1310nm and 0.25dB/km at 1550nm,
f. Dispersion: Less than 3.5ps/nm.km at 1310nm and 18ps/nm.km at 1550nm,
g. Fibre identification: As per TIA/EIA-598-A colour code,
h. Fibre protection : Modules of 6 fibers, filled with water blocking compound,
i. Water protection: Water blocking tape,
j. Flame retardant: In compliance with IEC 60332-1 or IEC 60332-3C,
k. Flame resistance: In compliance with IEC 60332 CR1, as necessary,
l. Inner sheath: Halogen-free thermoplastic (LSZH),
m. Overall outer sheath: UV-stabilized halogen-free thermoplastic (LSZH),
n. Overall cable diameter: More than 4mm,
o. Tensile strength: More than 1000N during installation and 300N during operation,
p. Compression strength: More than 150N/cm.
q. Typical minimum bending radius: 150mm (permanent).

9. Manufacturer: NEXANS

10. Designation: LANmark-OF Tight Buffer Universal 12

11. Part Number:N164.TBUN12

Fiber type	Attenuation at 1310nm in dB/km	Attenuation at 1550nm in dB/km
OS2 9/125	<0.4	<0.4

Maximum channel length	Optical fiber Category	Maximum channel attenuation in dB			
		Multimode		Single mode	
		850nm	1300nm	1310nm	1550nm
300m	OM3/OS2	2.55	1.95	1.8	1.8
2000m	OS2	-	-	3.5	3.5
5000m	OS2	-	-	4	4
10000m	OS2	-	-	6	6

2.2 TERMINATION SUB - SYSTEMS

1. The termination Sub - System, located within the telecommunications closet(s) or Work Areas (MC, MDC, TC (PP, DPP or VPP), or WA) is the connection point between:

Connection	Location
Backbone cables from the main Cross – connect and the Horizontal distribution cables serving the work areas.	(MDC or TC)
Horizontal distribution cables & work Area Telecommunications Outlet/Connector	(TC)
Horizontal cable & Work Area Telecommunications Outlet/Connector	(WA)

2. The size and number of closets required should be as defined in EIA/TIA 569. If these requirements cannot be met, it is mandatory that no modifications affect the cabling system performance or limit or 5 void the manufacturer certification. Any modifications to ANSI/TIA/EIA 568 A & B, EIA/TIA 569 or IEC 11801 guidelines must be pre-approved in writing by both customer and manufacturer.

B. Work Area Telecommunications Outlet/Connector

1. The Work Area telecommunications outlet/connector is the interface between the horizontal wiring and the work area telecommunications outlet/connectors.

2. Each work area shall be supplied with a telecommunications outlet/connector (previously called a modular jack) for connection to the horizontal media. All telecommunications outlet/connectors shall be installed in an appropriate faceplate. All telecommunications outlet/connectors shall be complete with faceplate and attached permanently to a fixed structure, such as building walls, utility poles or modular furniture partitions.

3. The work area telecommunications outlet/connector should provide maximum flexibility in supporting F/UTP, fiber, and coax while maintaining performance in order to meet the changing requirements that are likely to occur throughout the life of the system.

4. Nine (9) contacts F/UTP shielded folded RJ45 10GIGA modular telecommunication outlet/connectors as per IEEE 802.3an CAT6A shall accept 8 positions modular plugs plus ground terminal while providing proper electrical connection and not damaging telecommunications outlet/connector (jack). Manufacturer shall warrant all 9 positions modular outlets used in such a manner to be usable for 4 positions modular plugs in the future.

5. In order to allow normal expansion of service during the life of the cabling system, flush work area telecommunications outlets shall provide sufficient density to support up to a maximum of eight connectors per single gang telecommunications outlet and twelve connectors per double gang telecommunications outlet. Surface mount telecommunications outlets shall provide up to six telecommunications outlet/connectors.

6. Terminated conductor ends shall be properly trimmed to assure a minimum clearance of 0.250 in. between the conductors of adjacent modules.

7. Faceplates shall be clean in appearance. Mounting hardware shall not be visible on the faceplate if at all possible.

8. The work area telecommunications outlet/connectors shall not be responsible for creating “resonance” on short cable runs as described in the Field Testing TSB 67 (Draft 13 section 7.8 Short Links/Channels). This problem is related to return loss and/or the balance of the link and can cause transmission errors.

9. Telecommunications outlet/connector shall require (or specifically not allow more than) only one single connection to horizontal cable as per ANSI/TIA/EIA 568 A&B&C standard.

10. Telecommunications outlet/connectors shall be available in several colors.

11. Flush mounted faceplates shall accommodate modular telecommunications outlet/connectors and be available in one, two, four, six and eight connectors per single gang telecommunications outlet. The modular telecommunications outlet/connectors available shall include F/UTP 8 contacts and ground terminal, optical fiber in LC or SC terminations, BNC and F connector for coax and video

respectively. No additional mounting hardware shall be required to mount outlet/connectors into faceplate.

12. All telecommunications outlets shall be made of high impact plastic.

13. The same modular telecommunications outlet/connectors as found in the flush and surface mount telecommunications outlets shall be installable in utility poles and modular furniture using manufacturer faceplates or adapters for this purpose. Each telecommunications outlet/connectors.

14. The same modular telecommunications outlet/connectors as found in the flush and surface telecommunications outlets shall be installable in readily available single gang and double gang stainless steel faceplate using manufacturer faceplates or adapters for this purpose.

15. The nine positions modular F/UTP telecommunications outlet/connector and its pin assignments shall meet the requirements described in the standard ANSI/TIA/EIA 568 A or B (refer to property management requirements for pin assignment).

16. Each telecommunications outlet shall be uniquely labelled. The label shall form an integral part of the faceplate.

C. Telecommunications Closet & Horizontal Cross Connect

1. There shall be a one Telecommunications Closet in the building (TC, PP or VPP, VIPP, DIPP, MDPP, IPP & DPP) connected to Main Cross Connect of Campus.

2. The telecommunications closets may house, in cabinets or on racks, various data telecommunications equipment, controllers, multiplexes, bridges, routers, LAN switches, etc., in addition to the cross-connecting hardware. The telecommunications closets may also house telephone equipment.

3. Climate control shall be provided in the telecommunications closet seven days per week to prevent failure of electronic components and for all mission critical applications.

4. The copper cross-connect system shall be sized to support the telecommunications outlet/connectors served by that closet. The layout shall allow for anticipated growth. An IDC cross connect system or Patch Panels with 8 position modular connectors shall be used for all termination. Regardless of the method of termination, all pairs of the horizontal and backbone copper and fiber cables shall be terminated and tested.

5. The maximum number of patch panel ports per rack shall not exceed manufacturer's recommendations. For optical fiber termination and patching, refer to Main Cross-connect.

D. Main Cross - connect

1. The Main Cross - connect (MC) is the common point of appearance for the Inter and Intra - building copper and fiber backbone cables. This is integrated in Horizontal cross connect in our project, as we only have one Telecommunication closet serving the building.

2. Optical Fiber:
   a. The MC fiber cross - connect system shall accommodate a minimum of 24 fibers per IC or TC served.
   b. The panels shall accommodate SC or LC (as indicated in telecommunication panel's description, specifications and drawings) type adapter sleeves. Rack mounted fiber patch panels shall be rugged enclosures that can accommodate

both splices and field mountable connectors. Both sides of the connection shall be protected by the enclosures.

c. The patch/distribution panels shall be adequable to 19” wide equipment racks or allow for wall mounting.

d. The optical fiber distribution terminal a high level of manageability shall be selected.

e. The panels shall provide for grounding (where non-dielectric cables are used).

f. In order to active a level of readability that approximates that of a factory manufactured connector; field installable connector shall have a factory physical contact (PC) polish. Every fiber shall be terminated with the appropriate connector, tested results provided in writing to Purchaser.

E. System Documentation

1. Vendor shall provide a Manufacturer supplied End User Manual describing the end user’s responsibilities in maintaining the integrity of the cabling system over time.

2. Vendor shall provide a copy of Manufacturer supplied Application Guidelines describing proper implantation of current or planned applications to be supported by the cabling system.

PART 3 - MAIN TELECOM ROOM

3.1 EQUIPMENT RACKS

A. Equipment racks to store computer, data storage and networking equipment in the data centers, computer rooms and equipment rooms. Each rack shall be designed to provide a secure, managed environment for server and networking equipment. Racks shall be designed to accommodate power and cable management accessories that keep network and power cables organized.

1. The Racks shall include 19-inch standard mounting rails according to EIA-310.

2. The 42U units shall support a static load (weight supported by the casters and leveling feet) of at least 1,364 kg. (3,000 lb) total installed equipment weight.

3. The units shall ship with a perforated front door, perforated split rear doors, 2 or more removable side panels, two (2) vertical frame posts, four (4) adjustable vertical mounting rails, minimum of two (2) and maximum of four (4) vertical PDU mount cable organizers, four (4) leveling feet and four (4) casters, baying and grounding hardware pre-installed by the manufacturer.

4. All sheet metal parts shall be painted using a powder coat paint process.

5. The unit shall have ventilated front and rear doors to provide adequate airflow required by the major server manufacturers.

6. The unit shall provide 42U of equipment vertical mounting space.

7. Both the front and rear doors shall be designed with lift-off hinges allowing for quick and easy detachment without the use of tools.

8. The unit shall include side panels that are removed without tools using easy finger latches for fast access to cabling and equipment.

9. Grounding: All cabinet components such as doors, side panels, roofs, etc. shall be bonded directly to the frame. Grounding points shall be provided on the cabinet's frame to externally bond each unit to the building ground.

10. Cable Access: Top and bottom cable management openings shall be provided in the cabinet roof and base.

11. The vertical mounting rails shall be easily adjustable to allow different mounting depths. Each vertical mounting rail shall be marked on both sides with lines showing the top and bottom of each U and the number U space next to the middle hole.

3.2 PRECISION COOLING UNITS (COMPUTER ROOM AC)

A. The Main Telecommunication room will be cooled by 2 fully redundant CRAC units. The units will provide a controlled Temperature and Humidity environment for the room.

1. The 1st unit (CRAC A) will be a chilled water type and shall be connected to the Hotel Main Chiller

2. The 2nd unit (CRAC B) will be a direct expansion (DX) type with a dedicated outdoor unit to be installed in a close and secure location. This unit will be powered from the Dedicated Telecommunication room power panel.

3. The units should support Year round operation.

4. The units should be connected together and work in a duty-standby mode

5. The CRACs will have a down-flow configuration with a top return. (the units shall supply the cold air under the raised floor)

6. The units shall have EC-driven compressor with digital compressor controller for capacity modulation.

7. The units will include humidity control (humidification and dehumidification)

8. The units shall include a network management interface card for remote management and alerts.

9. The units shall be fitted with Large LCD graphic display for operation and control.

10. The CRACs shall be designed so all components are easily accessible for service and maintenance.

11. The units should include Automatic Start after power loss

3.3 FIRE SUPPRESSION SYSTEM

A. Refer to mechanical specifications Div. 13. Fire suppression system is under the mechanical tender.

3.4 ACCESS FLOOR (RAISED FLOOR)

A. The access floor system shall consist of interchangeable panels, understructure, and all labor, material, equipment, and installation as called for in the specifications and/or shown on the Drawings.

B. The access floor system shall be used as a plenum space for Cooling. All penetrations and openings should be treated with proper air tight seal to prevent air leakage from unwanted locations.

C. The subfloor surface must be free of moisture, dust, dirt and other debris. Once installed, the access floor must be maintained in the same manner.

D. Specifications:

1. Concentrated Load: 1,250 lb. on one square inch (25mm) at any location with a top surface deflection not to exceed 0.10" (2.5mm), and a permanent set not to exceed .010" (.25mm).

2. Uniform Load: 600 lb. per square foot with a maximum top surface deflection not to exceed .040" (1mm), and a permanent set not to exceed .010" (.25mm).

3. Ultimate Load: Panel shall be designed to withstand a load of 1800 lb. applied over one inch at the weakest point on a pedestal.

4. Rolling Load: Panels shall withstand a rolling load of 1,300 lbs. applied through a 3" (76mm) dia. x 1-13/16" (46mm) wide caster for 10 cycles over the same path with a maximum of .040" (1mm) top surface permanent set. Panels shall withstand a rolling load of 900 lb. applied through a hard rubber-surfaced wheel 6" (152mm) dia. x 2" (51mm) wide for 10,000 cycles over the same path with a maximum of .040" (1mm) top surface permanent set.

5. Impact Load: A 150 lb. load dropped from 36"(914mm) onto a one-inch square indenter shall not render the system unserviceable.

6. Flammability: Bare panel system shall meet Class A requirements for Flame spread and smoke development when tested in accordance with ASTM-E84 and a maximum Flame spread of 25, Smoke development of 50 based on the average of three runs when tested in accordance with CAN/ULC S102.

7. Combustibility: All components of the access floor system shall qualify as noncombustible by demonstrating compliance with requirements of ASTM E 136, Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 deg C.

8. Pedestal Axial Load Test: Provide pedestal assemblies without panels or other supports in place, capable of withstanding a 5000 lb (22 240 N) Axial load per pedestal, according to CISCA A/F, Section 5 "pedestal Axial Load Test."

9. Tolerances:
   a. Manufacturing tolerance:
   b. Nominal panel size ± 0.015" (.4mm) or less.
   c. Panel flatness ± 0.020" (.5mm) or less.
   d. Panel squareness ± 0.015" (.4mm) or less.
   e. Panel interchangeability–all panels, except those modified to meet special conditions, shall be interchangeable.

10. Pedestal assemblies shall be galvanized steel.

11. The base shall be a minimum of 16 square inches and shall be stamped and/or embossed on its underside and shall be adhered to the sub floor with an adhesive recommended by the access flooring manufacturer.

12. PERFORATED AIR SUPPLY PANELS: Air supply floor panels shall have galvanized dampers adjustable from the top of the panel, and shall provide minimum 25 percent free area. Contractor shall furnish air supply floor panels with adjustable dampers.

3.5 POWER SOURCES IN RACKS

A. The IT equipment installed in the racks will be powered either from the PDUs or the ATS.

B. Power distribution units (PDU):

1. 2 Power distribution units will be installed in each rack. Each PDU will be powered from 1 of the 2 available UPS sources.

2. All dual powered equipment will be connected to both PDUs. This will provide power redundancy to all dual powered equipment from source to destination

3. PDUs will be 0U vertically mounted 32Amp

4. The power source of each PDU will be clearly Labeled on it

C. Automatic Transfer Switch ATS:

1. The ATS shall be installed to take power from the 2 UPS sources in the Main Telecommunication room and outputs the primary source. In case of problem with Primary source, the ATS will switch the load to the secondary source.
   a. The Automatic Transfer switch ATS Shall be rated to 16Amps
   b. The ATS shall be rack mountable to a standard 19-inch rack.
   c. Transfer Time: 5-12ms Typical, 16ms Maximum.
   d. ATS shall include a network management interface card to allow the IT team to monitor its status remotely. It should be configured to send alerts in case of problem.
   e. All single power equipment in the racks shall be connected to the ATS to provide power redundancy

3.6 ENVIRONMENTAL MONITORING SYSTEM:

A. The Server environment monitoring system will monitor critical environmental conditions such as Temperature, humidity, water presence etc. When a sensor goes out of the range of a configurable threshold, the system will notify the IT Team via email, SNMP trap, voice call, SMS or other.

1. The system shall include digital inputs and relay outputs.

2. The system shall be connected to the IT network.

3. The system shall support sensors including temperature, Humidity, water leakage, smoke, motion detection, voltage presence, differential pressure etc

4. The System should have configurable thresholds for each sensor and send alerts in case of alarm

B. Temperature sensors:

1. To be mounted in the front or back of the rack as per drawings

2. Measurement range 0 to 50°C

3. Accuracy ±0.50°C

4. No required recalibration after initial startup

C. Combined temperature humidity sensors:

1. The sensors shall have the same specs as temperature sensors

2. Measurement range 0 to 80% Relative humidity

3. Accuracy ±4%

4. No required recalibration after initial startup

D. Leak Rope:

1. 100% waterproof electronics

2. Detects any conductive liquid

3. The Rope should be available in different length to match the required length needed in the Telecommunication room

E. The environmental monitoring system shall have the threshold configured according to ASHRAE environmental requirements for telecommunications spaces:

1. Temperature: 18 – 27°C (64 – 81°F)

2. Maximum relative humidity (RH): 60%

3. Minimum dew point : 5.5°C (42°F)

4. Maximum dew point: 15°C (59°F)

PART 4 - EXECUTION

4.1 INSTALLATION

A. All telecommunications outlet/connectors, patch panels, cross connects, cabinets… etc. shall be labelled using a mechanically imprinted label or a system as defined by the Purchaser. Regardless of the numbering scheme, every cable shall have the same permanent identifier on its termination hardware at both ends.

B. All 4 pairs of each F/UTP cable shall be terminated on a single port. The splitting of cable pairs between different jacks is not permitted. Terminating resistors required in certain applications shall be placed externally to the telecommunications outlet/connector.

C. Terminating cable pairs (Category 6A as indicated on riser diagrams, drawings, equipment specifications and drawings) shall have a maximum of 13 mm (1/2 inch) of each untwisted before termination or even less if required by the standard.

D. All data equipment shall be properly installed in the telecommunications closets to meet the manufacturer's requirements.

E. Horizontal & vertical cable & cord management accessories shall be provided and utilised in the MC and TC's to manage cables in an orderly fashion. Cabling management should be installed in racks and on walls as per manufacturer's recommendations.

F. Appropriate fire barriers shall be placed around the cables in the sleeves, and unused sleeves shall be properly fire stopped.

G. Installation should be performed in a professional manner using the best practices in the industry. Best practices shall include, but not be limited to, the following points:

1. Backbone cabling utilising a shield shall be bonded at each sheath opening.

2. All grounding conductors must be rated CMP and must be neatly tied in bundles and fastened to the under-slab or metal structure at intervals not to exceed 6 feet.

3. All cabling shall be continuous without joins, or splices from the work area to the telecommunications closet.

4. All cables installed by Vendor or subcontractor shall be properly contained in conduit, cable tray, raceway, or duct. Where none of these support media are available, the individual cables shall be formed into cable harnesses, neatly run, properly dressed, supported and secured intervals not to exceed 6 feet.

5. All exposed cabling is to be installed and routed in a neat and professional manner. Proper manufacturer systems training provide instruction in this area. All exposed cable bundles to be tie-wrapped at a maximum of every 12 inches. All cable-ties used shall be hand tightened only to a point where the sheath does not kink.

6. If conduit is used, the maximum number of bends between cable pulling points shall be two ninety-degree bends over a maximum of 100 feet.

7. Horizontal fill ratios for conduit, cable trays, raceways and ducts shall conform to standards and manufacturer recommendations.

8. Standards for separation distances from electromagnetic sources are currently under study. Minimum clearance between cables and power sources until the new guidelines are available are found in EIA/TIA 569:

SEPARATION DISTANCES FROM EMI SOURCES

Condition:	Minimum Separation:		
Unshielded power lines or electrical Equipment in proximity to open/ non-metal pathway	<2KVA 127 mm 5 in.	2-5KVA 305 mm 12 in.	>5KVA 610 mm 24 in.
Unshielded power lines or equipment In proximity to a grounded metal conduit pathway.	64 mm 2.5 mm	152 mm 6 in.	305 mm 12 in.
Power lines enclosed in shielded or grounded metallic conduit in proximity to a grounded metal conduit pathway.	- -	76 mm 3 in.	305 mm 6 in.
Transformers & electrical motors		40 in.	
Fluorescent Light (coil or electric start)		12 in.	

9. All optical fiber and copper cables shall be handed, installed, and supported as per the manufacturer's guidelines. During the lying of the cable, installer shall take care not to over stress the cable. After the cable is installed, installer shall make sure that all parts of the cable are supported properly and shall be stress free at both ends and throughout their length.

10. Appropriate attention shall be given to the handling of Category 6A & 6 copper and optical fiber cables to ensure that bending radius conforms to the manufacturer's requirements. At no time shall the cable's static or dynamic bending radius be exceeded.

11. All telecommunications outlet/connectors shall be securely mounted at all work area locations and shall be located so that the cable required to reach the work area equipment will be no more than 3 meters long.

12. The total optical attenuation through the cross-connect from any terminated fiber to any other terminated fiber shall not exceed 2.0 dB.

13. Optical fiber splices, fusion or mechanical, shall not exceed a maximum optical attenuation of 0.3 dB when measured in accordance with ANSI/TIA/EIA-455-34.

4.2 INSPECTION & TESTING

A. Provide Commissioning Verification, Inspection and Certification.

1. Test requirements:
   a. End-to-end testing for F/UTP copper shall be conducted for 100% of pairs and shall identify pair reversal opens shorts and resistance. The test results shall be documented; corrections implemented and retesting conducted and documented. In addition documentation shall be presented to show the length of the cable between the Telecommunication Closet and the Work Area. The testing shall include all the parameters required for CAT6A by Penta Scanner, Wirescop or approved equal up to 500MHz (as required in BOQ, drawings and specifications). Any failed tests shall imply the correction of the problem by the contractor.
   b. Attenuation testing for optical fiber shall be done after the fiber is installed.
   c. Optical time domain reflect meter (OTDR) testing of all optical fiber backbone cables is required at installation.
   d. Verify labelling of all termination points.
   e. Provide written verification conforming that the testing and inspection has been completed and that all cable runs have passed. Also document that all deflects have been identified, corrected, and retested successfully.
   f. Inform Purchaser before testing is carried out so that the Purchaser may witness all tests.

g. Final testing shall be carried out only after substantial completion.

4.3 HOUSEKEEPING

A. All closets and terminal facilities must be free of cable clippings, empty reels, cartons, or other refuse from the installation.

B. SUMMARY OF STANDARDS

EIA/TIA 568-B.2-1: Performance Specification for 4-Pair 100 Ohm Category 6 Cabling (latest revision) and EIA/TIA 568-B.1 with TSB 75.

ANSI/TIA/EIA 568A & B & C: Formerly **EIA/TIA-568** is a Commercial Building Telecommunications Cabling Standard. It addresses the telecommunications wiring system requirements for commercial buildings that support various LAN, data, voice and image/video systems (first issued in July 1991). Released as the new ANSI/TIA/EIA 568A.5, which includes Enhanced CAT5 specifications.

EIA/TIA 569: Commercial Building standard for Telecommunications Pathways & Spaces. The purpose of this standard is to standardize the design and construction practices within and between buildings, mainly commercial establishments, which support telecommunications media and equipment.

EIA/TIA 606: Design Guidelines for Administration of Telecommunications Infrastructure in Commercial Buildings.

EIA/TIA - 607: Commercial Building Grounding and Bonding Requirements for Telecommunications. The purpose of this standard is provide standards for grounding and bonding for data and telecommunications equipment.

CSA T527: Canadian standard for Commercial Building Telecommunications Wiring Standard equivalent to EIA/TIA 568 (approved for publication).

CSA T530: Building Facilities, Design Guidelines for Telecommunications (same as EIA/TIA 569).

IEEE 802.3 Ethernet 10 Base - T LAN: The purpose (relative to cabling) of this standard is to define media and distance requirements for 10 Mbit/s LAN (issued in October 1990).

IEEE 802.5 Token Ring LAN: The purpose (relative to cabling) of this standard is to define media and distance requirements for 10 Mbit/s LAN (issued in October 1990).

IEEE 802.5 Token Ring LAN: The purpose (relative to cabling) of this standard is to define media and distance requirements for 4 & 16 Mbit/s Token Ring Local Area Networks (issued in October 1989).

ANSI X 3T9.5 FDDI: It defines standard for 100 Mbit/s LAN based on optical fiber cable as well as on Unshield Twisted Pair (UTP).

TSB 97: A proposed Telecommunications System Bulletin that will define field testing of UTP Basic Links (limited to the work area telecommunications outlet/connector to cross connect in wiring closet only) and Channels (complete connectivity from electronic wiring closet throughout to the work area device (including line cords in work area device (including line cords in work area and patch cords or cross-connect in closet).

PART 5 - GLOSSARY

BICSI - Building Industry Consulting Service International, an organization to promote education and standards within the telecommunications cabling industry.

Category 5 - This designation applies to 100 Ω ohm UTP cables and associated connecting hardware whose transmission characteristics are specified by the ANSI/TIA/EIA 568A&B standard up to 100 MHz.

Category 5E - This designation applies to 100 Ω ohm UTP cables and associated connecting hardware whose transmission characteristics are specified by the ANSI/TIA/EIA 568A&B standard up to 125 Mhz.

Category 6 – This designation applies to 100 Ω ohm UTP cables and associated connecting hardware whose transmission characteristics are specified by the ANSI/TIA/EIA 568A&B standard up to 250 MHz.

Category 6A – 10GIGA This designation applies to 100 Ω ohm F/UTP cables and associated connecting hardware whose transmission characteristics are specified by the ANSI/TIA/EIA 568A&B&C standard up to 500 Mhz.

IC - Intermediate Cross-Connect - A cross connect between first level and second level backbone cable.

IDC - Insulation Displacement Connection - A type of wire connection in which the wire is “punched” down into a split metal connector. The split metal connector cuts through the insulation to touch the cable inside and form a connection. The alternative connection is a screw terminal.

ISDN - Integrate Services Digital Network - A new concept of world wire telephone system including voice, data and signaling.

MC - Main Cross-Connect - A connects for first level backbone cables, entrance cables, and equipment cables.

NIC - Network Interface Card - The adapter card that plugs into users PC to interface with the particular network type and cable type being used (i.e. Ethernet over UTP, coax, optical fiber)

OTDR - Optical Time Domain Reflect meter - A device that measures the loss in an optical fiber and locates the point where the loss occurs.

RCDD - Registered Communication Distribution Designer - A professional designation provided by BICSI to individuals who pass the RDDC exam on cabling system design for commercial, campus, and multi family buildings.

TC, PP, VPP or DPP - Telecommunications Closet - An enclosed space housing telecommunications equipment, cable termination, and cross-connect cabling. The closet is the recognized location of the cross-connect between the backbone and the horizontal facilities.

F/UTP – overall shielded Twisted Pair - A cable medium with one or more pairs of twisted insulated copper conductors, color-coded with overall helicoidal Polyester shield bound in a single plastic sheath.

SECTION 16720 — TELEPHONE INSTALLATIONS

PART 1 - GENERAL

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

1.2 **DESCRIPTION OF WORK:** complete telephone distribution network including hybrid private telephone exchange system (EPABX specified in another section) including, but not limited to, the followings:

A. Telephone cables.

B. Telephone outlets.

1.3 **REGULATIONS AND STANDARDS:** telephone installations are to comply with the requirements of PTT and the relevant CCITT recommendations and the Electronic Industries Association / Telecommunication Industry Association Standard EIA/TIA- 568 “Commercial Building Telecommunication Wiring Standard” or ISO/IEC-11801 “Information Technology – Generic cabling for customer premises”.

1.4 **EQUIPMENT DATA:** submit data for approval including complete technical data and manufacturer’s catalogues for all equipment and materials.

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

A. Detailed system schematic diagram.

B. Detailed layout of all equipment in rooms, including elevations.

C. Exact routing and layout of all cabling and wireways.

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

PART 2 - PRODUCTS AND SYSTEMS

2.1 TELEPHONE DISTRIBUTION COMPONENTS

A. CONDUITS AND RACEWAYS are to be provided in accordance with Sections 16118 of the Specification.

B. TELEPHONE SYSTEM MAIN CABLES are to be 100 ohm unshielded twisted pair (UTP) to EIA/ TIA- 568 or IEC 11801 Category 3 wiring standard. Cables are to be four- pair to telephone outlets (RJ45 CAT6A) and multi- pair composite media cables for backbone distribution. Indoor cabling is to be polyethylene insulated, tinned solid copper conductors, twisted into pairs, color coded and gray PVC sheath. Minimum diameter of conductor is to be 0.6 mm.

C. MULTI-PAIR CABLES for installation in duct banks, outdoors are to be non- hygroscopic, waterproof, polyethylene insulated, tinned solid copper conductors, minimum 0.6 mm diameter, twisted into pairs, color coded, with wrapping of aluminized polyester tape, PVC tape, aluminum or copper sheath and PVC over- sheath.

D. CABLE RATING: cables are to be rated for maximum operating voltage of 150 V, with insulation resistance of 10,000 megaohm/km, and tested at 500 V d.c. applied core- core and core- earth.

E. TELEPHONE/DATA OUTLETS are to have modular grid box and cover plates similar to other socket outlets and switches described in the Specification. Jacks are to be modular shielded 8 positions and ground terminal RJ 45 CAT.6A compatible with RJ45 plugs.

PART 3 - FIELD AND INSTALLATION WORK

3.1 INSTALLATION

A. EQUIPMENT INSTALLATION ON SITE is to be limited to fixation and inter- wiring of various items of the ready made equipment.

B. CABLES are to be run on cable trays, in conduits above suspended ceilings, in walls or under floors in a manner to protect them from physical damage and excessive heat, and to permit ease of accessibility for servicing and modifications. Fixing accessories are to include two- piece plastic clamps, galvanized screws, wall base- holders and fibber- plastic inserts or raw- bolts, subject to the approval of the Engineer.

C. CONDUITS: in accordance with the Specification.

D. EARTHING: provide interference- free earthing as necessary.

E. TOOLS: use only proper tools for all installations work particularly in making connections.

F. SUPERINTENDANCE: carry out installations under the direct supervision of a qualified technician, licensed by and trained at the factory.

3.2 MISCELLANEOUS ITEMS

A. SPARE PARTS AND TOOL KITS are to be provided as per the manufacturer's recommendations for electronic boards, IDC connection modules, telephone outlets, board extractors, cleaning kits, test stations, digital multimeter and battery testing kit.

SECTION 16730 - IP-PABX SYSTEM

PART 1 - GENERAL

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

A. Current specification section shall be read in conjunction with related drawings, risers and following section of specifications: Section 16715 — “STRUCTURAL CABLING FOR DATA AND TELECOMMUNICATION SYSTEM”; Section 16740 — “COMMUNICATIONS AND DATA-PROCESSING EQUIPMENT FOR NETWORK”.

1.2 **DESCRIPTION OF WORK**: complete private telephone exchange system (EPABX)

1.3 **REGULATIONS AND STANDARDS:** telephone installations are to comply with the requirements of PTT and the relevant CCITT recommendations and the Electronic Industries Association / Telecommunication Industry Association

1.4 **EQUIPMENT DATA:** submit data for approval including complete technical data and manufacturer’s catalogues for all equipment and materials.

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

A. Detailed system schematic diagram

B. Detailed layout of all equipment in rooms, including elevations

C. Exact routing and layout of all cabling and wireways

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

E. Detailed system specifications and features.

1.6 **APPROVED MANUFACTURERS:** Provide material from one of the following manufacturers or approved equal :

A. Alcatel-Lucent

B. AVAYA

C. Cisco

PART 2 - FIELD AND INSTALLATION WORK

2.1 INSTALLATION

A. EQUIPMENT INSTALLATION ON SITE is to be limited to fixation and inter- wiring of various items of the ready made equipment.

B. CABLES are to be run on cable trays, in conduits above suspended ceilings, in walls or under floors in a manner to protect them from physical damage and excessive heat, and to permit ease of accessibility for servicing and modifications. Fixing accessories are to include two- piece plastic clamps, galvanized screws, wall base- holders and fibber- plastic inserts or raw- bolts, subject to the approval of the Engineer.

C. CONDUITS: in accordance with the Specification.

D. EARTHING: provide interference- free earthing as necessary.

E. TOOLS: use only proper tools for all installations work particularly in making connections.

F. SUPERINTENDANCE: carry out installations under the direct supervision of a qualified technician, licensed by and trained at the factory.

PART 3 - IP PABX Telephony SYSTEM

3.1 SYSTEM ARCHITECTURE & FACILITIES

A. The IP telephony system shall be a hybrid system, handling both IP and analog phones. The system shall have multiple phone models that will fit the hotel needs. The IP-PBX shall use the SIP architecture that features high integration. It shall provide powerful networking capabilities. In the downstream direction, it shall support both narrowband and broadband access, allowing for hybrid networking of analog phones and IP phones. In the upstream direction, it can connect to the public switched telephone network (PSTN) or to voice switches in private networks using digital, analog, and broadband SIP trunks.

B. The PBX shall support the below:
1. Scale up to 1500 device
2. Should support IP and analog phones
3. Should support two T1/E1 modules
4. 2x 1 GB Ethernet ports
5. Support for T.38 Channel
6. Support for G.7298a compression
7. Support dual power supply
8. Internal storage
9. Should support SIP trunks
10. Should support voice mails
11. Should support STP and RSTP protocols
12. Should support for FIM modules
13. Should support echo canceller
14. Embedded BMI modules
15. Should support DTMF

C. Rich Services and Ports
1. Provides high-quality, built-in voice conference resources and web conference management portal for easy use and management.
2. Provides built-in voice mailboxes to implement the voicemail function and prevent call loss.
3. Supports diverse supplementary services (including One Number Link You (ONLY), emergency call, secretary station, and call barring) to meet different service requirements.
4. Supports PRA, SS7, R2, QSIG, AT0, SIP and BRI signaling messages and protocols and integrates narrowband and broadband services.

D. High Reliability and Low Costs
1. Provides 99.995% system reliability and supports both AC and DC power supplies with 1+1 redundancy backup.
2. Supports the local regeneration function at enterprise branches.
3. Adapts to requirements of small- and medium-sized enterprises and reduces the operation and maintenance costs for enterprises.
4. Can be expanded and upgraded to UC applications, protecting customers' investments.

E. Easy Deployment and Maintenance
1. Supports various networking modes, including the single-node network and centralized call management network. Both IPv4 and IPv6 networks are available, allowing for flexible deployment.
2. Supports unified network management, meeting requirements for centralized operation and maintenance (O&M) and highly efficient management.
3. Provides the local maintenance terminal (LMT) for routine maintenance.

4. Provides a built-in web management system for quick deployment and routine configuration.
5. Provides a built-in web self-service system for conference scheduling and personal service management.

3.2 BASIC VOICE SERVICES

A. Voice Communication

1. The IP-PBX should support basic voice communication, including Intra-office communication. Intra-office users under the IP-PBX can use various supported broadband and narrowband terminals to make voice calls to each other.
2. Narrowband trunk-based communication: The IP-PBX can be connected to the PSTN or TDM PBX using a digital trunk (E1/T1/BRI) or analog trunk (AT0). Intra-office users (either as calling or called parties) can have voice calls with users at the peer end of the narrowband trunk. Table 1 lists the E1/T1 trunk types supported by the IP-PBX.

Table 1. E1/T1 trunk types supported by the IP-PBX

Trunk Type	E1	T1
PRA	√	√
QSIG	√	√
R2	√	-
SS7 (ISUP/TUP)	√	-

3. Broadband trunk-based communication: The IP-PBX uses the SIP trunk to connect to the IP PBX, softswitch, or IMS. Voice calls can be made between intra-office users and the users under other devices.

B. Point-to-Point Multimedia Communication

1. The IP-PBX should support point-to-point (P2P) multimedia communication service, allowing SIP-based multimedia terminals to communicate with each other.
2. Supports video phones.
3. Supports P2P video calls between intra-office users and SIP-based P2P video calls between intra-office and outer-office users.

C. Call Rights Control

1. The IP-PBX should allow users to make intra-office calls, local calls, national toll calls, and international toll calls. In addition, a maximum of 32 types of call rights can be defined to restrict users from making specified types of calls.

D. Number Analysis and Processing

1. The IP-PBX should analyze the calling and called numbers based on their prefix and length to control incoming and outgoing call rights. The calling number is analyzed before the called number. Numbers with the same prefix are analyzed based on the length.
2. The IP-PBX can analyze and process a regular number or prefix containing a maximum of 32 digits and an intra-office number containing a maximum of 16 digits.

3. The IP-PBX can analyze a maximum of 1024 calling numbers and a maximum of 2048 called numbers.
4. Prefixes can identify emergency, intra-office, local, intra-office and local, national, and international calls, and support 32 levels of customized call rights. The intra-office and local prefixes are applied when the intra-office prefix is the same as the local outgoing prefix.
5. The IP-PBX can insert, change, or delete digits in calling and called numbers. The length of a changed number cannot exceed the maximum value. A maximum of 1024 change types are supported.

E. Voice Processing, Encoding, and Decoding: The IP-PBX should provide the following voice processing capabilities:

1. Supports the voice activity detection (VAD), comfort noise generator (CNG), echo cancellation (EC), gain adjustment, jitter buffer, and packet loss compensation (PLC) technologies, providing users with high-quality voice services.
2. Supports type of service (ToS) and Differentiated Services Code Point (DSCP) technologies, ensuring that voice streams are preferentially transmitted.
3. Supports the Real-Time Transport Control Protocol (RTCP) and provides statistical information about the total numbers of RTP packets sent and received, total numbers of bytes sent and received, delay, jitter, and packet loss rate.
4. Supports various codecs such as G.711 (A-Law/U-law), G.729a/b, iLBC, G.722, G.722.1 and G.722.2. In addition, it supports voice codec change and priority selection.

F. Fax:

1. The IP-PBX should support T.30 faxes in the circuit switched domain and T.38 faxes in the packet switched domain, and transparent transmission of G.711 faxes.
2. The end-to-end delay for transmitting signals using a fax machine cannot exceed 3 seconds. It is recommended that no more than four T.38 code switching gateways be deployed on the network.
3. For transparent transmission, IP-PBX supports converting voice calls in G.729 encoding mode into G.711 faxes.

G. IP telephony shall feature the following:

1. **Guest voice mail box:** This allows for external messages and messages from e.g. the concierge. A lamp on the phone indicates a message is waiting, and the guest then can retrieve it (and even return it) with a single touch.
2. **Wake up calls: This lets guests set their own, or ask the front desk to do it for them. You can even play a wake-up message to the guest.**
3. **'Meet-me':** This provides a valuable conferencing call facility for your business guests.
4. **Multilanguage selection:** This allows international guests to use the system with ease.
5. **Room to room dialing:** This helps guests to stay in touch with others in their party. This can be enabled or disabled on a room, group or system basis as required.
6. **Privacy:** Guests can enable the DND feature to block incoming calls, or choose to have them forwarded to mailbox. This can be overridden in the case of emergency.
7. **Direct dial:** Rooms can be telephoned directly from an external location if the guest chooses.

8. **Listen in/child monitoring**: This allows the guest to monitor the room from another room or another part of the hotel, perfect for families wanting to keep an ear out for children.
9. **Recorded information:** This allows you to record info about the hotel's services or local information for guests, which can be accessed with one touch.
10. **Class of service:** You can assign your guests different access rights to various features of the phone system and to outgoing call functionality - for example, depending on their room rate.
11. **Personalized service**: If the guest's name is entered on check in, this can be displayed whenever a call is made to or from their room (e.g. to front desk, room service, housekeeping etc) allowing for a more personalised experience.
12. **Warm welcomes:** The guestroom IP Phone can also be used to deliver welcome messages and personalised greetings with guest name display for further personalized service.
13. **Room status:** The status of any room can be checked from the front desk, to see if it is ready for your guest or still awaiting service. The cleaning team can update the status of the room from its guest phone. This allows you to keep your guest informed and offer an early check in where it is available.
14. **Call routing:** This allows calls to be routed to the cheapest carrier. The guest is, however, charged at the full standard rate, allowing you to make more profit on guest calls.
15. **Multiple 'front desks'**: Front desk functionality is available from more than one point, allowing you to deliver a better service.
16. **Room extensions**: The extension numbering can match the room numbering, up to 4 digits, making the system easier to use.
17. **One-touch services**: The hotel's facilities - front desk, concierge, housekeeping or restaurant, for example, can be accessed with a single number from any guest phone, for ease of use and maximizing revenue opportunities.
18. **Cost control**: The hotel phone system helps you keep track of costs, for example by adding bar and restaurant charges at point of sale.
19. **Vacant room barring**: On check out, the guest phones are set to internal calls only to prevent misuse. Maid status for the room and any minibar charges can still be input into the system.
20. **Prepaid call limit**: If a prepaid call limit is required, this can be entered by the front desk. This bars calls being made beyond the set limit until the limit is increased by front desk.
21. **Room changes**: If a guest needs to move room, messages can be transferred from one mailbox to another.
22. **Listen receipt**: Your staff can request a listen receipt to ensure that a guest has heard an important message.
23. **Announce only mailbox**: This lets you set an announcement only mailbox which plays a message and then transfers the guest back to the main menu, allowing you to deliver services and promotions information where required.
24. **Faster service**: Your staff can have WiFi handsets allowing them to be mobile and accessible around the building, and therefore provide faster, better service.
25. **Call center features:** These help minimize customer waiting time and boost hotel's marketing efforts.
26. **Integration with your CRM, PMS or sales database**: This allows you to offer a personalized experience and tailor promotions to your customers' needs. Integration is easy with Micros Fidelio, Tiger etc.

27. **Check in** / **check out**: Routine tasks such as check in and check out can be performed efficiently, freeing up hotel's team to spend more time looking after the guests.

3.3 TELEPHONE HANDSETS

A. Telephone for Administration Department:

1. 48 self-labeling, programmable keys
2. Wideband audio support
3. One-touch access to embedded applications
4. Hands-free speakerphone
5. Built-in HTML toolkit
6. Low power consumption
7. Dual embedded Gigabit Ethernet ports (LAN and PC)
8. Accepts standards-based (IEEE 802.3af) power over the LAN

B. Guest Room Telephones: Room Telephone Set (SIP telephone set):

1. 7" (800x480 pixel) color LCD Touch Display
2. Bluetooth 4.1
3. Mobile device integration
4. Mobile phone charging point
5. Cordless speech optimized handset
6. Enhanced full-duplex speakerphone
7. Dual 10/100/1000 Mbps Ethernet ports
8. Dedicated LED for call, message waiting and Mobile Device Connect indication
9. Low power consumption
10. Accepts standards-based (IEEE 802.3af) power over the LAN

C. Guest Room Telephones: Bathroom Telephone Set (Wall mounted SIP telephone set):

1. 40-character backlit display (with auto-dimming)
2. Two lines with LED indication: one prime line and one programmable key with LED
3. Eight programmable keys: speed dials, features access codes, paging, conferencing, voice mail access, etc.
4. Paging & page receive capability
5. Direct page & group page support
6. Incoming call visual indication
7. Message waiting indication
8. Adjustable volume / ringing controls
9. Wall-mountable
10. Multiple powering options (802.3af compliant)
11. Small footprint
12. Designed for power conservation: reduces power consumption for overall energy savings

D. Public Area Telephones:

1. Large graphics display (160 pixels x 320 pixels)
2. Eight programmable, one-touch, multi-function keys
3. 12 fixed function keys
4. Designed for power conservation; reduces power consumption for overall energy savings
5. Hands-free speakerphone operation (full duplex)
6. Multiple-languages support
7. Accepts standards-based (IEEE 802.3af) power over the LAN

3.4 HAND HELD TELEPHONES

A. Hand held telephones shall feature the following:

1. Should be able to connect to hotel Wi-fi
2. Enhanced, customizable Graphical User Interface (GUI)
3. Multiple-language support
4. HD voice quality
5. Programmable multi-function button (e.g., Alarm, Push to Talk, etc)
6. Messaging capable (send / receive / acknowledge)
7. Swappable battery pack (for shared use)
8. Base for recharge

3.5 IP-PHONE OPERATOR CONSOLE

The IP-PBX should provide a built-in console server to work with IP phones (serving as console terminals) for basic console functions.

A. Operator Console:

1. 6-line IP Phone with user-friendly interface:
2. Color screen: 5 inch, 800 x 480 pixels
3. 6 line buttons: dual-color
4. 5 programmable buttons: dual-color
5. 9 fixed function buttons
6. 4 softkeys
7. 2 GE ports: support for Power over Ethernet (PoE)
8. 1 USB 2.0 port
9. Bluetooth embedded 2.1 module
10. 1 headset port: RJ-9

3.6 SYSTEM PROGRAMMING

A. The system installer can carry out the software configuration/programming of the IP-PABX by either using a High-End Digital station or a PC programming tool.

B. The system installer can carry out remote system configuration and software maintenance from the installer's service center through internet.

C. The system is able to run its own self-diagnostic routines, and the system installer has the facility to view history reports on system events and fault alarms at any time.

D. It is possible to back up the system configuration data on a PC file and on a non-volatile memory in the system to hold system data in case of power failure or cold reset.

3.7 SYSTEM CONFIGURATION

Number of external trunk lines:	: 25 lines
Number of internal IP extensions for guestrooms	: 750 addresses/lines (202 Rooms)
Number of internal IP extensions for administration	: 100 addresses/lines
Number of internal IP extensions for Technical areas	: 50 addresses/lines
Number of internal IP extensions for handheld handsets	: 25 addresses/lines
Integrated Voice Mail with Automated Attendant	: for 60 users
Rectifier charger	: 12V, 50Hz, for 6 hours autonomy

SECTION 16740 — COMMUNICATIONS AND DATA-PROCESSING EQUIPMENT FOR NETWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Divisions 1 & 16 Specification Sections, apply to this Section where applicable.

1.2 SUMMARY

A. This Section includes wire, cable, connecting devices, installation, and testing for wiring systems to be used as signal pathways for voice and high-speed data transmission.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. IDC: Insulation displacement connector.

C. LAN: Local area network.

D. PVC: Polyvinyl chloride.

E. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

A. Product Data: Include data on features, ratings, and performance for each component specified.

B. Shop Drawings: Include dimensioned plan and elevation views of components. Show access and workspace requirements.

1. System labeling schedules, including electronic copy of labeling schedules, as specified in Part 3, in software and format selected by Owner.

C. Samples: For workstation outlet connectors, jacks, jack assemblies, and faceplates for color selection and evaluation of technical features.

D. Product Certificates: Signed by manufacturers of cables, connectors, and terminal equipment certifying that products furnished comply with requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article. Provide evidence of applicable registration or certification.

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

G. Maintenance Data: For products to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is a registered communication distribution designer. The installer shall be certified to be capable of installing CAT6 and CAT6A structured cabling in addition to Ethernet, FAST Ethernet, Gigabit Ethernet, ATM networks and 10 Gigabit Ethernet networks (compliant to IEEE 802.3ae) from a known certification body in addition to Power over Ethernet PoE (compliant to IEEE 802.3an). The installer should have previously executed at least 3 projects with more than 500 CAT6A outlet points each and should have ISO 9001 certification covering the installation and testing of telecommunication networks.

B. Comply with IEC 364 & NF C 15-100.

C. Electrical Components, Devices, and Accessories: Compliant to applicable European standards (EN) and marked for intended use.

D. The system shall be certified to be CAT 6A or 10GIGA from a known certification body.

1.6 COORDINATION

A. Coordinate Work of this Section with Campus Intra-Building infrastructure and LAN equipment suppliers. Coordinate service entrance arrangement with local exchange carrier.
   1. Meet jointly with representatives of above organizations and Owner's representatives to exchange information and agree on details of equipment arrangements and installation interfaces.
   2. Record agreements reached in meetings and distribute record to other participants.
   3. Adjust arrangements and locations of distribution frames, patch panels, and cross connects in equipment rooms and wiring closets to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

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. Cable: 250 feet (76 m) of each size and type used for Project. Furnish on reels.
   2. Patch-Panel Units: One of each type for every six installed, but not less than one.
   3. Connecting Blocks: One of each type for every 25 installed, but not less than one.
   4. Outlet Assemblies: One of each type for every 25 installed, but not less than one.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cable:
   a. Belden Wire & Cable Company.
   b. Essex Group, Inc.; Telecommunications Products Division.
   c. Lucent Technologies, Inc.; Network Systems.
   d. Legrand
   e. Northern Telecom, Inc.
   f. Infra Plus.
   g. Alcatel
   h. Pouyet
   i. AMP, Inc
   j. Leviton

2. Terminal and Connector Components and Distribution Racks:
   a. AMP, Inc.
   b. Molex.
   c. Infra Plus.
   d. Lucent Technologies, Inc.; Network Systems.
   e. Legrand
   f. Krone.
   g. Siemon.
   h. Pouyet.
   i. Alcatel.
   j. Northern Telecom, Inc.

3. Cabinets, Frames, Covers & Enclosures
   a. Vero
   b. Legrand
   c. Cannon
   d. Alcatel
   e. Krone
   f. Pouyet
   g. Infra Plus.
   h. APW

4. Switches and active equipment
   a. HP
   b. Cysco

2.2 SYSTEM REQUIREMENTS

A. General: Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance.

B. Expansion Capability: Unless otherwise indicated, provide spare fibers and conductor pairs in cables, positions in patch panels, cross connects, and terminal strips, and space in backbone cable trays and wireways to accommodate 30 percent future increase in active workstations.

2.3 MOUNTING ELEMENTS

A. Cable Trays: Comply with Division 16 Section "Cable Trays."

B. Raceways and Boxes: Comply with Division 16 Section "Raceways and Boxes."

C. Distribution Racks: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
   1. Module Dimensions: refer to B.O.Q. and relevant drawings.
   2. Finish: Baked-polyester powder coat.

2.4 TWISTED-PAIR CABLES, CONNECTORS, AND TERMINAL EQUIPMENT

A. Listed as complying with Categories 6A of EIA/TIA-568-C.2.

B. Listed as complying with PoE of IEEE 803.3an.

C. Conductors: Solid copper.

D. F/UTP Workstation Cable: Comply with EIA/TIA-568-C.2. Four thermoplastic-insulated, twisted pairs of conductors; No. 23 AWG, color-coded, overall polyester helical shield; enclosed in PVC jacket.

E. F/UTP Plenum Cable: Listed for use in air-handling spaces. Features are as specified above, except materials are modified as required for listing.

F. F/UTP Cable Connecting Hardware: Comply with EIA/TIA-568-C.2. for connectors, plugs, and jack assemblies.

G. Patch Panel: Modular panels housing multiple, numbered RJ45 jack units with IDC-type connectors from behind at each jack for permanent termination of pair groups of installed cables. The patch panels shall include a cable management and anchoring device in the back section.
   1. Number of Jacks per Field: **One for each four-pair F/UTP cable plus spares and blank positions adequate to satisfy specified expansion criteria**.
   2. Mounting: **19 inches Rack**.

H. Jacks and Jack Assemblies for F/UTP Cable: Modular, color-coded, RJ-45, CAT 6A 10GIGA, 9 contacts receptacle units with integral IDC-type terminals. Use keyed jacks for data service.

I. F/UTP Patch Cords: Four-pair flexible cables, CAT 6A in 48-inch (1200-mm) lengths, minimum or as required through horizontal & vertical cable management terminated with RJ-45, CAT 6A, 9 Contacts including ground terminal plug at each end. Use keyed plugs for data service. (To be US or European made and factory tested).

J. Workstation Outlets: RJ45, CAT 6A, 9 Contacts including ground terminal shielded, jack-connector mounted in single or multigang faceplate. (to include CAT 6A F/UTP cable to corresponding patch panel).
   1. Faceplate: High-impact plastic; color as selected by Architect.
   2. Mounting: Flush, unless otherwise indicated.
   3. Legend: Factory label top jack, "Voice" and bottom jack, "Data"; by silk-screening or engraving.

K. Data network consumer access point: RJ45, CAT 6A, 9 Pins shielded, jack-connector mounted in single or multigang faceplate (to include CAT 6A F/UTP cable to corresponding patch panel).
   1. Faceplate: High-impact plastic; color as selected by Architect.
   2. Mounting: Flush, unless otherwise indicated.
   3. Legend: Factory label “Data”; by silk-screening.

2.5 FIBER-OPTIC CABLES, CONNECTORS, AND TERMINAL EQUIPMENT

A. Cables: Factory fabricated, jacketed, low loss, glass type, fiber optic, single mode, graded index, operating at 850 and 1300 nm as per ANSI/TIA/EIA-568-C.3 & ISO/IEC 11801:2011 Ed2.2
   1. Workstation, Strands per Cable: Two.
   2. Backbone, Strands per Cable: 6, unless otherwise indicated.
   3. Dimensions: 9.1-micrometer core diameter, 125-micrometer cladding diameter.
   4. Maximum Attenuation: Less than 0.38dB/km at 1310nm and 0.25dB/km at 1550nm,
   5. Dispersion: Less than 3.5ps/nm.km at 1310nm and 18ps/nm.km at 1550nm Minimum
   6. Operating Temperature Range: Minus 20 to plus 70 deg C.

B. Plenum Cable: Listed for use in plenums.

C. Cable Connectors: Quick-connect, duplex-type SC or LC couplers with self-centering, axial alignment mechanisms or MTRJ as indicated in telecommunication panels description, specifications and drawings. Insertion loss not more than 0.7 dB.

D. Patch Panel: Modular panels housing multiple-numbered duplex cable connectors.
   1. Permanent Connection: Permanently connect one end of each connector module to installed cable fiber.
   2. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to satisfy specified expansion criteria.
   3. Mounting: **19 inches Rack**.

E. Patch Cords: Dual fiber cables in 36-inch (900-mm) lengths, minimum or as required through horizontal & vertical cable management.
   1. Terminations: Two duplex connectors arranged to mate with patch-panel connectors, one at each end of each fiber in cord.

F. Workstation Outlets: Flush LC or SC fiber-optic connector assemblies mounted in two-gang faceplate and/or flush dual RJ-45 jack assembly (as indicated on drawings).
   1. Faceplate: High-impact plastic; color as selected by Architect.
   2. Mounting: Flush, unless otherwise indicated.
   3. Legend: Factory label fiber-optic connectors, "Data" and RJ-45 jacks, "Voice" or “Data” as applicable.

2.6 IDENTIFICATION PRODUCTS

A. Comply with Division 16 Section, "**Basic Electrical Materials and Methods", "Electrical Identification"** and the following:
   1. Cable Labels: Self-adhesive vinyl or vinyl-cloth wraparound tape markers, machine printed with alphanumeric cable designations.

2.7 NETWORK SWITCHES

A. Access Switches 48 ports POE+

Feature	Required Minimum Specifications
Type	10/100/1000 MB layer 2 switch, rackmount (Stackable or virtual stack), should have minimum two ports 10Gb SFP+ Fully Managed
Ports	48 Ethernet 10/100/1000 ports, PoE+ required
Management	Built in Web based management support or Built in Console port SNMP v1, v2, v3 Should support auto-sensing and auto-negotiation Network Timing Protocol (NTP) or SNTP (Simple NTP)

B. Access Switches 48 ports Non-POE

Feature	Required Minimum Specifications
Type	10/100/1000 MB layer 2 switch, rackmount (Stackable or virtual stack), should have minimum two ports 10Gb SFP+ Fully Managed
Ports	48 Ethernet 10/100/1000 ports.
Management	Built in Web based management support or Built in Console port SNMP v1, v2, v3 Should support auto-sensing and auto-negotiation Network Timing Protocol (NTP) or SNTP (Simple NTP)

C. Access Switches 24 ports POE+

Feature	Required Minimum Specifications
Type	10/100/1000 MB layer 2 switch, rackmount (Stackable or virtual stack), should have minimum two ports 10Gb SFP+ Fully Managed
Ports	24 Ethernet 10/100/1000 ports, PoE+ required
Management	Built in Web based management support or Built in Console port SNMP v1, v2, v3 Should support auto-sensing and auto-negotiation Network Timing Protocol (NTP) or SNTP (Simple NTP)

D. Access Switches 24 ports Non-PoE

Feature	Required Minimum Specifications
Type	10/100/1000 MB layer 2 switch, rackmount (Stackable or virtual stack), should have minimum two ports 10Gb SFP+ Fully Managed
Ports	24 Ethernet 10/100/1000 ports,
Management	Built in Web based management support or Built in Console port SNMP v1, v2, v3 Should support auto-sensing and auto-negotiation Network Timing Protocol (NTP) or SNTP (Simple NTP)

E. Core Switch

Feature	Required Minimum Specifications
Type	Modular layer 3 core switch, rackmount, Supports 10Gb
Ports	12 Ethernet 10 Gb ports 10 Ethernet 10/100/1000 Mb ports, 24 SFP+ Fiber 10Gb ports to connect to access switches Transceivers required for all types of ports
Management	Built in Web based management support or Built in Console port SNMP v1, v2, v3 Should support auto-sensing and auto-negotiation Network Timing Protocol (NTP) or SNTP (Simple NTP)
High Availability	Support high availability active/passive, Spanning Tree and rapid Spanning Tree, Link Aggregation Protocol
Services	Support routing protocol (RIP, OSPF), Route, Policy-based routing
Security	Access Control List (ACL), IEEE 802.1x, DHCP protraction, Port Security
Power Supply Units	Two redundant

2.8 WIRELESS SYSTEM

A. Access Points Specifications (Normal density)

Wi-Fi standard	- **802.11a/b/g/n/acW2**
Radios	- Dual 2.4 GHz and 5 GHz, up to 80 MHz maximum bandwidth
MIMO radio design: spatial streams	- 3x3:2 MU/SU-MIMO
Density	- Normal
Interfaces	- Uplink: 1x 10/100/1000BASE-T Ethernet (RJ-45, PoE) - USB 2.0 - Management console port (RJ-45)

B. Access Points Specifications (high density)

Wi-Fi standard	- **802.11a/b/g/n/acW2**
Radios	- Dual 2.4 GHz and 5 GHz, up to 80 MHz maximum bandwidth
MIMO radio design: spatial streams	- 3x3:2 MU/SU-MIMO
Density	- High
Interfaces	- Uplink: 1x 10/100/1000BASE-T Ethernet (RJ-45, PoE) - USB 2.0 - Management console port (RJ-45)

C. Outdoor Access Points Specifications

Wi-Fi standard	- **802.11a/b/g/n/acW2**
Radios	- Dual (2.4 and 5 GHz)
MIMO radio design: spatial streams	- 4x4:3 MU/SU-MIMO
Interfaces	- 2x10/100/1000BASE-T auto-sensing (RJ-45) - USB 2.0 - Management console port (RJ-45)

D. Controller specifications:
1. Scale for a total number of 500AP
2. Scale for a total of 20,000 clients
3. Optimize 802.11ac Wave 2 next-generation networks with 20 Gb throughput
4. Dual 10G connectivity from each controller to the core switches
5. Active / and HA

E. Controller features:
1. Radio Management capabilities
2. Application Visibility and Control
3. Quality of Service
4. Bi-directional rate limiting
5. shall support link aggregation and load sharing between Access Point and controller
6. The Controller shall provide Virtual Controller option, using Standard Container packaged, supported under VMWare

7. The controller shall support hardware encrypted data plane between Access Point and Controller
8. The controller shall be proposed with complete feature set including licensed feature
9. High Availability mode shall support tunnel as well as local switching mode and Mesh mode
10. High Availability mode shall allow geographically dispersed installation between Controllers
11. The controller failover shall not cause client connection drop and re-association
12. The redundant Controller shall sync Access Point and Client Status, including DHCP IP lease status
13. Access Point shall be able to proactively distributes Client connection before and after association and tracking client condition in real time using data packet RSSI
14. The controller shall support Inter-Controller Wireless Roaming
15. The controller shall maintain per-user Application usage and .11r fast roaming key across mobility domain
16. The controller shall support Cellular offload by PMIPv6 tunneling to Mobile Core network
17. The controller shall support multiple RF Management policy, including Transmit Power Control and Dynamic Channel Assignment on both 2.4GHz and 5Ghz
18. The controller shall be able to identify and avoid interferences with network performance impact analysis report
19. The controller shall support dynamic, automatic channel bandwidth (20~80Mhz) allocation using 802.11h
20. Vendor shall support fair throughput with HD clients' environment. Vendor shall provide 3rd party test result, using minimum 100 clients
21. The controller shall support application recognition and prioritization
22. The controller shall provide policy-based mDNS gateway including Chromecast gateway
23. The controller shall support new application signatures without upgrading controller software
24. The controller shall provide MS Lync Certification
25. The controller shall provide Device Profiling using multiple profiling method to reduce false-detection
26. The system shall provide secure onboarding service for both employee and guest based on standard-based security protocol
27. The controller shall be able to embedded custom web portal page (HTML) to fully customize user experience without additional cost or extra box
28. The controller shall provide rule-based rogue classification and automatically run rogue mitigation action
29. The controller shall be able to detect employee device connection to Rogue Access Point and contain it automatically
30. The system shall support control plane encryption on both IPv4 and IPv6
31. The Controller's image upgrade shall be done through secure, encrypted transport
32. The controller shall provide FIPS-140/CC certification, including certification pending
33. The controller shall support mapping of specific VLANs to single SSID, depending on Access Point location and user
34. The controller shall support automatic VLAN assignment per SSID to load-balance user connection.
35. assigned VLAN pool shall be same as number of available VLAN in the system
36. The controller shall support embedded best practice configuration guide and recommendation
37. The system shall support monitoring and provisioning from Mobile App, supporting iOS and Android
38. The controller shall provide concentrator mode access for all of telecommuter user and business traveler

2.9 SOFTWARE MANAGEMENT SPECIFICATIONS:

1. The solution should allow to manage, visualize and monitor the network from a single graphical interface.
2. The solution should support the total number of Access Points and should be installed over VM.
3. The features needed include network service provisioning, monitoring and assurance.
4. In addition, the solution should support:
5. Converged solution delivers all the existing wireless capabilities for radio frequency (RF) management, user access visibility, reporting, and troubleshooting along with network infrastructure lifecycle functions such as discovery, inventory, configuration and image management, compliance reporting, integrated best practices, and reporting.
6. Maps engine supporting high-resolution images with pan and zoom controls. Search within maps should also supported.
7. Should automatically create maps and assign access points to maps using regular expressions. Should allow creating campus, building, and floor hierarchies and assigning access points to the floor.
8. Should provide the ability to automatically identify the switch and port information for a rogue access point connected to the switch, to allow to quickly identifying and mitigating the threat posed by a rogue access point and attached end clients
9. Ability to discover and monitor third-party switches
10. Ability to configure events notifications, alerts and advanced reporting.
11. The solution should simplify the day-to-day operational tasks associated with managing the network infrastructure for all devices including; routers, switches, access points, and more.
12. The solution should deliver application-level visibility through the normalization, aggregation, and correlation of rich performance instrumentation data to help ensure application delivery and an optimal end-user experience.
13. Zero-touch AP and PoE Switch deployment, AP & Switch shall be able to discover Controller and NMS over WAN and automatically join to it without pre-staging
14. Network Management shall be able to display Top-N Application and User by Site, Controller and per AP
15. Network Management System shall be able to provide Network Topology View for both Wired and Wireless Network domain
16. Central Network Management shall be able to manage WLAN network regardless its controller-based or controller-less AP
17. Network Management System shall be able to provide RF health dashboard that provide geographic map view and historical AP Health index

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 APPLICATION OF MEDIA

A. Backbone Cable for Data Service (incoming from campus): Use fiber-optic cable.

B. Horizontal Cables for Data Service: **Use F/UTP cable complying with Category 6A of EIA/TIA-568-C.2** for runs between wiring closets and workstation outlets (except where indicated on tender documents that fiber-to-the-desk architecture is used).

3.3 INSTALLATION

A. Select and edit one of first two paragraphs below to suit Project.

B. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where cable wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and wiring except in unfinished spaces.

D. Retain category below to match selection in Part 2.

E. Install cable using techniques, practices, and methods that are consistent with Category 6A (depending on the specified requirements) rating of components and that ensure Category 6A performance (depending on the specified requirements) of completed and linked signal paths, end to end.

F. Install cable without damaging conductors, shield, or jacket.

G. Do not bend cable in handling or in installing to smaller radii than minimums recommended by manufacturer.

H. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
   1. Pull cables simultaneously if more than one is being installed in the same raceway.
   2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
   3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage media or raceway.

I. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.

J. Secure and support cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

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

L. Separation of Wires: Comply with EIA/TIA-569 rules for separating unshielded copper communication and data-processing equipment cables from potential EMI sources, including electrical power lines and equipment.

M. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect and patch panels.

N. Use splice and tap connectors compatible with media types.

3.4 INSTALLATION IN EQUIPMENT ROOMS AND WIRING CLOSETS

A. Mount patch panels, terminal strips, and other connecting hardware in adequate telecommunication cabinets, unless otherwise indicated.

B. Group connecting hardware for cables into separate logical fields.

C. Use patch panels to terminate cables entering the space, unless otherwise indicated.

3.5 IDENTIFICATION

A. Identify system components complying with applicable requirements in Division 16 Section **"Basic Electrical Materials and Methods", "Electrical Identification"** and the following Specifications.

B. System: Use a unique, three-syllable alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
   1. First syllable identifies and locates wiring closet or equipment room where cable originates.
   2. Second syllable identifies and locates cross-connect or patch-panel field in which cable terminates.
   3. Third syllable designates type of media (copper or fiber) and position occupied by cable pairs or fibers in the field.

C. Workstation: Label cables within outlet boxes.

D. Distribution Racks and Frames: Label each unit and field within that unit.

E. Within Connector Fields, in Wiring Closets and Equipment Rooms: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both communication and data-processing equipment, use a different color for jacks and plugs of each service.

F. Cables, General: Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

G. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).

H. Cable Schedule: Post in prominent location in each wiring closet and equipment room. List incoming and outgoing cables and their designations, origins, and destinations. Protect with

rigid frame and clear plastic cover. Provide electronic copy of final comprehensive schedules for Project, in software and format selected by Owner.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform field quality-control testing. The installer shall provide all test results in the format required by the testing party and fulfill all additional tests, repairs, rewiring, material replacement….etc such that all requirements deemed necessary by the testing party to confirm compliance with the tender documents and client's operator are satisfied.

B. Testing: On installation of cable and connectors, 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.
   1. Copper Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2 bi-directional Category 6A tester similar to PentaScan or WireScop Pro. Test for faulty connectors, splices, and terminations. Test according to EIA/TIA-TSB 67, "Transmission Performance Specifications for Field Testing of unshielded Twisted-Pair Cabling Systems." Link performance for F/UTP cables must meet minimum criteria of EIA/TIA-568 or ISO/IEC 11801.
   2. Fiber-Optic Cable Procedures: Perform each visual and mechanical inspection and electrical test, including optional procedures, stated in NETA ATS, Section 7.25 or IEC 11801. Certify compliance with test parameters and manufacturer's written recommendations. Test optical performance with optical power meter capable of generating light at all appropriate wavelengths.

C. Correct malfunctioning units at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

D. Category 6 links and channels must be certified & guaranteed to pass all ANSI/EIA/TIA, IEC and EN standards requirements.

3.7 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.
   1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
   2. Train designated personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and extending wiring to establish new workstation outlets.
   3. Review data in maintenance manuals."
   4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
   5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.9 MEASUREMENT

All items below shall contain but not limited to the following:

A. PATCH PANELs

Refer to BOQ for Detail.

B. DATA OUTLETS SHALL HAVE THE FOLLOWINGS:

1. Wall telecommunication socket outlet CAT.6A 10GIGA with shutter, to include CAT.6A F/UTP cable to corresponding patch panel.

SECTION 16770 – PUBLIC ADDRESS AND AV EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. All Public Address and audio drawings, Bill of Quantity, Design criteria and general provisions of the Contract, including General and Supplementary.

1.2 SUMMARY

A. This Section includes Public Address System, Music System with related Amplifiers, Audio Matrix, Panel, Speakers, Speakers select unit, Microphone, CD Player, Tuner, Personal Computer and relative devices, and Video projector System.

B. Related Sections include the following:
   1. Divisions 15 & 16 of the specifications.

1.3 DEFINITIONS

A. Definitions in NFPA 70 apply to terms used in this Section.

B. EIA – Electronic Industries Association

C. IEC 149 – Sockets and Accessories for Electronic Plug-In Devices

D. IEC 268 – Sound System Equipment

E. IEC 574 – Audio-Visual, Video and Television Equipment and System

1.4 SYSTEM DESCRIPTION

A. General: Public Address and Background music covering the whole project with number of paging zones divided as shown on related drawings for paging and background music, individually per zone or in group; Video projector system for Ball Room.

1.5 SUBMITTALS

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

B. Shop Drawings:
   1. Wiring Diagrams: Detail wiring and differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
   2. Battery: Sizing calculations.
   3. Floor Plans: Indicate final outlet locations and routings of raceway connections.
   4. Device Address List: Coordinate with final system layout.
   5. 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.
   6. Paging Zone schedule & sequence of operation in case of fire alarm.

7. Details of graphics display panel

C. Coordination Drawings: Plans, sections, and elevations drawn to scale and showing installation details.

D. Operating Instructions: For mounting main audio rack.

E. Product Certificates: Signed by manufacturers of system components certifying that products furnished comply with requirements.

F. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.

G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Comply with NFPA 70

H. Maintenance Data: To include in maintenance manuals specified in Division 1. Comply with NFPA 70 or EIA and IEC.

I. Certificate of Completion: Comply with NFPA 70.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the Public Address System manufacturer, ISO 9002 certified for both installation and maintenance of units required for this Project.

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. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.

D. Single Source Responsibility: All components and accessories shall be product of single manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following for **public address and background music** with a possible combination of the listed below manufacturers, if necessary.
1. TOA Audio Systems, Germany
2. JBL
3. Russound
4. RCF Audio & Sound Systems, Italy
5. Samsung Electronics
6. Sony
7. LG Electronics
8. Alpha Communications.
9. Altec Lansing Technologies, Inc.
10. Atlas Sound LP.
11. Bogen Communications, Inc.
12. Dukane Communication Systems; part of GE Infrastructure, Security.
13. Edwards Signaling & Security Systems; part of GE Infrastructure, Security.
14. Electro-Voice; Telex Communications, Inc.
15. Federal Signal Corporation; Electrical Products Division.
16. Peavey Electronics.
17. Rauland-Borg Corporation.
18. Whelen Engineering Company, Inc.

2.2 COMMON AREAS

A. Power Amplifier: Single Channel: 100W / 100V:
1. Rated Output Power (T.H.D 0.1%, AES17) 100W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8
4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃
10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 130W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

B. Power Amplifier: Single Channel: 240W / 100V:
1. Rated Output Power (T.H.D 0.1%, AES17) 240W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8
4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃

10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 200W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

C. Power Amplifier: Single Channel: 600W / 100V:
1. Rated Output Power (T.H.D 0.1%, AES17) 600W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8
4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃
10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 200W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

D. Audio Matrix/DSP
1. Advanced Audio Matrix System
2. 8 in 8 out Analog Audio and input/output configuration
3. Play source through SD Card
4. PC Program / Mobile App for system control and management
5. Power Source: AC 100 – 240V 50/60Hz
6. Weight 3.6 Kg
7. Dimensions: 482 x 44 x 320

E. Audio Monitor Panels:
1. Output power monitoring
2. Led Level Meter
3. Built In Monitor Speaker
4. 8 Simultaneous Outputs
5. Weight> 3.5 KG
6. Dimensions 382 x 88 x 280

F. Wired Touch Panel:
1. Advanced Touch Screen Control
2. Smart Graphics
3. Soft Touch Buttons
4. Built in camera
5. Voice recognition
6. Streaming Video and Web Browsing
7. Rava SIP Intercom
8. Native Sonos App
9. On Screen Keyboard and Multi Touch Support
10. Audio Feedback
11. Single-wire connectivity
12. Power over Ethernet
13. Simple, versatile, and secure mounting
14. Tabletop Option

G. Control System
1. High speed real-time multitasking to run multiple programs simultaneously
2. Ethernet and IP Control
3. Features control apps, XPanel, and Crestron Fusion Cloud
4. On board control ports
5. Onboard 512MB RAM & 4GB flash memory (Expandable up to 1TB)
6. High speed USB 2.0 host port

7. Increased network throughput and security

H. Ceiling Speakers: Type 1
1. Rated 20W / 2 Way
2. SPL 88 dB / Freq. resp. 200hz ~ 20Khz
3. 8 / 500 / 1k / 2k
4. Cutout Diameter: 20 CM
5. Weight: 2KG
6. Dimensions: 230mm x 180 mm

I. Ceiling Speakers: Type 2 (in Elevators)
1. Rated 3W
2. SPL 86 dB / Freq. resp. 260hz ~ 12kHz
3. 3.3Kω
4. Cutout Diameter: 10.5 CM
5. Weight: 230G
6. Dimensions: 120 mm x 41 mm

J. Volume Control
1. Installation without ID setting
2. Remote volume control and selection of BGM
3. Independent local MIC and BGM broadcasting
4. Flush-Mounts in a single-gang electrical box
5. Power Source: 24VDC
6. Weight: 130g / 0.28LB
7. Dimensions: 70mm x 114mm x 52mm

K. Internet Radio / USB / CD Player

L. CD Player
1. Anti-Shock CD Player
2. Can play CD-DA, WMA, WAV, and MP3
3. USB Playback
4. Can be controlled by Crestron remote control
5. Weight: 4.7 KG
6. Dimensions: 482 mm x 88 mm x 280 mm

M. Internet Radio
1. +13,000 free internet radio stations
2. Wi-Fi and Ethernet connection to route.
3. Bandwidth: 20hz – 20khz
4. RJ-45 connector
5. Weight: 3.3 Kg
6. 482 mm x 280mm x 44mm

N. Paging Microphone
1. Used in a single and expansion system
2. All & 8 Zones Paging
3. Remote mic for paging broadcast
4. Voice input using gooseneck condenser mic
5. 2,4” OLED display
6. Broadcasting zone selection & control through 10 key button
7. Connected to NPX-8000 via RM Link Terminal
8. Power supply via RM Link terminal or power adapter

O. Equipment Rack
1. Contemporary, sleek appearance, Strong frame structure
2. Multiple vendor equipment compatibility
3. Full line of accessories & a Family of sizes and styles
4. Width: EIA Standard 19″ Rack Rails

5. External Width: 23.6″ – 600mm
6. Height: 78.74″ – 2,000mm – Rack Units: 42U
7. Depths: 39.37″ & 41.34″
8. Racks in other dimensions are available.
9. Sidewalls, Split rear doors
10. Baying Kits, tool less Shelves, casters, Bolt Down Kits, Cable Management
11. Power Strips – vertical or Rackmount, Enclosure Monitoring System
12. Toolless Blanking Panels, Fans

2.3 RESTAURANT 1 – DAPINO

A. Audio Amplifiers
1. 240W / 100V
2. SMPS (High Efficiency and low weight)
3. 5 Zone Output and all zone selectable
4. Tone Control (Bass/Treble)
5. 3 XLR input
6. 2 Mic input or line input (Phone jack)
7. Front USB input (Mp3, Wav, WMA)
8. Large 2.8” LCD display
9. USB Audio Stream
10. Network Audio: Audio Signal and radio can be broadcasted in real time
11. Power Source: 220V – 240VAC 50/60Hz
12. Dimensions: 420mm x 88mm x 328mm

B. Ceiling Speakers: Type 1
1. Rated 20W / 2 Way
2. SPL 88 dB / Freq resp 200hz ~ 20Khz
3. 8 / 500 / 1k / 2k
4. Cutout Diameter: 20 CM
5. Weight: 2KG
6. Dimensions: 230mm x 180 mm

C. Internet Radio / USB / CD player:
1. CD Player:
   a. . Anti-Shock CD Player
   b. . Can play CD-DA, WMA, WAV, and MP3
   c. . USB Playback
   d. . Can be controlled by Crestron remote control
   e. . Power Consumption: 12W
   f. . Weight: 4.7 KG
   g. . Dimensions: 482 mm x 88 mm x 280 mm

2. Internet Radio:
   a. +13,000 free internet radio stations
   b. Wi-Fi and Ethernet connection to route.
   c. Bandwidth: 20hz – 20khz
   d. RJ-45 connector
   e. Weight: 3.3 Kg
   f. 482 mm x 280mm x 44mm
   g. Dimensions: 482 mm x 88 mm x 280 mm

2.4 RESTAURANT 2 – DINING ROOM

A. Audio Amplifier 1 (For Ceiling Speakers): Single Channel: 240W / 100V
1. Rated Output Power (T.H.D 0.1%, AES17) 240W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8

4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃
10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 200W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

B. Audio Amplifier 2 (For Wall Speakers): Single Channel: 600W / 100V
1. Rated Output Power (T.H.D 0.1%, AES17) 600W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8
4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃
10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 200W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

C. Wall Speakers
1. 6.5”, ABCS Resin
2. 80W Continuous, 8 90dB Sensitivity
3. Coverage: 120* Near, 60* Far
4. Weight: 3.5kg
5. Dimensions: 210mm x 311mm x 169mm

D. Ceiling Speakers: Type 1
1. Rated 20W / 2 Way
2. SPL 88 dB / Freq resp 200hz ~ 20Khz
3. 8 / 500 / 1k / 2k
4. Cutout Diameter: 20 CM
5. Weight: 2KG
6. Dimensions: 230mm x 180 mm

E. Internet Radio / USB / CD player:

1. CD Player:
   a. Anti-Shock CD Player
   b. Can play CD-DA, WMA, WAV, and MP3
   c. USB Playback
   d. Can be controlled by Crestron remote control
   e. Power Consumption: 12W
   f. Weight: 4.7 KG
   g. Dimensions: 482 mm x 88 mm x 280 mm
2. Internet Radio:
   a. +13,000 free internet radio stations
   b. Wi-Fi and Ethernet connection to route.
   c. Bandwidth: 20hz – 20khz
   d. RJ-45 connector
   e. Weight: 3.3 Kg
   f. 482 mm x 280mm x 44mm

2.5 RESTAURANT 2 – DINING ROOM

A. Audio Amplifier 1 (For Ceiling Speakers): Single Channel: 240W / 100V

1. Rated Output Power (T.H.D 0.1%, AES17) 240W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8
4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃
10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 200W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

B. Audio Amplifier 2 (For Wall Speakers): Single Channel: 600W / 100V

1. Rated Output Power (T.H.D 0.1%, AES17) 600W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8
4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃
10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 200W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

C. Wall Speakers

1. 6.5” , ABCS Resin
2. 80W Continuous, 8 90dB Sensitivity
3. Coverage: 120* Near, 60* Far
4. Weight: 3.5kg
5. Dimensions: 210mm x 311mm x 169mm

D. Ceiling Speakers: Type 1

1. Rated 20W / 2 Way
2. SPL 88 dB / Freq resp 200hz ~ 20Khz

3. 8 / 500 / 1k / 2k
4. Cutout Diameter: 20 CM
5. Weight: 2K
6. Dimensions: 230mm x 180 mm

E. Internet Radio / USB / CD player

1. CD Player
   a. Anti-Shock CD Player
   b. Can play CD-DA, WMA, WAV, and MP3
   c. USB Playback
   d. Can be controlled by Crestron remote control
   e. Power Consumption: 12W
   f. Weight: 4.7 KG
   g. Dimensions: 482 mm x 88 mm x 280 mm
2. Internet Radio
   a. +13,000 free internet radio stations
   b. Wi-Fi and Ethernet connection to route.
   c. Bandwidth: 20hz – 20khz
   d. RJ-45 connector
   e. Weight: 3.3 Kg
   f. 482 mm x 280mm x 44mm

2.6 GUEST ROOMS

A. LED TV Type:

1.	40 Inches, 4K Full HD	
2.	Active Crystal Color	Quad Core Processor
3.	Slim Design	Nano Crystal Technology
4.	Smart Remote	UHD Up scaling
5.	EHD Upscaling Picture Engine	Contrast Enhancer
6.	HDR Premium	Ultra Clear Panel
7.	Smart TV / Smart View 2.0	Briefing on TV / Full Web Browser
8.	Built in Wi-Fi	Connect Share Movie

B. LED TV Type 2

1.	50 inches, 4K Full HD	
2.	. Nano Crystal Technology	Quad Core Processor
3.	. Smart Remote	UHD Upscaling
4.	. EHD Upscaling Picture Engine	Contrast Enhancer
5.	. HDR Premium	Ultra Clear Panel
6.	. Smart TV / Smart View 2.0	Briefing on TV / Full Web Browser
7.	. Built in Wi-Fi	Connect Share Movie
8.	. Slim Design	

C. Remote Control

D. Infrared Keyboard

E. IPTV –Set Top Box Player (STB)

1. “Carrier class” Wi-Fi capability – add a simple USB dongle for high quality HD content delivery around the home
2. Pause Live TV and trick play support
3. HTTP Live Streaming (HLS) with trick play and record – delivering a great uninterrupted DVR-like user experience even in high latency networks
4. TML5 compliant browser – designed to maximize the user experience with web-delivered content

5. compatible with our Fusion Home solutions to enable you to offer a unique home monitoring service that is easily integrated with your existing TV service offering; a seamless experience with on-screen motion alerts, live PiP and event playback.
6. Size and weight: 114mm x 100mm x 35mm. 280g (excluding accessories and packaging).
7. Inputs: Ethernet 10/100 BaseT via RJ-45 shielded connector.
8. Outputs: HDMI 1.3a. (Excl. Deep color and DTS audio) with HDCP. S/PDIF (optical). USB2.0. 10-way Mini-DIN for Composite video, Component (YPrPb), RGB, S-Video and analogue audio. RF Modulator and loop through.
9. Power: 5V DC at 1.5A via external power supply. Less than 8W typical usage (external supply input voltage 100-240V AC 50-60Hz, 0.8A max, output 5VDC 3A)
10. Video resolutions: Decodes up to 720p and 1080i. Displays up to 1080p
11. Graphics resolutions: HD graphics up to 1280×720.

2.7 GYM

A. Ceiling Speakers:
1. Type 1
2. Rated 20W / 2 Way
3. PL 88 dB / Freq resp 200hz ~ 20Khz
4. 8 / 500 / 1k / 2k
5. Cutout Diameter: 20 CM
6. Weight: 2KG
7. Dimensions: 230mm x 180 mm

B. Internet Radio / USB / CD player:
1. CD Player
2. Anti-Shock CD Player
3. Can play CD-DA, WMA, WAV, and MP3
4. USB Playback
5. Can be controlled by Crestron remote control
6. Power Consumption: 12
7. Weight: 4.7 KG
8. Dimensions: 482 mm x 88 mm x 280 mm
9. Internet Radio
10. +13,000 free internet radio stations
11. Wi-Fi and Ethernet connection to route.
12. Bandwidth: 20hz – 20khz
13. RJ-45 connector
14. Weight: 3.3 Kg
15. 482 mm x 280mm x 44mm

C. Volume Control:
1. Installation without ID setting
2. Remote volume control and selection of BGM
3. Independent local MIC and BGM broadcasting
4. 1.3” OLED Display
5. Flush-Mounts in a single-gang electrical box
6. RS-422 Communication for long distance
7. Power Source: 24VDC
8. Weight: 130g / 0.28LB
9. Dimensions: 70mm x 114mm x 52mm

D. Volume Control with input:
1. Used in a single and expansion system
2. Wall type local machine audio input
3. 1 x XLR audio input (MONO ,Gain control)
4. Phantom power support

5. RCA Audio input (Stereo)
6. LM Link in terminal

2.8 MEETING ROOMS

A. LED Monitor TVs:
1. 65 Inches, Full HD 1080P
2. Wide Color Enhancer
3. Micro Dimming Pro
4. Quad Core Processor
5. Motion Rate 120
6. Eco Sensor
7. Smart TV / Smart View 2.0
8. Full Web Browser
9. Anynet+

B. 4K Video Projector with Interchangeable Lens:
1. Advanced SXRD panels for ultra-smooth 4K, 3D, and 2D pictures A high pressure 330W lamp that generates intense brightness up 2000 ANSI-lumens for vibrant contract on screens up to 510 cm diagonally
2. Advanced SXRD panels for ultra-smooth 4K, 3D, and 2D pictures
3. Clear, dynamic movies with 1,000,000:1 and 2000 IM brightness
4. Reality creation engine for 4K Upscaling
5. Smoother and sharper images with Motion flow XR
6. Vivid colors with Triluminos display

C. Motorized Lifts for Projectors:
1. Designed for heavy duty use
2. All Metal construction
3. Rack and Pinion drive
4. Quiet Operation
5. Low voltage, radio frequency or infrared remotes
6. 3 position control switch; two electrical outlets furnished on the platform
7. Unit Weight: 40kg | Weight capacity: 136kg
8. Overall Dimensions: 78cm x 51cm x 86cm

D. Motorized Projection Screens:
1. Dimensions: 198 cm x 353 cm (159”)
2. Motor Mounting System
3. Smooth Roll Technology to keep screen perfectly flat
4. Tensioning cable system
5. Decora-Style three position wall switch

E. HDMI Presentation Switcher:
1. Ultra high-definition, multi-format presentation switcher, scaler, mic preamp, audio DSP, and control system
2. Out of the box Crestron Connect It™ collaboration system functionality
3. Supports up to four TT-100 series Crestron Connect It Cable Caddies [1]
4. Built-in .AV Framework™ delivers a fully-functional system without any programming [3]
5. Integrated 3-Series Control System® allows fully-programmable room control
6. Includes four auto-switching HDMI®, VGA, and stereo analog audio inputs [6]
7. Includes two DM 8G+® inputs
8. Also supports Dual-Mode Display Port, DVI, HDBaseT®, and analog video sources [4,5]
9. Input auto-detection configures each input automatically
10. QuickSwitch HD™ technology manages HDCP keys for fast, reliable switching
11. Auto-Locking® technology achieves rapid switching between disparate sources
12. Performs automatic AV signal format management via EDID

13. Provides adjustable input level compensation on each audio input
14. Includes a single microphone input with EQ, gating, and compression
15. Provides parallel HDMI and DM 8G+ outputs for one or more display devices
16. Digital Media 8G+® connectivity enables long-distance wiring over CAT type twisted pair cable [9]
17. Integrates seamlessly with Digital Media™ matrix switchers to allow facility-wide signal distribution
18. HDBaseT Certified — Enables direct connection to other HDBaseT certified equipment
19. Features a built-in, high-performance 4K scaler
20. Upscale input signals to match the native resolution of any screen — including 4K and Ultra HD displays!
21. Downscales 4K, UHD, and ultra-high-resolution computer signals to fit 1080p and other lower-resolution displays
22. Handles any input resolution from standard NTSC 480i or PAL 576i, to UHD and 4K
23. Provides intelligent frame rate conversion, content-adaptive noise reduction, and motion-adaptive de-interlacing
24. Provides 3D to 2D signal conversion, and passes 3D video (without scaling) to 3D displays [7]
25. Provides a balanced stereo audio output with graphic EQ, limiting, and delay
26. Enables analog-to-HDMI audio embedding and de-embedding [6]
27. Handles Dolby® TrueHD, Dolby Atmos®, DTS-HD®, and uncompressed 7.1 linear PCM audio [8]
28. Enables USB signal routing via DM transmitters and receivers or USB-EXT-DM extenders [10]
29. Includes onboard IR, RS-232, relay, digital input, and Cresnet® control ports
30. Supports Crestron® touch screens, keypads, and wireless remotes
31. Supports XPanel with Smart Graphics™ computer and web based control
32. Supports iPhone®, iPad®, and Android™ control apps
33. Supports universal remotes via built-in RC-5 compatible IR receiver
34. Communicates natively with Crestron Fusion® Cloud
35. Enables IT-friendly network integration via SNMP
36. Integrated Ethernet switch provides a single-point LAN connection
37. Private Network Mode — requires just one IP address for the complete system
38. Includes front panel controls for switching and volume adjustment
39. Includes customizable front panel label strips
40. Allows complete AV setup and adjustment via a web browser
41. Features an internal universal power supply for worldwide compatibility
42. Furnishes Power over DM® or HDBaseT for PoDM/PoH-powered devices
43. Mounts under the table or in a single 19” rack space.

F. HDMI TX/RX over UTP:
1. Digital Media 8G+® transmitter and multimedia interface
2. Built-in 2x1 AV switcher with auto-switching and analog audio-breakaway
3. QuickSwitch HD™ technology achieves fast, reliable switching
4. Connects to a DM® switcher or receiver over a single CAT type twisted pair cable [1]
5. Supports cable lengths up to 330 ft (100 m) using DM 8G® cable or CAT5e [1]
6. HDBaseT® Certified — Enables direct connection to other HDBaseT certified equipment
7. Provides HDMI® and RGB/component video inputs [4]
8. Also supports DVI and Dual-Mode DisplayPort sources [3]
9. Handles video resolutions up to Full HD 1080p
10. Handles computer resolutions up to WUXGA
11. Handles Dolby Digital®, DTS®, and uncompressed 7.1 linear PCM audio
12. HDCP compliant
13. Includes a mini-TRS stereo analog audio input
14. Detects and reports detailed video and audio input information
15. Performs automatic AV signal format management via EDID
16. Enables device control via CEC
17. Enables USB HID signal extension for a local keyboard/mouse

18. Allows quick, easy setup and diagnostics
19. 2-gang wall box mount design (2-3/4" deep)
20. Also fits in a typical 6” deep floor box
21. Available in black or white finish
22. Powered via the DM connection or local power pack (included)

G. Microphone:
1. 8 hours continuous battery life with AA alkaline or rechargeable batteries
2. Microphone clip
3. Automatic transmitter setup
4. 50 to 15000hz Frequency response
5. Legendary quality, ruggedness, and reliability
6. Unidirectional dynamic cardioid microphone
7. Backlist LCD with timeout feature
8. Frequency and power lockout
9. Weight: 290Grams
10. Dimensions: 254 mm x 51 mm

H. Audio Amplifier: Single Channel: 240W / 100V:
1. Rated Output Power (T.H.D 0.1%, AES17) 240W
2. Output Level/Impedance 100V/33.3
3. 70V/16.3 , 49V/8
4. Input Sensitivity 1V/10k
5. THD (AeS17) Rated Power Less than 0.1%
6. 1/3 Power Less than 0.03%
7. S/N (20kHz LPF) More than 103dB
8. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
9. Operating Temperature -10℃ ~ +40℃
10. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
11. Power Consumption (1/8 Power) 200W
12. Weight (SET) 6.1kg / 13.5lb
13. Dimensions (W x H x D)

I. Wired Touch-Panel:
1. Advanced Touch Screen Control
2. Smart Graphics
3. Soft Touch Buttons
4. Built in camera
5. Voice recognition
6. Streaming Video
7. Web Browsing
8. Native Sonos App
9. On Screen Keyboard
10. Multi Touch Support
11. Audio Feedback
12. Single-wire connectivity
13. Power over Ethernet
14. Simple, versatile, and secure mounting
15. Tabletop Option

J. Control System:
1. Enterprise-class control system
2. 3-Series® Control Engine — substantially faster and more powerful than other control systems
3. Exclusive modular programming architecture
4. Onboard 512MB RAM & 4GB Flash memory
5. Expandable storage up to 1TB
6. Rear panel memory card slot
7. High-speed USB 2.0 host port
8. Industry-standard Ethernet and Cresnet® wired communications

9. XPanel with Smart Graphics™ computer and web based control
10. iPhone®, iPad®, and Android™ control app support
11. Crestron Fusion® Cloud Enterprise Management Service support
12. SNMP remote management support
13. One RS-232/422/485 COM port with hardware and software handshaking
14. Two RS-232 COM ports with software handshaking only
15. Eight IR/serial, eight relay, and eight Versiport I/O ports
16. Programmable event scheduling with astronomical time clock
17. Native BACnet™/IP support [1]
18. Installer setup via Crestron Toolbox™ software or web browser
19. C#, symbol based, and drag-and-drop programming environments
20. Full Unicode (multi-language) support
21. Increased network throughput and security
22. Secure access through full user/group management or Active Directory integration
23. Hardware level security using 802.1X authentication
24. JITC certified model available for use in secure network environments
25. TLS, SSL, SSH, and SFTP network security protocols
26. FIPS 140-2 compliant encryption
27. IIS v.6.0 Web Server
28. IPv6 ready
29. Front panel USB computer console port
30. 1-space rack-mountable

K. Ceiling Speakers:
1. 8 Inch treated paper with cloth surround & steel basket
2. 60 Watts, 8
3. Freq Resp: 80Hz to 20Khz
4. Coverage: 95 Degrees Conical
5. Weight: 4.9Kg
6. Dimensions: Diameter of 308mm and depth of 135mm

L. Table Cubby with HDMI VGA/Audio:

1. Cable Cubby Furniture-Mountable enclosures offer an elegant cable management solution, providing discreet access to AV cables and power. The enclosures blend seamlessly into aesthetically sensitive, high profile surroundings, mounting nearly flush with the tabletop. Cable Cubby enclosures are available in four sizes for AV connectivity and power needs; most models are available in a black anodized or brushed aluminum finish. The enclosures are fully customizable and accommodate a wide range of AV connectivity and control options.

M. Blu-Ray Player:
1. HDMI, USB, and Coaxial connectivity.
2. Supports Anynet+, BD Wise, and Allshare.
3. DTS, Dolby Digital+, and Dolby True HD.

N. IPTV –Set Top Box Player (STB):
1. “Carrier class” Wi-Fi capability – add a simple USB dongle for high quality HD content delivery around the home.
2. Pause Live TV and trick play support.
3. HTTP Live Streaming (HLS) with trick play and record – delivering a great uninterrupted DVR-like user experience even in high latency networks.
4. HTML5 compliant browser – designed to maximize the user experience with web-delivered content.
5. Compatible with our Fusion Home solutions to enable you to offer a unique home monitoring service that is easily integrated with your existing TV service offering; a seamless experience with on-screen motion alerts, live PiP and event playback.
6. Size and weight: 114mm x 100mm x 35mm. 280g (excluding accessories and packaging).
7. Inputs: Ethernet 10/100 BaseT via RJ-45 shielded connector.

8. Outputs: HDMI 1.3a. (excl. Deep color and DTS audio) with HDCP. S/PDIF (optical). USB2.0. 10-way Mini-DIN for Composite video, Component (YPrPb), RGB, S-Video and analogue audio. RF Modulator and loop through.
9. Power: 5V DC at 1.5A via external power supply. Less than 8W typical usage (external supply input voltage 100-240V AC 50-60Hz, 0.8A max, output 5VDC 3A).
10. Video resolutions: Decodes up to 720p and 1080i. Displays up to 1080p.
11. Graphics resolutions: HD graphics up to 1280×720.
12. Audio: Stereo audio and Dolby 5.1 surround via S/PDIF and HDMI. Dolby Digital+ passes through to external decoder.

2.9 PRE FUNCTION

A. TV:

1. 50 inches, 4K Full HD
2. Nano Crystal Technology — Quad Core Processor
3. Smart Remote — UHD Upscaling
4. EHD Upscaling Picture Engine — Contrast Enhancer
5. HDR Premium — Ultra Clear Panel
6. Smart TV / Smart View 2. — Briefing on TV / Full Web Browser
7. Built in Wi-Fi — Connect Share Movie
8. Slim Design

B. IPTV –Set Top Box Player (STB):

1. “Carrier class” Wi-Fi capability – add a simple USB dongle for high quality HD content delivery around the home
2. Pause Live TV and trick play support
3. HTTP Live Streaming (HLS) with trick play and record – delivering a great uninterrupted DVR-like user experience even in high latency networks
4. HTML5 compliant browser – designed to maximize the user experience with web-delivered content
5. Compatible with our Fusion Home solutions to enable you to offer a unique home monitoring service that is easily integrated with your existing TV service offering; a seamless experience with on-screen motion alerts, live PiP and event playback.
6. Size and weight: 114mm x 100mm x 35mm. 280g (excluding accessories and packaging)
7. Inputs: Ethernet 10/100 BaseT via RJ-45 shielded connector
8. Outputs: HDMI 1.3a. (Excl. Deep color and DTS audio) with HDCP. S/PDIF (optical). USB2.0. 10-way Mini-DIN for Composite video, Component (YPrPb), RGB, S-Video and analogue audio. RF Modulator and loop through.
9. Power: 5V DC at 1.5A via external power supply. Less than 8W typical usage (external supply input voltage 100-240V AC 50-60Hz, 0.8A max, output 5VDC 3A)
10. Video resolutions: Decodes up to 720p and 1080i. Displays up to 1080p
11. Graphics resolutions: HD graphics up to 1280×720

C. Ceiling Speakers:

1. Type 1
   a. . Rated 20W / 2 Way
   b. . SPL 88 dB / Freq resp 200hz ~ 20Khz
   c. . 8 / 500 / 1k / 2k
   d. . Cutout Diameter: 20 CM
   e. . Weight: 2KG
   f. . Dimensions: 230mm x 180 mm

2.10 BALL ROOM

A. 4K Video Projector with Interchangeable Lens:

1. Type 1:
   a. Advanced SXRD panels for ultra-smooth 4K, 3D, and 2D pictures A high pressure 330W lamp that generates intense brightness up 2000 ANSI-lumens for vibrant contract on screens up to 510 cm diagonally
   b. Advanced SXRD panels for ultra-smooth 4K, 3D, and 2D pictures
   c. Clear, dynamic movies with 1,000,000:1 and 2000 IM brightness
   d. Reality creation engine for 4K Upscaling
   e. Smoother and sharper images with Motion flow XR
   f. Vivid colors with Triluminos display

2. Type 2:
   a. Screen Size Range: 42-88 inches from 8 feet; 62-130 inches from 12 feet,
   b. 81-172 inches from 16 feet
   c. Resolution: Full 4K (4096 x 2160)
   d. White Brightness: 2000 Lumens; Color Brightness: 2000 Lumens; Calibrated Brightness (cinema 1 mode): 1315 Lumens
   e. Contrast Ratio: 1,000,000:1; Lens Shift: Vertical +/- 80%; Horizontal +/- 31%
   f. Warranty: 3 Year Limited
   g. Lamp Life: 2,500 hours
   h. Connectivity: HDMI (2); Y Pb/Cb Pr/Cr (pin jack); RGB/ Y Pb/Cb Pr/Cr (D-sub 15)

B. Motorized Lifts for Projectors:
   a. Designed for heavy duty use
   b. All Metal construction
   c. Rack and Pinion drive
   d. Quiet Operation
   e. Low voltage, radio frequency or infrared remotes
   f. 3 position control switch; two electrical outlets furnished on the platform
   g. Unit Weight: 40kg | Weight capacity: 136kg
   h. Overall Dimensions: 78cm x 51cm x 86cm

C. Motorized Projection Screens:

1. Type 1:
   a. . Dimensions: 198 cm x 353 cm (159”)
   b. . Motor Mounting System
   c. . Smooth Roll Technology to keep screen perfectly flat
   d. . Tensioning cable system
   e. . Decora-Style three position wall switch

2. Type 2:
   a. . Dimensions: 449 cm x 599 cm (254”)
   b. . Motor Mounting System
   c. . Smooth Roll Technology to keep screen perfectly flat
   d. . Tensioning cable system
   e. . Decora-Style three position wall switch

D. 4K Digital Media Matrix:
1. Delivers a unified HD signal distribution solution incorporating both point-to-point wired and IP streaming technologies
2. Provides lossless HD AV signal routing over twisted pair copper wire or fiber
3. Integrates video, audio, networking, and control over one wire or fiber strand
4. Enables high-performance H.264 streaming from any input source up to 1080p or WUXGA
5. Affords full matrix switching with ultra-high 12.5 Gbps backplane data rate

6. Handles HDMI® with Deep Color, 3D, 4K, and high-bitrate 7.1 encoded audio [3]
7. HDBaseT® Certified — Enables direct connection to other HDBaseT certified equipment
8. HDCP 2.2 compliant via compatible 4K input and output cards [3]
9. Distributes Full HD 1080p, Ultra HD, and 4K signals over CAT type twisted pair cable at distances up to 330 ft (100 m) via DM 8G+® and HDBaseT [4,9]
10. Distributes 1080p and WUXGA signals over multimode fiber at distances up to 1000 ft (300 m) via DM 8G® Fiber [5,9]
11. Distributes 1080p and WUXGA signals over single-mode fiber at distances up to 7.5 miles (12 km) via DM 8G SM Fiber [6,9]
12. Allows streaming of 1080p signals over an IP network with no distance limitations
13. Also supports all first-generation DM® CAT and DM Fiber products [7,8,9]
14. Configurable with up to 16 DM, HDBaseT, and/or HDMI outputs
15. Configurable with up to eight streaming outputs [1]
16. Easy output expansion using multiple DM switchers
17. Modular inputs support a complete range of digital, analog, and streaming signal types
18. QuickSwitch HD™ technology manages HDCP keys for fast, reliable switching
19. Auto-Locking® technology achieves rapid switching between disparate sources
20. Detects and displays detailed video and audio input information
21. Performs automatic AV signal format management via EDID
22. Allows independent scaling for every display through select output cards and DM receivers [12]
23. Enables device control via CEC
24. Distributes and routes USB HID mouse and keyboard signals [15]
25. Expanded USB routing capabilities available using USB over Ethernet Extenders [15]
26. Allows full audio and USB breakaway switching
27. Supports analog audio embedding and de-embedding
28. Integrates with analog audio distribution systems
29. Enables simultaneous output of stereo and surround sound audio
30. Includes integrated Ethernet switch with Gigabit LAN port
31. Private Network Mode — requires just one IP address for the complete DM system
32. Half-million hour rated internal universal power supply
33. 7-space 19-inch rack-mountable

E. 4K Digital Media Transmitter-Wall Type:
1. Digital Media 8G+® transmitter and multimedia interface
2. Built-in 2x1 AV switcher with auto-switching and analog audio-breakaway
3. QuickSwitch HD™ technology achieves fast, reliable switching
4. Connects to a DM® switcher or receiver over a single CAT type twisted pair cable [1]
5. Supports cable lengths up to 330 ft (100 m) using DM 8G® cable or CAT5e [1]
6. HDBaseT® Certified — Enables direct connection to other HDBaseT certified equipment
7. Provides HDMI® and RGB/component video inputs [4]
8. Also supports DVI and Dual-Mode DisplayPort sources [3]
9. Handles video resolutions up to Full HD 1080p
10. Handles computer resolutions up to WUXGA
11. Handles Dolby Digital®, DTS®, and uncompressed 7.1 linear PCM audio
12. HDCP compliant
13. Includes a mini-TRS stereo analog audio input
14. Detects and reports detailed video and audio input information
15. Performs automatic AV signal format management via EDID
16. Enables device control via CEC
17. Enables USB HID signal extension for a local keyboard/mouse
18. Allows quick, easy setup and diagnostics
19. 2-gang wall box mount design (2-3/4" deep)
20. Also fits in a typical 6” deep floor box
21. Available in black or white finish
22. Powered via the DM connection or local power pack (included)

F. 4K Digital Media Room Receiver:
1. Digital Media 8G+® receiver and display controller
2. Connects to a DM® switcher or transmitter over a single CAT type twisted pair cable [1]
3. HDBaseT® Certified — Enables direct connection to other HDBaseT certified equipment
4. Provides one HDMI® or DVI display output [2]
5. Handles video resolutions up to 4K and Ultra HD
6. Handles 3D video and Deep Color
7. Dolby® TrueHD, Dolby Atmos®, DTS-HD®, and uncompressed 7.1 linear PCM audio
8. HDCP 2.2 compliant
9. Supports cable lengths up to 100m for all resolutions up to UHD and 4K using DM Ultra cable [1]
10. Supports cable lengths up to 100m for 1080p, WUXGA, and 2K using DM 8G® cable or CAT5e
11. Supports cable lengths up to 70 m for UHD & 4K using DM 8G cable, or 50m using CAT5e
12. Provides a 10/100 Ethernet LAN connection
13. Enables device control via CEC, IR, RS-232, and Ethernet
14. Compatible with Crestron® USB over Ethernet Extenders [5]
15. Allows quick, easy setup and diagnostics
16. Low-profile surface mount design
17. Powered via the DM connection or local power pack (included)

G. Blu-Ray Player:
1. HDMI, USB, and Coaxial connectivity
2. Supports Anynet+, BD Wise, and Allshare
3. DTS, Dolby Digital+, and Dolby True HD

H. IPTV –Set Top Box Player (STB):
1. “Carrier class” Wi-Fi capability – add a simple USB dongle for high quality HD content delivery around the home
2. Pause Live TV and trick play support
3. HTTP Live Streaming (HLS) with trick play and record – delivering a great uninterrupted DVR-like user experience even in high latency networks
4. HTML5 compliant browser. Compatible with our Fusion Home solutions to enable you to offer a unique home monitoring service that is easily integrated with your existing TV service offering; a seamless experience with on-screen motion alerts, live PiP and event playback.
5. Size and weight: 114mm x 100mm x 35mm. 280g (excluding accessories and packaging)
6. Inputs: Ethernet 10/100 BaseT via RJ-45 shielded connector
7. Outputs: HDMI 1.3a. (Excl. Deep color and DTS audio) with HDCP. S/PDIF (optical). USB2.0. 10-way Mini-DIN for Composite video, Component (YPrPb), RGB, S-Video and analogue audio. RF Modulator and loop through.
8. Power: 5V DC at 1.5A via external power supply. Less than 8W typical usage (external supply input voltage 100-240V AC 50-60Hz, 0.8A max, output 5VDC 3A)
9. Video resolutions: Decodes up to 720p and 1080i. Displays up to 1080p
10. Graphics resolutions: HD graphics up to 1280×720
11. Audio: Stereo audio and Dolby 5.1 surround via S/PDIF and HDMI. Dolby Digital+ passes through to external decoder.

I. Audio DSP Matrix Mixer:
1. Engineered to deliver exceptional pro audio performance
2. Ready to go out of the box and extensively configurable
3. Hybrid channel strip architecture
4. Customizable inputs and outputs
5. Eight internal aux buses
6. Real-time configuration and adjustment
7. Work offline or live via Ethernet or USB

8. Native Crestron system integration for rapid programming [1]
9. Highest-quality converters, preamps, and line amps
10. Twelve mic/line inputs with 66 dB gain range
11. Eight +24 dB balanced line outputs
12. Internal universal power supply
13. Single-space 19” rack mountable

J. Gooseneck Microphones:
1. Frequency response: 50hz to 17Khz
2. Silent mute switch with LED indicator
3. Wide dynamic range and frequency response for accurate sound reproduction across the audio spectrum
4. Interchangeable cartridges provide the right polar pattern for every application
5. Balanced, transformer less output for increased immunity to electromagnetic hum and RF interference over long cable runs
6. Shock mount provides over 20 dB isolation from surface vibration noise
7. Locking flange mount for permanently securing microphone to lecterns or conference tables
8. Snap-fit foam windscreen

K. Wireless Microphones:
1. 8 hours continuous battery life with AA alkaline or rechargeable batteries
2. Microphone clip
3. Automatic transmitter setup
4. 50 to 15000hz Frequency response
5. Legendary quality, ruggedness, and reliability
6. Unidirectional dynamic cardioid microphone
7. Backlist LCD with timeout feature
8. Frequency and power lockout
9. Weight: 290Grams
10. Dimensions: 254 mm x 51 mm

L. CD/USB Players:
1. Anti-Shock CD Player
2. Can play CD-DA, WMA, WAV, and MP3
3. USB Playback
4. Can be controlled by Crestron remote control
5. Power Consumption: 12W
6. Weight: 4.7 KG
7. Dimensions: 482 mm x 88 mm x 280 mm

M. Ceiling Speakers:
1. 8 Inch treated paper with cloth surround & steel basket
2. 60 Watts, 8
3. Freq Resp: 80Hz to 20Khz
4. Coverage: 95 Degrees Conical
5. Weight: 4.9Kg
6. Dimensions: Diameter of 308mm and depth of 135mm

N. Audio Amplifiers:
1. Single Channel: 240W / 100V
2. Rated Output Power (T.H.D 0.1%, AES17) 240W
3. Output Level/Impedance 100V/33.3
4. 70V/16.3 , 49V/8
5. Input Sensitivity 1V/10k
6. THD (AeS17) Rated Power Less than 0.1%
7. 1/3 Power Less than 0.03%
8. S/N (20kHz LPF) More than 103dB
9. Frequency Response (1W, ±3dB) 50Hz ~ 20kHz
10. Operating Temperature -10℃ ~ +40℃

11. Operating Power 120VAC, 60Hz, 220-240VAC, 50/60Hz
12. Power Consumption (1/8 Power) 200W
13. Weight (SET) 6.1kg / 13.5lb
14. Dimensions (W x H x D)

O. Wired Touch Panel – Wall or Lectern Type:
1. Advanced Touch Screen Control
2. Smart Graphics
3. Soft Touch Buttons
4. Built in camera
5. Voice recognition
6. Streaming Video
7. Rava SIP Intercom
8. Web Browsing
9. Native Sonos App
10. On Screen Keyboard
11. Multi Touch Support
12. Audio Feedback
13. Single-wire connectivity
14. Power over Ethernet
15. Simple, versatile, and secure mounting
16. Tabletop Option

P. Control System:
1. Enterprise-class control system
2. 3-Series® Control Engine — substantially faster and more powerful than other control systems
3. Exclusive modular programming architecture
4. Onboard 512MB RAM & 4GB Flash memory
5. Expandable storage up to 1TB
6. Rear panel memory card slot
7. High-speed USB 2.0 host port
8. Industry-standard Ethernet and Cresnet® wired communications
9. XPanel with Smart Graphics™ computer and web based control
10. iPhone®, iPad®, and Android™ control app support
11. Crestron Fusion® Cloud Enterprise Management Service support
12. SNMP remote management support
13. One RS-232/422/485 COM port with hardware and software handshaking
14. Two RS-232 COM ports with software handshaking only
15. Eight IR/serial, eight relay, and eight Versiport I/O ports
16. Programmable event scheduling with astronomical time clock
17. Native BACnet™/IP support [1]
18. Installer setup via Crestron Toolbox™ software or web browser
19. C#, symbol based, and drag-and-drop programming environments
20. Full Unicode (multi-language) support
21. Increased network throughput and security
22. Secure access through full user/group management or Active Directory integration
23. Hardware level security using 802.1X authentication
24. JITC certified model available for use in secure network environments
25. TLS, SSL, SSH, and SFTP network security protocols
26. FIPS 140-2 compliant encryption
27. IIS v.6.0 Web Server
28. IPv6 ready
29. Front panel USB computer console port
30. 1-space rack-mountable

Q. Lectern Podium:
1. Floor Standing model
2. Incorporates a high intensity reading light and LED digital clock/timer with countdown capability.

3. Wood Finishing: TBD.

2.11 BOH – STAIRS – PARKING

A. Ceiling Speakers: Type B for BOH & Offices:
   1. Rated 3W
   2. SPL 86 dB / Freq. resp. 260hz ~ 12kHz
   3. 3.3kg
   4. Cutout Diameter: 10.5 CM
   5. Weight: 230G
   6. Dimensions: 120 mm x 41 mm

B. Wall Speakers for Stairs:
   1. Rated Input: 30, 20, 10W @ 100v line
   2. Frequency Response: 126Hz ~ 16KHz
   3. SPL (1M/1W): 93dB
   4. Modern, discreet styling
   5. Available in black or white
   6. Screw terminal connection
   7. High quality 100v line transformer
   8. Dimensions: 315(W) x 183(H) x 124(D)mm
   9. Weight: 2.2kg

C. Horn Speakers for Parking:
   1. Rated Input: 15W & 30W @ 100v line
   2. Frequency Response: 110Hz ~ 18kHz
   3. SPL: 93dB
   4. Indoor or outdoor use
   5. Wide frequency range with remarkable vocal clarity
   6. Excellent for public address systems
   7. Easy installation
   8. Dispersion control
   9. Dimensions: 294 x 209 x 320
   10. Weight: 3.4kg

D. Volume Control for offices:
   1. Rated Power: 30W
   2. Input Impendence: 1.4k - 330
   3. Method: Transformer
   4. MODERN STYLISH WALL PLATE
   5. ELEGANT DESIGN
   6. SIMPLE INSTALLATION
   7. SCREWLESS TERMINAL BLOCK WIRING
   8. FOUR-STEP VOLUME CONTROL
   9. Dimensions in mm: 68 x 120 x 38

PART 3 - CABLES & CONNECTORS

3.1 CABLES: FIRE RATED LSF SPEAKER CABLE 2X2MM² FOR PAGING AND BGM CEILING SPEAKERS

CONSTRUCTION

A. Individually Screened: Tinned copper conductor 22(7) AWG 0.35mm2, polypropylene insulation, red/black & green/white conductors, twisted into pairs, each pair aluminium/polyester foil screened, common tinned copper drain wire (24AWG), PVC sheath. The duct grade version has a black UV stable polyethylene sheath over the standard PVC cable to provide a high degree of weather resistance, while the armored version is protected by heavy galvanized steel wires and an external grade sheath.

B. Individually and Overall Screened: Tinned copper conductor 22(7) AWG 0.35mm2, polypropylene insulation, twisted into pairs, color code red/black & green/white, each pair individually screened with aluminium / polyester foil and 24AWG tinned copper drain wire, overall aluminium/polyester foil and 24AWG tinned copper drain wire, PVC sheath.

TECHNICAL INFORMATION:	
Voltage Rating:	300V
CE:	450/750V†
Temperature Rating:	+60°C
Nominal Impedance:	45 Ohms
Capacitance:	
Core to core:	115 pF/m
Core to screen:	203 pF/m
UL Style*:	
Individually & Overall Screened:	2717
Color Code:	Red / black & green / white

3.2 SINGLE PAIR SHIELDED CABLE FOR INTERCOM & AUDIO LINE

A. Features and Benefits.

B. 7-strand annealed bare copper conductors.

C. Plenum rated PVC alloy insulation.

D. Twisted, shielded with drain out.

E. Plenum rated PVC alloy jacket.

F. NEC CMP, CEC CMP FT6, RoHS compliant.

G. 1000 foot spools.

H. Applications.

I. Line Level, Microphone level Audio runs under 100 feet.

J. Balanced and unbalanced Audio formats.

K. Infrared (IR), RS-232C signaling.

3.3 SNAKE AUDIO CABLE 12 PAIRS EACH SHIELDED

A. Simplify field termination with three series of audio snake cables - jacketed plenum, Banana Peel® plenum, and water blocked.

B. Individually jacketed pairs eliminate the need for heat shrink, saving an extra step in installation and reducing labor costs.
   1. Each component is bundled and affixed to a center spline, eliminating the need for an overall jacket.
   2. Foil is bonded to the jacket for easier termination.
   3. Smaller OD occupies less space in conduit.
   4. Better bend radius than traditional jacketed products.
   5. Requires less effort and less installation time.

C. Part No.1818P.

D. UL NEC/ C(UL) CEC.

E. Type NEC: CMP CEC: CMP.

F. No. of Pairs12.

G. Standard Lengths (Ft.) 500 1000.

H. Standard Unit Weight (Lbs.)144.

I. Inner Pair Jacket O.D. (in.).119".

J. Nominal OD (In.).524.

K. Nominal DCR Conductor14.1 /M'.

L. Nominal DCR Shield (Inner Pair)10.5 /M'.

M. Nominal Capacitance (Between Conductors) 27 pF/Ft.

N. Nominal Capacitance (Between Conductor/ Shield)52 pF/F.

3.4 MICROPHONE 1 PAIR SHIELDED CABLE

A. Contractor balanced microphone cable - Flex

B. 2 x 0.32mm² / 22 AWG

C. Flamoflex™ IEC 60332-1 installation jacket

D. Stranded conductors

E. Double Al-Foil & braided shielding

F. INNER CONDUCTORS:

G. Tinned copper

H. SHIELDING:

I. Tinned copper BRAIDING

J. Aluminium Foil

K. Type of cable : Balanced microphone cable - 22 AWG stranded

L. Inner conductor : TC 30 x 0.12 mm

M. Inner conductor section : 0,34 mm²

N. Insulation : PE Ø 1.16 mm

O. Number of conductors : 2

P. Conductor twisting : Yes

Q. Shielding : TC 16 x 4 x 0.12 - braiding + TC 20 x 0.12 - drain wire

R. Outer jacket : NHFR

S. Outer Jacket Color : Black

T. Outer jacket dimensions : Ø 4.0 mm

U. Lead resistance - 100 m : 5.94 Ohm

V. Dielectric strength : 2 kV

W. American Wire Gauge : 22 AWG

3.5 2-18 AWG UTP WITH 2-22 AWG STP CONTROL CABLE FOR AUTOMATION

A. Data Pair Colors: Blue/white

B. Conductors: 22 AWG (0.33 mm²) x2 stranded bare copper

C. Insulation: Foam Polyolefin

D. Shield: Aluminum/Polyester (100% coverage)

E. Drain: 24 AWG (0.20 mm²) stranded tinned copper

F. Capacitance: 12.5 pF/ft (41 pF/m), nominal

G. Impedance: 100 Ohms, nominal

H. Power Pair Colors: Red/black Conductors: 18 AWG (0.82 mm²) x2 stranded bare copper

I. Insulation: PVC Shield: none Outer Jacket

J. Material: PVC

K. Thickness: 0.032 inch (0.813 mm) nominal

L. Outer Diameter: 0.250 inch (6.35 mm) nominal

3.6 DIGITAL MEDIA CABLE 4 PR 24AWG STP (SHIELDED)

A. Construction:
   1. F/UTP with four twisted pairs, inner jacket, drain, overall foil shield, ripcord, and overall jacket

B. Electrical & Performance:
   1. Mutual Capacitance: 17.1 pF / ft
   2. Velocity of Propagation: 69% Propagation
   3. Delay Skew: 45nS / 100 m
   4. DC Resistance: 28.6 Ohms / 1000 ft maximum
   5. DC Resistance Unbalance of a Pair: 5% maximum
   6. Capacitance Unbalance: 330 pF / 100 m
   7. Characteristic Impedance: 100 Ohms ±15% (1-250 MHz)

3.7 CAT6A DATA F/UTP CABLE FOR IPTV & NETWORK

A. Refer to Section 16715 Structure Cabling System.

3.8 RG58AU COAXIAL CABLE FOR WIRELESS MICROPHONES

A. 20 AWG stranded (19x33) .035" tinned copper conductor, polyethylene insulation, tinned copper braid shield (95% coverage), PVC jacket.

B. Conductor AWG: # Coax AWG Stranding Conductor.

C. Material Dia. (mm) 1 20 19x33.

D. TC - Tinned Copper 0.889.

E. Total Number of Conductors: 1.

F. Insulation Material: Insulation Material Dia. (mm) PE - Polyethylene 2.9464 Outer Shield Outer Shield Material: Type Outer Shield Material Coverage (%) Braid TC - Tinned Copper 95 Outer Jacket Outer Jacket Material: Outer Jacket Material Nom. Wall Thickness (mm) PVC - Polyvinyl Chloride 0.6985 Overall Cable Overall.

G. Nominal Diameter: 4.902 mm.

3.9 CONNECTORS

A. Connectors listed below are suggested for use with the specified cabling. The list may not include all of the connectors required to complete the installation of the systems. If a different cable is submitted for approval by the consultant, provide the appropriate connector for the cable as part of the cable submission.

1. Audio Mic/Line/Intercom: XLR Male Panel Mount Neutrik model :NC3MX
2. Mic/Line/Intercom: XLR Female Panel Mount Neutrik model: NC3FD
3. Combo Line XLR plus ¼” Phone Panel Mount Neutrik model:NCJ5FI-S
4. Mic/Line Multipin 12 Pair Female Panel Mount Whirlwind model:W1CM
5. Speaker 4-Pole Panel Mount Neutrik model: NL4MP
6. 50 Ohm Antenna.50 Ohm BNC Cable Mount West Penn model: CN-BM53-13
7. Ruggedized RJ-45Cat 6 ReceptacleRuggedizedRJ-45Panel Mount Neutrik model:NE8FDY-C6-B
8. RS232 Connector RS232 Inline Cable Amphenol model: DB9S-SFJ w/metal back shell
9. DM Connector Shielded RJ45 Crestron model: DM-Conn

PART 4 - BILL OF QUANTITIES

Area: Common Area		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	Ceiling Speakers type A	28
B	Ceiling Speakers type B	4
C	Audio Amplifier 100W	1
D	Audio Amplifier 240W	3
E	Audio Amplifier 600W	6
F	Audio Matrix / DSP 8 in - 16 out	1
G	Audio Monitor Panels	1
H	Wired Touch Panel	1
I	Control System	1
J	CD Player	1
K	Internet Radio	1
L	Paging microphone	1
M	42U Rack	2

Area: Dapino Restaurant		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	Ceiling Speakers type A	9
B	Audio Amplifier 240W/100V	1
C	CD Player	1
C	Internet Radio	1
E	Music Rack 18U	1

Area: Dining Room		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	Ceiling Speakers Type A	17
B	Wall Speakers Type A	4
C	Audio Amplifier 480W/100V	1
D	Audio Amplifier 240W/100V	1
E	CD Player	1
F	Internet Radio	1

Area: Guest Rooms		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	40" LED	TBA
B	50" LED	TBA
C	Set Top Box	1

Area: Gym		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	Ceiling Speakers type A	12
B	CD Player	1
C	Internet Radio	1
D	Volume Control	1
E	Volume Control + Input	1

Area: Prefunction		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	Ceiling speakers type A	6
B	Digital Signage Player	2
C	TV 48"	2

Area: Meeting Room		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	65" LED TV	3
B	Ceiling Speaker Type C	6
C	159" motorized screen	1
D	Motorized projector lift	1
E	4k Video projector	1
F	HDMI presentation switch	3
G	HDMI TX/RX over UTP	3
H	Wireless Microphone	3
I	Audio Amplifier 100W/100V	3
J	Wired Touch Panel	3
K	Control System	1
L	Table Cubby with HDMI/VGA/Audio	3
M	Blu Ray Player	3
N	IPVT Top Box	3

Area: Ballroom		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	4k Video projector type 1	3
B	4k Video projector type 2	1
C	159" motorized screen	3
D	254" motorized screen	1
E	Projector lift	4
F	Motor Relay Module	2
G	Ceiling Speakers (Type C)	18
H	Power Amp	3
I	Digital Media Matrix	1
J	Mixer/DSP	1
K	Wireless Microphone	6
L	Gooseneck Mics	3
M	CD Player	1
N	Audio from video matrix	1
O	Audio DSP	1
P	Stage box	2
Q	IPTV Set Top Box	1
R	Blu Ray Player	1
S	IPVT STB	1
T	HDMI /VGA UTP RX	7
U	Touch Panel	2
V	19" rack monitor	1
W	Lectern podium	3
X	Microphone outlets	3
Y	IPVT Set Top Box	1
Z	AV Wall Outlets	3
AA	Control Processor	1
AB	POE Lan Switch	1
AC	Rack 42U	1

Area: BOH, Stairs, Parking		
Supply, install, connection, testing and commissioning of wiring and equipment for audio visual System including all necessary materials and accessories to reflect complete system installation.		
A	Ceiling Speakers Type B	111
B	Wall Speakers	26
C	Horn Speakers for Parking	21
D	Volume Control for Offices	15

PART 5 - EXECUTION

5.1 GENERAL

A. All types of equipment installed by competent workers at locations shown on the drawings in strict accordance with approved shop drawings and manufacturer's instructions.

B. All equipment except portable equipment firmly held in place. This shall include loudspeakers, enclosures, amplifiers, cables, etc. Fastenings and supports adequate to support their loads with a safety factor of at least three unless otherwise stated.

C. Take such precautions as necessary to prevent and guard against electro-magnetic and electro-static hum and to install the equipment so as to provide safety for the operator.

D. Protect all equipment, including patch panels, connectors, receptacles, racks, consoles, and video projectors, from construction dust and debris until final acceptance of the system.

5.2 EQUIPMENT INSTALLATION

A. The entire sound system shall be installed in accordance with the manufacturer's drawings, instructions and recommendations.

B. All electrical conduits, wiring and methods shall conform to the requirements of Basic Materials and Methods.

C. Wall-Mounted Smoke Detectors: At least 10 cm, but not more than 30 cm, below the ceiling.

D. Smoke Detectors near Air Registers: Install no closer than 150 cm.

5.3 TESTING

A. The complete installation shall be tested in accordance with the manufacturer's recommendation. Testing shall be conducted by representative of the manufacturer.

5.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Basic Electrical Materials and Methods."

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

C. Install instructions frame in a location visible from the PA.

5.5 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.

5.6 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.

5.7 LABELS

A. Except where otherwise specified, label as shown on drawings and as specified each item of rack-mounted equipment, all switches, controls, and receptacles.
   1. Connector and Rack Panels: Constructed of engraved and filled anodized aluminum plates. Minimum 1/8" plate thickness. Dry transfer or other types of adhesive labels not acceptable.
   2. Rack-Mounted Equipment: Labels constructed of engraved and filled plastic laminate engraving stock. Designate function and input and output line(s) or loudspeaker(s) served by labeled equipment. Key all designations to system functional and patch panel diagrams. Where possible, mount labels on blank panel directly above corresponding component. For modular equipment, provide label on inside of mainframe door identifying type of module for each slot (unless there is only one type) and gain setting as established at final checkout.
   3. Identification Panel: Install panel with 1/8"-high engraved characters on the front of the bank of equipment racks serving each space. Clearly identify the Project, and System Installation CONTRACTOR.

5.8 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.

5.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
   1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 8 hours' training.

2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

5.10 ON-SITE ASSISTANCE

A. 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.

SECTION 16780 — IP VIDEO SURVEILLANCE & VMS

PART 1 - GENERAL

1.1 SUMMARY

A. Electrical Work generally is to be in accordance with the requirements of other sections of the specifications.

B. Video signals are to comply with CCIR (or FCC) recommendations and standards. Central control unit interfaces and related equipment are to comply with CCITT (or EIA) recommendations and standards for data signal characteristics, formats and communication protocols.

C. Integrated IP CCTV system with IP cameras, lenses, mounts, IP network video recorders, disk array, display, system controllers, associated accessories. The system shall include also workstations, software, licenses and interfaces as described thereafter.

D. The IP CCTV shall be integrated with the Network Video Management Software (NVMS).

E. Power supply up to the LAN switches that supply PoE to the IP cameras and telecom racks where the network video recorders are installed, is provided by others. (Refer to electrical trade documents).

F. Structured cabling system and active LAN equipment is specified in another section.

G. Interface of outdoor cameras to KAUST with fiber optic cable through telecom entry rack connection from KAUST.

1.2 SYSTEM DESCRIPTION

A. Works are to include complete IP closed circuit television system including the following:

1. IP CCTV cameras of fixed mounting type with lenses, housings, mounting brackets, IR illuminators and terminal boxes.

2. Central control equipment with power supply units, interfacing equipment, racks and cabinets and related ancillaries.

3. Central monitoring consoles with CCTV monitors, control keyboard and network video recording units.

4. IP Video Monitoring and Management Software

5. Shared CCTV workstation

6. CCTV Management server

1.3 SUBMITTALS

A. Submit full technical information for approval including manufacturer’s catalogues for all system equipment and components, indicating the following:

1. Multiplexing, recording and switching technique of video and control signals.

2. System expandability.

3. Operating parameters and limitations, ambient conditions, heat dissipation, power requirements etc.
1. Recommended coaxial cable specifications and characteristics.

B. Equipment is to be tested for quality and operation at factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Engineer before dispatch to site.

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

1. Detailed system schematic diagrams.

2. Exact camera locations, layouts and mounting details.

3. Configuration and construction details of central control cabinet and operating consoles.

4. Attenuation, connector losses and signal levels.

5. Calculation notes for selected lenses and area covered to be submitted by contractor.

1.4 SPARE PARTS

A. Provide manufacturer's recommended spare parts for replacement and one year's maintenance including, but not limited to, the followings:
1. Power supply: Quantity equal to 3 percent of amount of each type installed, but not less than one unit of each type.
2. Network video recorders: should be available from the supplier within 1 week notice.
3. Disk array: should be available from the supplier within 1 week notice.
4. Camera Lens: Quantity equal to 3 percent of amount of each type installed, but not less than one unit of each type.
5. Camera Housing: should be available from the supplier within 1 week notice.
6. Camera: Quantity equal to 3 percent of amount of each type installed, but not less than one unit of each type.
7. One unit of any single point of failure device that could inhibit the usage of the whole system.

1.5 APPROVED MATERIALS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the IP CCTV System include, but are not limited to, the following:
1. Avigilon (Canada)
2. Honeywell building solution (USA).
3. American dynamics (USA).
4. Bosch (Germany).
5. Comerson (Italy).
6. Axis (USA)
7. Hitachi (Japan).
8. Panasonic (Japan).
9. Pelco (USA).
10. Philips (Holland).
11. Sony (Japan).
12. Sanyo (Japan).
13. Toshiba (Japan).
14. Vicon (USA).

15. Siemens (Germany).
16. Samsung (S. Korea).
17. Substitution: or approved equal.

1.6 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: A written warranty, signed by Contractor and manufacturer, agreeing to replace any component of the CCTV system that do not meet requirements or that fail within the specified warranty period.
   1. Warranty Period: 2 years from date of Substantial Completion for any component of the system.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer approved by the manufacturer for both installation and maintenance of equipment required for this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in European EN, UL and IEEE Standards by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with relevant IEC and IEEE standards.

PART 2 - PRODUCTS

2.1 DESIGN AND OPERATION

A. CCTV is to provide camera surveillance for the selected building areas from the “control room”. The selected areas are to be monitored selectively using 32” HD LCD monitors with the facility of digitally recording or playing back signals from IP network video recorders. The system shall allow the live monitoring of all cameras or archive playback, even during recording, from any computer system connected to the building’s network and provided with the proper software and access rights.

B. CCTV system is to allow multi-camera display on a single monitor with various configurations (full screen, quad, 16…etc) and with the facility of twice zoomed diameter.

C. The control system will also allow sequencing of cameras in full screens, freezing frames and full on-screen camera identification with date and time encoded with each picture.

D. System is to include:
   1. IP network video recorders (NVRs), fully programmable for display, record and playback single or multi-image video signals. Cameras & NVRs shall be suitable for integration in the access control system software.
   2. IP cameras with various configurations (megapixel, 4CIF, dome and standard types, IP rated…etc.), PoE (to IEEE 802.3af-2003 or IEEE 802.3-2008) power supply or fiber interface, H.264/MPEG-4 AVC encoding/streaming with simultaneous JPEG-2000 encoding/streaming.
   3. Optional IP Keyboards (with Ethernet RJ45 ports) for programming and control of all operations, automatic and manual switching of cameras, associated with appropriate encoding and interfacing units.
   4. On screen text equipment with programmable manual keying facilities
   5. Time and date generation equipment for recorder and spot monitor inputs.
   6. 32” full HD (1920x1080) monitors
   7. Video and Control transmission over IP network (refer to section 16715 Structured Cabling System).
   8. Equipment above (except central monitoring consoles and monitors) is to be housed in telecommunication racks as specified in section 16715 (structured cabling System) and indicated on security drawings.

2.2 CENTRAL CONTROL EQUIPMENT

A. The system shall allow selectable full screen, sequencing full screen, picture-in-picture, ‘quad’ multiscreen, and 16-way multiscreen displays while full frame recording is taking place. The system shall also provide a digital freeze frame and x2 electronic zoom in full screen live and playback modes, including the ability to move around a zoomed image.

B. Operational mode shall be either manual or automatic for the full features of camera selections, display modes and interfaces with alarms and output devices.

C. On screen help is to be provided for all programming functions. The use of the keyboard will be through dedicated keys for camera and display mode selection to ensure simple and easily understood operation. Text is programmed using the standard keyboard.

D. System is to decide and transmit to the camera all instructions originating from central monitoring consoles via LAN network, directly to the cameras and NVRs.

2.3 CAMERA AND ANCILLARIES

A. Cameras are to be IP color CCD cameras, PoE (to IEEE 802.3af-2003 or IEEE 802.3-2008) supply (except for those with fiber interface) with day/night automatic switch mode for night vision (where specified), with resolution as indicated below, suitable for operation under harsh climatic conditions outdoor (extreme heat, sand storms, high humidity).

B. Brackets are to be cast aluminium alloy wall/ceiling type, adjustable 360 degrees horizontally and -75/+15 degrees vertically and suitable for mounting arrangements of fixed cameras. Brackets for controllable cameras are to be rigid non-adjustable. All brackets are to be flanged at wall/ceiling, with minimum four fixing bolts (expansion type for concrete structures).Night vision cameras (where specified), include day/night automatic switch and adopt DSP technology. It includes a red remote filter to provide a colorful image at day and high sensitivity black and white image at night.

C. Camera Types are:

2.4 2 MEGAPIXEL INDOOR NETWORK DOME CAMERA

A. The indoor network dome camera shall offer multiple simultaneous video streams with up to 2 megapixel (MPx) 1920 x 1080 resolution, auto iris and varifocal lens.

B. The indoor network dome camera shall provide a manual 3-axis (pan/tilt/rotation) positioning to allow adjustment for optimum camera rotation and placement.

C. The indoor network dome camera shall provide options for clear and smoked lower dome.

D. The indoor network dome camera shall provide Sure Vision™ technology that seamlessly delivers extended Wide Dynamic Range (WDR), low-light performance, and anti-bloom technology, operating simultaneously.

E. The indoor network dome camera shall feature an unsupervised/supervised alarm input, relay output and line level/external microphone input connections and built-in microphone.

F. The indoor network dome camera shall provide a removable, local storage medium (Micro SD) for scheduled and event-based recording of images.

G. The indoor network dome camera shall provide a service video stream in addition to and independent of the video streams.

H. The indoor network dome camera shall provide advanced low-light capabilities for day/night models with sensitivity down to 0.005 lux in color and 0.0013 lux in monochrome.

I. The indoor network dome camera shall support industry standard Power over Ethernet (PoE) IEEE 802.3af, Class 3 to supply power to the camera over the network.

J. The indoor network dome camera shall provide Wide Dynamic Range (WDR) up to 100dB with dynamic adjustments through the User Interface.

K. The indoor network dome camera shall have a mechanical IR cut filter mechanism for increased sensitivity in low-light installations. Set points for the IR cut filter feature shall be configurable through an embedded Web browser.

L. The indoor network dome camera shall support H.264 High, Main or Base profiles, using constrained variable bit rate (CVBR) as the default, variable bit rate (VBR), or constant bit rate (CBR) with target range.

M. The indoor network dome camera shall support two simultaneous, configurable video streams. H.264 and MJPEG compression formats shall be available for primary and secondary streams with selectable Unicast and Multicast protocols.

N. The indoor network dome camera shall support configurable frame rates, bit rates and group of pictures (GOP) structures for additional bandwidth administration.

O. The indoor network dome camera shall provide high reliability with ≥ 200,000 POH MTBF.

P. The indoor network dome camera shall be conformant to the ONVIF, Profile S and support open architecture best practices with a published API available to third-party network video recording and management systems.

Q. The indoor network dome camera shall provide 802.1x port security to establish point-to-point access through a wired or wireless port using Extensible Authentication Protocol (EAP). Supported EAP methods shall include EAP-MD5, EAP-TLS, EAP-TTLS, EAP-PEAP and EAP-FAST.

R. The indoor network dome camera shall support SNMP v2c and v3.

S. The indoor network dome camera shall support IPv6 configurations in conjunction with IPv4.

T. The indoor network dome camera shall provide Auto or Manual exposure settings for adjusting the amount of light detected by the camera sensor.

U. The indoor network dome camera shall provide user-selectable configurations for day/night auto mode. Transitional levels shall be used to set the desired light level for transitioning to night mode. Transition detect time shall control the length of time that the camera is exposed to a light level before changing to color or monochrome mode.

V. The indoor network dome camera shall provide flicker correction.

W. The indoor network dome camera shall provide motorized zoom capabilities with a Web browser interface for remote configuration and administration.

X. The indoor network dome camera shall provide autofocus capabilities with a Web browser interface for remote configuration and administration. The automatic autofocus shall be triggered when the camera detects an environmental temperature change within 9°F (5°C) and when the camera changes from color to monochrome or vice versa. User-selectable options for full-range auto-focus and quick auto-focus shall be available.

Y. The indoor network dome camera shall support 16 window blanks to conceal user-defined privacy areas that cannot be viewed by an operator.

Z. The indoor network dome camera shall provide I-Frame interval configuration to increase or decrease the number of I-Frames per second.

AA. The indoor network dome camera shall provide User and Group settings to assign permissions and access levels to the camera. The camera shall provide local management where the camera manages the access levels or remote mode where the camera authenticates the user through a Lightweight Directory Access Protocol (LDAP) server.

AB. The indoor network dome camera shall provide Adaptive Motion analytic to intelligently detect motion within a user-defined field of view. Such behaviors shall trigger an alarm. The embedded analytic shall support customized profiles allowing multiple configurations for varying conditions.

AC. The indoor network dome camera shall provide Camera Sabotage analytics to detect changes in the camera's field of view, including obstruction of the lens and unauthorized

movement of the camera. Such behaviors shall trigger an alarm. The embedded analytic shall support customized profiles allowing multiple configurations for varying conditions.

AD. The indoor network dome camera shall be plenum-rated per 2008 NEC article 300.22(C) (2) for in-ceiling mounted applications.

AE. The indoor network dome camera shall provide a 3/4-inch NPT conduit attachment on the back box for in-ceiling mounted applications.

AF. The indoor network dome camera shall attach to a standard single-gang electrical box for surface mounted applications.

AG. The indoor network dome camera shall provide a 3/4-inch NPT conduit attachment for pendant mounted applications.

AH. The indoor network dome camera shall be capable of firmware upgrades through a network using a software-based device utility.

1. Camera Specifications:

a. Imaging Device	1/3-inch
b. Imager Type	CMOS
c. Imager Read	Progressive scan
d. Maximum Resolution	
1. 4:3 Aspect Ratio	1.9MPx (1600 x 1200) 1.2 MPx (1280 x 960) 0.5 MPx (800 x 600) 0.3 MPx (640 x 480) 0.08 MPx (320 x 240)
2. 16:9 Aspect Ratio	1080p MPx (1920 x 1080) 720p MPx (1280 x 720) 0.5 MPx (800 x 448) 0.2 MPx (640 x 352) 0.06 MPx (320 x 176)
e. Signal-to-Noise Ratio	>60 dB
f. Auto Iris Lens Type	DC drive
g. Electronic Shutter Range	1~1/77,000 sec
h. True Wide Dynamic Range	Up to 100 dB
i. White Balance Range	2,000° to 10,000°K
j. Sensitivity 3~9 mm	f/1.2; 2,850°K; SNR >20dB
1. Color (33 ms)	0.2 lux
2. Color (500 ms)	0.005 lux
3. Mono (33 ms)	0.05 lux
4. Mono (500 ms)	0.0013 lux
k. Day/Night Capabilities	Yes
l. Mechanical IR Cut Filter	Yes, (ON/OFF/AUTO selectable), with different set points on lux
m. Available Languages	Chinese, English, French, German, Italian, Portuguese, Russian, Spanish, and Turkish

2. Lens Specifications:

a. Lens Type	Built-in; varifocal
b. Focal Length	f/1.2, 3~9 mm
c. Focus	Autofocus, motorized
d. Zoom	Remote
e. Auto Iris Type	DC drive P-iris lens

3. Video Specifications:

a. Video Streams	Multiple simultaneous streams with up to 2different configurations plus service stream; the second stream is variable based on the setup of the primary stream.
b. Available Resolutions	Two configurable streams as follows:
1. 4:3 Aspect Ratio	1.9MPx (1600 x 1200) 1.2 MPx (1280 x 960) 0.5 MPx (800 x 600) 0.3 MPx (640 x 480) 0.08 MPx (320 x 240)
2. 16:9 Aspect Ratio	1080p MPx (1920 x 1080) 720p MPx (1280 x 720) 0.5 MPx (800 x 448) 0.2 MPx (640 x 352) 0.06 MPx (320 x 176)
c. Frame Rate	Up to 30, 25, 15, 12.5, 10, 5, 1 (depending on the coding, resolution, and stream configuration)
d. Video Encoding	H.264 High, Main, or Base profiles and MJPEG
e. Bit Rate Control	Constant bit rate (CBR), and constrained variable bit rate (CVBR) with target range
f. Service Stream	JPEG stream; the aspect ratio will be consistent with the independent streams
g. Supported Protocols	TCP/IP, UDP/IP (Unicast, Multicast IGMP)UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4,IPv6, SNMP v2c/v3, QoS, HTTP, HTTPS, LDAP (client), SSH, SSL, SMTP, FTP, ARP, ICMP, and 802.1x (EAP)
h. Users	
1. Unicast	Up to 20 simultaneous users depending on the resolution settings
2. Multicast	Unlimited H.264
i. Security Access	Password protected
j. Software Interface	Web browser view and setup
k. Mobile Application	Integrated with Mobile Application
l. Minimum PC Requirements	
1. Processor	Intel® Core™ i3 processor, 2.4 GHz
2. Operating System	Microsoft® Windows® 7 (32- and 64-bit), or Windows Vista®; or Mac OS® X 10.4 (or later)
3. Memory	4 GB RAM
4. Network Interface	100 Mbps (or greater)
5. Monitor	Minimum of 1024 x 768 resolution, 16- or 32-bit pixel color resolution
6. Web Browser	Internet Explorer® 7.0 (or later) or Mozilla® Firefox® 3.5 (or later); Internet Explorer 8.0 (or later) is recommended for configuring analytics
7. Media Player	Media Player or QuickTime® 7.6.5 for Windows 7, XP, or Vista; or QuickTime 7.6.4 or Mac OS X 10.4 (or later)

4. Electrical Specifications:

a. Network Port	RJ-45 for 100Base-TX, Auto MDI/MDI-X
b. Accessory Port	Micro B USB connector
c. Cable Type	Cat5e cable or better for 100Base-TX
d. Input Power	PoE (IEEE802.3af, Class 3)
e. Power Consumption	8.5 W nominal
f. Current Consumption	350 mA maximum
g. Local Storage	Micro SD
h. Alarm	Unsupervised/supervised modes
1. Unsupervised	Detects open or closed alarm state

2. Supervised — Detects open and short alarm state with external 1 kohm resistor
3. Input — 3.5 VDC maximum, 3.5 mA maximum

i. Relay Output — ±32 VDC maximum, 150 mA maximum

j. Audio
1. Streaming — Bidirectional; full or half duplex
2. Input/Output — Line level/external microphone input; 600-ohm differential, 1 Vp-p max signal level; built-in microphone
3. Compression
4. G.711 PCM 8 bit, 8 kHz mono at 64 kbit/s

5. Mechanical Specifications:
a. Dome Attenuation
1. Clear — Zero light loss
2. Smoked — f/13.0 light loss

b. Pan/Tilt Adjustment
1. Pan — 355°
2. Tilt — 180°
3. Rotation — 360°

6. Environmental Specifications:
1. Operating Temperature — -10° to 50ºC (14° to 122°F)
2. Cold Start — –10ºC (14ºF)
3. Operating Humidity — 20% to 80%, RH noncondensing

7. Certifications:
1. CE, Class A
2. FCC, Class A
3. UL/cUL Listed
4. KCC
5. CCC
6. C-Tick
7. S-Mark
8. Cisco® Medianet Media Service Proxy 2.0 compatible
9. ONVIF Profile S Conformant

AI. Warranty: 6 months, parts and labor.

2.5 INDOOR NETWORK FIXED BOX CAMERAS (0.5MP, 1MP, 2 MP)

A. The indoor camera system shall offer multiple simultaneous video streams with up to 2.0 megapixel (MPx) resolution, auto iris and varifocal lens.

B. The indoor camera system shall feature an unsupervised alarm input, relay output and line level/external microphone input connections.

C. The indoor camera system shall provide a removable, local storage medium (Micro SD) to capture video clips of varying lengths upon camera sabotage, motion, or relay alarm. Video can be retrieved from the card through the FTP protocol.

D. The indoor camera system shall provide a service video stream in addition to and independent of the video streams.

E. The indoor camera system shall provide advanced low-light capabilities for day/night models with sensitivity down to 0.01 lux in night.

F. The indoor camera system shall support industry standard Power over Ethernet (PoE) IEEE 802.3af, Class 3 to supply power to the camera over the network.

G. The indoor camera system shall have a mechanical IR cut filter mechanism for increased sensitivity in low-light installations. Set points for the IR cut filter feature shall be configurable through an embedded Web browser.

H. The indoor camera system shall support H.264 High or Main profiles and MJPEG, using constant bit rate (CBR) or variable bit rate (VBR) with target range.

I. The indoor camera system shall support two simultaneous, configurable video streams. H.264 high or main profiles or MJPEG compression formats shall be available for primary and secondary streams with selectable Unicast and Multicast protocols.

J. The indoor camera system shall support configurable frame rates, bit rates and group of pictures (GOP) structures for additional bandwidth administration.

K. The indoor camera system shall be conformant to the ONVIF Profile S. It supports open architecture best practices also with a published API available to third-party network video recording and management systems.

L. The indoor camera system shall support 4 window blanks to conceal user-defined privacy areas that cannot be viewed by an operator.

M. The indoor camera system shall provide the ability to backup and restore camera settings through an embedded Web browser.

N. The indoor camera system shall provide 802.1x port security to establish point-to-point access through a wired or wireless port using Extensible Authentication Protocol (EAP). Supported EAP methods shall include EAP-MD5, EAP-TLS, EAP-TTLS, EAP-PEAP.

O. The indoor camera system shall support SNMP v2c and v3.

P. The indoor camera system shall provide flicker correction with selections for 50 Hz or 60 Hz line frequency.

Q. The indoor camera system shall provide autofocus capabilities with a Web browser interface for remote configuration and administration. The automatic autofocus shall be triggered when the camera detects an environmental temperature change and when the camera changes from color to monochrome or vice versa. User-selectable options auto-focus shall be available.

R. The indoor camera system shall provide user-selectable configurations for day/night auto mode. Transitional levels shall be used to set the desired light level for transitioning to night mode. Transition detect time shall control the length of time that the camera is exposed to a light level before changing to color or monochrome mode.

S. The indoor camera system shall provide User and Group settings to assign permissions and access levels to the camera. The camera shall provide local management where the camera manages the access levels or remote mode where the camera authenticates the user through a Lightweight Directory Access Protocol (LDAP) server.

T. The indoor camera system shall provide simple motion detection to detect motion within a user-defined field of view or within a user specified rectangular zone. Such behaviors shall trigger an alarm.

U. The indoor camera system shall provide camera sabotage analytics to detect changes in the camera's field of view, including obstruction of the lens and unauthorized movement of the camera. Such behaviors shall trigger an alarm.

V. The indoor camera system shall be capable of firmware upgrades through a network using a web user interface or a software-based device utility.

W. The indoor camera system shall meet or exceed the following design and performance specifications.

1. Camera Specifications:

a. Imaging Device	2 MPx, 1/3-inch 1 MPx, 1/4-inch SD, 1/4-inch
b. Imager Type	CMOS
c. Imager Readout	Progressive scan
d. Maximum Resolution	2.1 MPx (1920 x 108 0.9 MPx (1280 x 720) 0.5 MPx (800 x 600)
e. Auto Iris Lens Type	DC drive
f. Electronic Shutter Range	1/5 ~ 1/10,000 sec
g. Wide Dynamic Range	Up to 65 dB
h. White Balance Range	2,500° to 8,000°K
i. Digital Noise Reduction	Yes (ON/OFF selectable)
j. Sensitivity	Down to 0.01 lux — mono mode, 220 ms f/1.2
k. Day/Night Capabilities	Yes
l. Mechanical IR Cut Filter	Yes, (ON/OFF/AUTO selectable), with different set points on lux
m. Available Languages	Chinese, English, French, German, Italian, Portuguese, Russian, Spanish, and Turkish

2. Lens Specifications *:

a. Lens Mount	CS mount; adjustable
b. Focus	Auto back focus
c. Auto Iris Type	DC drive iris *Selection of CS lenses available as optional accessories.

3. Video Specifications:

a. Video Streams	Multiple simultaneous streams with up to 2 different configurations plus service stream; the second stream is variable based on the setup of the primary stream.
b. Available Resolutions	Two configurable streams as follows:
1. 5.0 Megapixel	2592 x 1944; 4:3 aspect ratio
2. 3.1 Megapixel	2048 x 1536; 4:3 aspect ratio
3. 2.1 Megapixel	1920 x 1080; 16:9 aspect ratio
4. 1.9 Megapixel	1600 x 1200; 4:3 aspect ratio
5. 1.2 Megapixel	1280 x 960; 4:3 aspect ratio
6. 0.9 Megapixel	1280 x 720; 16:9 aspect ratio
7. 0.6 Megapixel	1024 x 576; 16:9 aspect ratio
8. 0.5 Megapixel	800 x 600; 4:3 aspect ratio
9. 0.3 Megapixel	640 x 480; 4:3 aspect ratio
10. 0.1 Megapixel	320 x 240; 4:3 aspect ratio
11. 0.1 Megapixel	320 x 180; 16:9 aspect ratio
c. Frame Rate	Up to 30, 25, 20, 16.67,15, 12.5, 12, 10, 5, 1 (depending on the coding, resolution, and stream configuration)
d. Video Encoding	H.264 high or main profiles; and MJPEG
e. Bit Rate Control	Constant bit rate (CBR), and variable bit rate (VBR) with target range
f. Service Stream	320 x 240 or 320 x 180; 2 ips, MJPEG
1. Supported Protocols	TCP/IP, UDP/IP, ICMP, IPv4, SNMP v2c/v3,HTTP, HTTPS, SSL, SSH, SMTP, FTP, RTSP, UPnP, DNS, NTP, RTP, RTCP, LDAP
2. Unicast	Minimum of 2 unicast streams

3. Multicast — Unlimited H.264

g. Snapshot — JPEG capture at resolution of live view stream

h. Security Access — Password protected

i. Software Interface — Web browser view and setup

j. Mobile Application — Integrated with Mobile Application

4. Electrical Specifications:

a. Network Port — RJ-45 for 100Base-TX, Auto MDI/MDI-X

b. Cable Type — Cat5 cable or better for 100Base-TX

c. Input Power
   1. 2, 3, 5 MPx — PoE (IEEE 802.3af, Class 3)
   2. SD, 1 MPx — PoE (IEEE 802.3af, Class 2)
   3. All Resolutions — 24 VAC nominal, 18 to 32 VAC range

d. Power Consumption — <8.0 W

e. Local Storage — Micro SDHC

f. Alarm
   1. Input — 1
   2. Output — 1; PhotoMOS™ relay (30V, 1 A)
   3. Triggers — Unsupervised mode that detects switch closures (N.O. and N.C.)

g. Audio
   1. Streaming — Dual-channel
   2. Input/Output — Line-in/Line-out/terminal block
   3. Compression — G.711 A-law / G.711 U-law

5. Environmental Specifications:

a. Operating Temperature — –10º to 50ºC (14º to 122ºF)

b. Operating Humidity — 15 to 85%, RH non-condensing

6. Certifications:

a. CE, EN 55022 (Class A), EN 50130-4, EN 60950-1

b. FCC (Class A) – 47 CFR Part 15

c. UL/cUL Listed, UL60950-1

d. CAN/CSA-C22.2 No. 60950-1-07

e. ICES-003

f. KCC

g. NOM

h. ONVIF Profile S Conformant

X. Warranty: 36 months, parts and labor

2.6 LISENCE PLATE RECOGNITION MACHINE

A. Camera Resolution

Single Lane 1280 x 720
Dual Lane 2592 x 720
Illuminator Technology High-power SMT LED Wavelength 850 nm

B. Network

Network 100BASE-TX
Cabling Type CAT5
Connector RJ-45
Security SSL Protocol UDP, TCP, SOAP, DHCP, Zeroconf

C. Mechanical

Enclosure Dimensions (LxWxH) 284 mm x 279 mm x 221 mm (11.0” x 11.2” x 8.7”)
Weight 4.0 kg (8.8 lbs)
Mount 4x M5 holes at 40mm x 62mm (1.57” x 2.44”)
Illuminator Power Supply Dimensions (LxWxH) 160 x 160 x 81 mm (6.3” x 6.3” x 3.2”)
Weight 1.85 kg (4.1 lbs)
Mount 4 x M4 holes at 145 mm x 123 mm (5.71” x 4.85”)

D. Electrical

Camera Power Source 24 VDC, 24 VAC, PoE: IEEE802.3af Class 3 compliant
Power Consumption 6 W per camera
Power Connector 2-pin terminal block
Illuminator Power Source 24 VDC, 24 VAC
Power Consumption 72 W
Power Connector 3-wire terminal block, 12-20 AWG

E. Environmental

Environmental Rating IP66 Operating Temperature -10 °C to +45 °C (14 °F to 113 °F)
Storage Temperature -10 °C to +70 °C (14 °F to 158 °F)

F. Certification

UL 60950 CSA60950 EN 60950-1
CE ROHS WEEE

2.7 INDOOR/OUTDOOR, ENCLOSURE

A. The indoor/outdoor enclosure shall allow use for IP network cameras.

B. The indoor/outdoor enclosure shall have a camera mounting sled and track assembly.

C. The indoor/outdoor enclosure shall be IK10 impact resistant.

D. The indoor/outdoor enclosure shall meet IP66 Standards.

E. The indoor/outdoor enclosure shall meet or exceed the following design and performance specifications.

1. Electrical Specifications:
   a. Input Power — 24 VAC, IEEE802.3at, or 230 VAC
   b. Input Voltage
      1. PoE — IEEE802.at
      2. 24 VAC, 230 VAC — ±10% VAC

2. General Specifications:
   a. Construction — Die-cast aluminum
   b. Finish — Alodine with gray polyester powder coat
   c. Environment — Indoor/outdoor
   d. Operating Temperature — –30° to 60°C (–22° to 140°F)
   e. Unit Length
      1. Base — 33.99 cm (13.38 in.)
      2. Overall — 36.55 cm (14.39 in.)

3. Mechanical Specifications:
   a. Camera Mounting — Single slot for adjustable camera positioning on-snap-in camera sled
   b. Camera and Lens Size — Accepts camera and lens combinations up to 27.86 x 7.92 x 7.62 cm (9.00” L x 3.12” W x 3.00” H)
   c. Viewing Window — 0.3 cm (0.118-inch) thick, high optic grade, scratch-resistant Lexan™
   d. Viewing Area — 7.14 x 6.27 cm (2.81” W x 2.47” H)
   e. Cable Entry — 1 x PG9 and 1 x PG11 compression glands on bottom
   f. Maximum Cable Diameters
      1. PG9 — 0.80 cm (0.312 in.)
      2. PG11 — 1.00 cm (0.395 in.)
   g. Cable Entry Holes — 1.00 x 1.91 cm (0.750 in.) diameter and 1.00 x 1.60 cm (0.630 in.) diameter; 1.91 cm (0.750-inch) hole will accept 1/2-inch NPT conduit fitting when enlarged to 2.22 cm (0.875 inches); 1.60 cm (0.630-inch) hole will accept 1/4-inch NPT conduit fitting
   h. Lid Fastening — 3 Torx-head T30 screws

4. Certifications:
   a. CE
   b. UL/cUL Listed
   c. Meets IP66 standards
   d. IK10 Mechanical Impact Resistance

F. Warranty:
   5. 36 Months, parts and labor

2.8 IP NETWORK VIDEO RECORDERS (NVR)

A. The network video recorders shall be provided with suitable storage capacity to accommodate the number of cameras indicated on drawings with the following assumptions:

Activity Factor in %	Location of Cameras
20	Corridor
30	Parking
50	Entrance + lift lobby
20	Circulation area

1. Recording archive for 30 days
2. 12 hours per day operation (assuming that very low activity shall be present during the 4 remaining hours)
3. Each event shall be recorded with 10 seconds pre-event in addition to 10 seconds post-event
4. Non-megapixel cameras shall record with full resolution, best picture quality, JPEG or MPEG-4 (H-264), 10 IPS or better
5. Megapixel cameras shall record with full resolution, best quality, MPEG-4 (H-8264), 10 IPS or better
6. At least 20% additional storage capacity to account for future cameras or exceptional circumstances
7. Extra HDDs for RAID5 configuration
8. It shall be located in the data center main telecom cabinet.

B. IP Network Video Recorders shall offer the following features and benefits:

IP NETWORK VIDEO RECORDERS (NVR)		
Supported Cameras	TV System	PAL
	Supported Cameras	IP cameras with MPEG-4 H.264, M-JPEG and JPEG encoding
	Telemetry (over IP)	Pan/Tilt, Zoom, Focus, Brightness, Preset Position, Auto mode
	Supported Image Format	MPEG-4, JPEG, M-JPEG
	Supported Image Resolution	1920 x 1080, 1280 x 720, 960 x 720, 640 x 480, 320 x 240 (depending on the camera)
	Supported Audio Format	G.726 (ADPCM) 32 kbps or approved equal
	Maximum Number of Cameras	32 (as indicated on drawings)
Recording	Recording Mode	Manual, Schedule including Event (Pre/Post), Emergency
	Pre-Event Recording	Up to 15 minutes for pre-event.
	Scheduled Recording Mode	8 programs, 6 time zones or schedules/day, Independent setup for each day of the week
	Frame Rate/Camera	Up to 30 IPS (depending on the Camera)

IP NETWORK VIDEO RECORDERS (NVR)		
Browser GUI	Camera Control	Pan/Tilt, Zoom, Focus, Brightness, Preset position call and program (up to 256), Auto mode
	REC/Playback Control	REC, PLAY, Rev PLAY, Pause, Stop, FF, REW, Prev Record, Next Record, Prev Image, Next image, Goto Date, Goto Last (5 sec. ~ 5 min.), Area select
	Search Mode	Filtered search: Time date, Event type, Camera number, video activity detection search: one detection areas per search
	Display Mode	Spot/Quad (16 patterns) / Spot Sequence / Quad Sequence (Sequence: Live only)
	Camera Grouping	8 groups each with 16 characters title
	Image Download	Recorded data of selected camera and time range can be downloaded to a PC. Viewer software provided for free.
	SD Memory Data Download	Images recorded in the SD card slots of the cameras can be transferred to the recorder automatically.
	Copy	Recorded data of selected cameras and time date range can be copied to a HDD dedicated partition.
	Camera Title	On the browser, up to 20 Characters
	Clock Display	On the browser. Time: 12 H/24 H, Date: 3 formats (YY.MM.DD, MMM.DD.YY, DD.MMM.YY)
	Alarm Control	Reset, Suspend
	Digital Zoom	2x, 4x
	System Log	Operator access (100), Network error (1,000), Error (100), Event (750)
	System Setup	Setup page in English, French, Italian, Spanish, German, Russian, Chinese, Japanese
	GUI Language	English, French, Italian, Spanish, German, Russian, Chinese, Japanese
	Supported OS	Windows 7 Professional, Microsoft Windows Vista Business, Windows XP Professional SP2
	Supported Browser	Windows Internet Explorer 8.0, Windows Internet Explorer 7.0, Microsoft Internet Explorer 6.0 SP2
Alarm/ Event	Alarm Source	32x Terminal inputs, 64x Camera alarms, Panasonic Alarm Protocol
	Event Mode	Alarm / Activity / OFF
	Alarm Action	Alarm recording, e-mail notification, Alarm message, Camera positioning, FTP image transfer, Terminal output, Panasonic alarm protocol output, Buzzer, LED
	Alarm Control	Reset, Suspend
	Event log	750 or better
Network	Network Interface	Camera port: 10Base-T / 100Base-TX / 1000Base-T (RJ-45) Client port: 10Base-T / 100Base-TX / 1000Base-T (RJ-45) Maintenance port: 10Base-T (RJ-45)
	Maximum Bandwidth	Total 250 Mbps or better
	Bandwidth Control (Client Port)	32 K / 64 k / 128 k / 256 k / 512 k / 1,024 k / 2 M / 5 M / 10 M (bps) and unlimited
	Supported Protocol	TCP/IP, UDP/IP, HTTP, FTP, SMTP, DHCP, DNS, DDNS, NTP, SNMP, RTP
	E-mail	Upon Alarm or Warning
	FTP Client	Upon alarm or Periodic transfer
	No. of Simultaneous Users	16
	User Registration	Up to 32 users or better
	User level	4 Levels (Programmable)

IP NETWORK VIDEO RECORDERS (NVR)		
	Partitioning	User - Camera (View only, View & Control, No Access)
	Security Method	User authentication (ID and password), Host authentication (IP address), Alteration detection, HTTP Port No. (1 ~ 65,535 except for reserved numbers), FTP Port No. (1 ~ 65,535 except for reserved numbers)
External Interface	Alarm & Control Input / Outputs	32 general alarm inputs
		2 alarm outputs, 1 alarm reset input, 1 alarm suspend input
		Emergency recording input, Power outage detection input, External recording mode switching, Power outage recovery completion output, Time adjustment input/output
	Error/ Warning	Network error output, Available disk space warning output, HDD error output, Camera error output, Error output
	EXT Storage	High-speed serial interface 1.5 Gbps for external HDD extension unit
Other Functions	Time Synchronization	Terminal (Master or Slave), NTP (Server/Client)
	Summer Time	User definable
	Multi NVR / Multi Site Integration	Using a video management software
HDD	Type	Up to 9 x 3.5” SATAHDDs (size up to 1TB minimum per drive) can be installed. Hot plug-in of extra drives shall be allowed.
	Maximum Capacity	54 TB with up to 5 HDD extension Units each carrying up to 9x 3.5” SATA HDDs (size up to 1TB minimum per drive)
	RAID	RAID 5/6 support (RAID 5 to be configured)
	Partitioning	Normal / Event / Pre-Event / Copy
Viewer Software	Playback Control	Play, Rev Play, Pause, FF, REW, Previous Record, Next Record, Previous Image, Next image
	Additional Functions	Alteration detection, Save as JPEG, Two times zoom, Print
	Supported OS, Language	Same as browser GUI, English software language
General Specifications	Safety/EMC Standard	UL (UL60065), FCC (Part15 ClassA), C-UL (CAN/CSAC22.2 No.60065), DOC (ICES003 ClassA), CE (EN60065, EN55022 ClassB, EN55024), C-Tick
	Power Source	220 / 240 AC, 50 Hz
	Power Consumption	Not exceeding 200W
	Ambient Operating Temperature	+5 °C to +45 °C
	Ambient Operating Humidity	5 % ~ 90 % (no condensation)
	Mounting	Rack mounted in standard 19" cabinets

2.9 OPTIONAL IP CCTV SYSTEM CONTROLLERS (shown as "KEYBOARD" on drawings)

A. Connectivity:
   1. The keyboard shall control the IP cameras and network video recorders. It shall include an RJ45 Ethernet port to be connected to the LAN in addition to an RS 485 and RS-232 buses for daisy-chaining of system controllers and configuration sharing.

B. Camera Control
   1. Joystick controls Pan/Tilt and Zoom, allowing seamless tracking.
   2. Numeric keypad provides direct access to cameras.

C. Recorder Control
   1. Jog dial and shuttle ring for fine recorder control
   2. Dedicated Record, Play, and Search buttons

D. Switcher Control
   1. Image switching and sequencing buttons.

E. System Management Capability
   1. User level management
   2. User assignable buttons (not less than 6)
   3. Setup data can be transferred to another unit

2.10 LCD MONITOR

A. 1920x1080 pixels 32" LCD MONITORS

1. The full HD LCD Monitors shall have a durable design suitable for a control room environment. They shall use a combination of high and low reflection layers that perform perfectly in any lighting condition.
2. The monitor shall have a Dynamic Contrast Ratio of up to 50,000:1. The enhanced Digital Dynamic Contrast shall reduce the duty ratio, minimize the black level and create deeper black colors. Faster dimming of the LCD backlight shall deliver deeper contrast of each video source, such that dark colors take on extra depth and light colors become brighter and clearer.
3. The monitor shall deliver smooth moving images and exceptional sharpness of detail.
4. 100Hz technology shall intelligently extrapolate the action, and then consequently insert an extra frame between frames to create a comfortable, crisp and fluid viewing experience. Through the insertion of this bridge frame, images shall be seamless, motion judder and image blurring shall be eliminated.
5. The 32" monitor shall have the following technical specifications:

Feature		Description
VIDEO	Screen Size	32 inches diagonal
	Resolution	1920x1080pixels
	Dynamic Contrast	50,000:1
	Viewing Angle	178°/178° (H/V)
	Response Time	4ms
	400Hz feature	Provided

AUDIO	Sound Output (RMS)	10W x 2
	Sound Effect System	SRS
INPUT / OUTPUT CONNECTIONS	HDMI	3
	Component Video	2
	S-VHS	2
	Composite Video	2
	USB 2.0 JPEG compatible	1
	Headphones	1
	PC Input (D-Sub)	1
ELECTRICAL POWER	Input Voltage	110 - 240V AC, 50/60Hz
	Electrical Load on Stand-by	≤1W
	Electrical Load	≤150W
Mounting	Wall mounting bracket	Bracket with adjustable vertical and horizontal orientation shall be included

B. 1920x1080 pixels 42" LCD MONITORS

1. The full HD LCD Monitor shall have a durable design suitable for a control room environment. It shall use a combination of high and low reflection layers that perform perfectly in any lighting condition.
2. The monitor shall have a Dynamic Contrast Ratio of up to 4,000:1
3. The monitor shall deliver smooth moving images and exceptional sharpness of detail.
4. The 49" monitor shall have the following technical specifications:

Feature	Description
Panel Size (in.)	42 inches diagonal
Contrast Ratio	1000:1 Static / 50,000:1 Dynamic
Video Response (ms)	5 (black-white-black); 3 (grey-to-grey)
Color Saturation	110% NTSC color saturation
Viewing Angle (H/V)	160°/160°
Optimum Resolution	1920x1080
Light Source Lifetime (hours)	40,000
Brightness (cd/m2)	400
Panel Surface	Anti-glare
Input Interface	non-interlaced Analog/Digital (DVI-D HDCP, HDMI)
Input Frequency	Fh: 24~92kHz, Fv: 50~85Hz
Wall Mount Option	Yes
Power Supply	Integrated
Input Voltage	110 - 240V AC, 50/60Hz
Electrical Load on Stand-by	≤1W
Electrical Load	~150W
Ergonomic Adjustments	Height, swivel, tilt
Emission Standard	TCO'03

2.11 IP CCTV WORKSTATIONS (2 units; CCTV server & shared workstation)

A. The project includes **CCTV & access control workstation in addition to a CCTV management server** (the server shall be rack mounted in data center, Level basement 1).

B. The systems shall operate on the Windows environment. The platform specification required are desktop PCs (DELL, IBM or HEWLET PACKARD) compatible with the following minimum specifications:

1. (Server & Workstation): Second Generation Core i7 Sandy Bridge processor, 3.4 GHz speed, 12MB Intel Smart cache, 16 processing threads
2. (Server & Workstation): Intel motherboard, triple channel DDR3 1066/1333/1600 MHz bus, 4 USB 3.0 ports, 8 USB 2.0 ports and two e-SATA ports, 1 PCI slot, 2 PCI Express (x16 data), 1 PCI Express (x4 data), 2 PCI Express (x1 data)
3. (Server & Workstation): 32 GB RAM DDR3 1066/1333 MHz, 2 channels, 21 GB/s
4. (Server & Workstation): 1TB SSD with 2 TB SAS storage min capacity, HDDs in RAID 1 configuration.
5. (Workstation): Graphics: Video graphic adapter, minimum 2560 x 1600 pixels, 2GB GDDR3 video memory, 3 DVI-D (or HDMI) and one VGA outputs with independent multi-monitor resolution and refresh rate selection (ATI or N-Vidia). Each DVI-D (or HDMI) output shall be provided with DVI-D to HDMI interface.
6. (Server): Graphics: on-board.
7. (Workstation): Active desktop speakers (Creative or approved equal); only for workstations.
8. (Server & Workstation): Microsoft keyboard.
9. (Server & Workstation): Microsoft optical mouse with rotating wheel.
10. (Server & Workstation): DVD+/-R/W (5x) dual layer drive.
11. Operating System for CCTV & Access Control Workstations: Microsoft Windows 10 Professional Edition, 64 bit version or later.
12. Operating System for CCTV Server: Microsoft Windows Server 2012R2, 64 bit version or later.
13. (Server & Workstation): Back-up software similar to Veam solutions with system image (snap-shots) creation capability and facilities to re-deploy images to identical or different hardware on either physical or virtual machines.
14. (Server & Workstation): Gigabit Ethernet network interface card.
15. (Server & Workstation): RS232 Interface.

N.B: The above mentioned computer systems hardware specifications are adequate for 8 months from the specifications date. The contractor shall submit an equivalent time-upgraded specifications at the actual system commissioning time. Only branded computers shall be accepted (Dell, IBM, HP).

2.12 IP CCTV MANAGEMENT SOFTWARE

A. IP CCTV management software shall provide the following functions:

1. The system shall be able to manage up to 15 recorders, 10 encoders (in case analogue cameras are added) and 128 directly connected IP cameras can be registered.
2. The IP CCTV workstation specified above shall be fully licensed for the IP CCTV management software.
3. The system shall be able to directly receive live images from the cameras or encoders or recorders.
4. A multi-monitor capability shall enable the simultaneous use of operation display in 1 / 4 / 9 / 16 split, live display in 1 / 4 / 9 / 16 split and map/architectural (up to 100 maps) view display each on a dedicated monitor.
5. Single or two monitor operation shall be provided. The system shall be able to display a total of 20 screens by the simultaneous use of the operation display and the live display at a time.
6. The system shall be able to display up to 30 IPS per camera in 16 split-screens in MPEG-4 H.264 for up to 8 Mbps per camera displayed.
7. The system shall allow up to 100 camera groups such that cameras and multi-screen mode for the operation display can be programmed and called up by manual or sequence operation.
8. The image resolution shall dynamically change depending on the screen mode: VGA for Quad screen, QVGA for 16 split screen to enable optimum network usage.
9. The system shall include Telemetry camera control: Pan/Tilt, Zoom, Focus, Brightness, Preset position call and program (up to 256 programs), Auto mode, centering and wheel zoom.
10. The system shall include the functionality that a camera, a group or a sequence; be called up on the operation display by their ID. The camera displayed in the active window can be controlled by the IP CCTV system controller. The network video recorders playback operation also is possible by the IP CCTV system controller with jog/shuttle controls.
11. Alarm notification: A pop-up alarm message shall be displayed.
12. Individual alarm reset and all alarm reset shall be allowed. The operation display, live display, map display, and wall monitor shall react correspondingly with the alarm. The system shall display the present alarm log in red.
13. When an alarm occurs, the monitor changes into the map automatically showing where the alarm happened and the system shall display the alarmed monitor in red.
14. The system shall have illustrated icons for cameras, alarms and recorders. The system shall allow up to 64 camera icons that can be freely positioned on a map (architectural layout) with their alarm status indicated by the color of the icons.
15. The recorded images of up to 64 cameras can be downloaded by a single operation. The downloaded images can be viewed by the freely provided viewer software.
16. The system shall provide sophisticated user management: User authentication with time limited password, 5 user levels, User-Camera view/control partitioning in conjunction with the respective recorder's user management function, up to 32 user registrations.
17. The system's logs can be saved in CSV or other approved database format. The operation logs can be automatically erased (over-written) when a user programmable specified time has elapsed (31 / 92 / 184 / 366 days).
18. The audio from a camera can be heard and the operator voice can be transmitted to the camera's audio output through the network (single channel at a time, full/half duplex as per camera specifications).The recorded audio can be played back (single channel at a time) as well.
19. The system shall allow that video activity based search, be operated.

2.13 NETWORK VIDEO MANAGEMENT SOFTWARE (NVMS) SPECIFICATIONS

A. The NVMS should be based on Open Platform architecture that shall support recording and management of video and audio sources from at least 10 different camera manufacturers as native support with dedicated drivers documented and also additionally should support ONVIF conformant Cameras. It shall allow to integrate the Multi head cameras and16 MP resolution cameras used for perimeter / parking viewing

B. The NVMS shall be an enterprise level software solution that shall be scalable from one client, server, and camera to hundreds of clients, servers, and cameras.

C. The NVMS shall consist of server software applications and client software applications.

D. The NVMS shall permit server and client software applications to be installed and run on both the same computer or on separate computers.

E. The NVMS shall include a gateway software application that connects mobile devices to the NVMS.

F. The NVMS mobile client shall be supported by Android and Apple mobile devices.

G. The NVMS shall include but not limited to the following applications:

1. Server Software Applications
   a. Server
   b. Admin Tool
   c. Gateway
2. Client Software Applications
   a. Client
   b. Virtual Matrix
   c. Web Client
   d. Player
   e. Camera Installation Tool
   f. Mobile

H. The NVMS design and performance requirements for the NVMS software are as follows:

1. The NVMS shall be available as a stand-alone software offering or pre-loaded on turn-key workstations and servers running Microsoft Windows with configurable storage.
   a. The NVMS shall be available in a licensed: Enterprise Edition supporting
   b. One Hundred Twenty Eight (128) cameras per server
   c. One Hundred (100) servers per site
   d. Unlimited concurrent site connections
   e. Unlimited client licenses

I. The NVMS shall support HD Stream Management for local and remote users and mobile devices to conserve bandwidth.

J. The NVMS shall support HD Stream Management architecture which includes:

1. Support for industry standard JPEG2000, MJPEG, MPEG-4, and H.264 compression formats
2. Support for reducing the required client bandwidth and processing power by only transmitting what is necessary to view the video stream at full quality (e.g. if a user is viewing a 16MP camera in a 1MP window then a 1MP representation of the 16MP image shall be transmitted).
3. Support for quality “data-aging”, enabling a low quality and high quality stream to be recorded under the same logical ID. After an administrator defined period of time, the

higher stream would be deleted and the lower stream would remain until the end of the desired retention period.

K. The NVMS shall support storage and processing of video and audio.
   1. Audio and video must be recorded natively from the camera with no transcoding.
   2. Audio and video must be synchronized regardless of frame-rate, resolution or bitrate.

L. The NVMS shall support receiving digital input triggers and triggering digital outputs through an I/O board.

M. The NVMS shall support recording and monitoring video and audio streams from sources with bandwidth up to 90 Mbit/sec, frame rate up to 60 fps, and video resolution up to 16 MP (4864 x 3248).

N. The NVMS shall support the decompression of H.264 video through the client graphics card/graphical processing unit instead of using the client processing power.

O. The NVMS shall support Arabic and English Language primarily.

P. The NVMS shall require no proprietary recording hardware, no hardware multiplexer or time-division technology for video and audio recording or monitoring.

Q. The Network Video Management Software (NVMS) shall support recording and management of video and audio sources through the use of industry standard drivers. These drivers shall include:
   1. ONVIF Profile S
   2. Publically Published API

R. The NVMS shall not limit the storage capacity and shall allow for upgrades of recording capacity.

S. The NVMS shall digitally sign recorded video and audio using 256-bit encryption so video can be authenticated for evidentiary purposes.

T. The NVMS shall securely transmit all command and control data via TCP/IP using cryptographic keys based on SSL to prevent eavesdropping or tampering.

U. The NVMS will provide the mechanism by which individual alarm(s) from external systems can be pre-selected and configured to be monitored and, in turn, trigger event driven video operations

V. The NVMS shall support software level integration via an Application Programming Interface (API). The API integration should include but not limited to:
   1. Bi-directional alarm event processing for monitoring and acknowledgement
   2. Receiving card access activity events
   3. Receiving digital input events
   4. Receiving intrusion zone events

W. The NVMS shall be capable of being upgraded from one version to another without having to uninstall the previous version.

X. The NVMS shall be capable of being upgraded from one edition to another without having to uninstall the application.

Y. The NVMS shall automatically detect if video or audio source firmware is out of date with respect to the current installed software and upgrade it.

Z. The NVMS shall automatically detect if client application software is out of date with respect to the current installed server software and upgrade it.

AA. The NVMS shall run as a service configured to automatically start when the server or workstation is powered on and automatically recover from failure or attempted tampering.

AB. The NVMS shall allow system administration, and live and recorded video and audio monitoring all from a single client application that can be located anywhere on the network.

AC. The NVMS shall automatically discover all Server instances running on computers connected to the same network as the Client.

AD. The NVMS shall provide a search functionality to discover Server instances running on computers connected on a different network segment than the Client by using IP addresses or hostnames.

AE. The NVMS shall manage and synchronize servers as a cluster with shared data and tasks to provide crash-proof enterprise server management.

AF. The NVMS shall automatically discover video and audio sources that are connected to the same network as the Server.

AG. The NVMS shall provide a search functionality to discover video and audio sources that are connected on a different network segment than the Server.

AH. The NVMS shall provide the ability to connect a video or audio source to multiple NVRs to achieve redundant recording.

AI. The NVMS shall provide the ability to create a failover connection for a video or audio source. If the NVR that the video or audio source is connected to goes offline then the failover NVR will take over the connection.

AJ. The NVMS shall provide administration of all system connections from a single window.

AK. The NVMS shall provide multiple methods for providing fault tolerant solutions to maintain high availability recording in mission critical installations including:
1. The ability to cluster and synchronize up to 100 servers into a Site without a management server. In the event of a server failure, the system is able to continue running and other servers can take over the failed server's tasks.
2. The ability to maintain a centralized system administration so that the same operation and system configuration settings are shared between all servers in a Site. This allows the same user login details and other configurations to be used across a Site, and ensure that the settings remain active even if a server fails.
3. The ability to connect a video or audio source to multiple NVRs to achieve redundant recording.
4. The ability to create a failover connection for a video or audio source. If the NVR that the video or audio source is connected to goes offline then the failover NVR will take over the connection.

AL. The NVMS shall support receiving Simple Network Management Protocol (SNMP) messages from servers and alert the user.

AM. The NVMS shall detect if the video or audio signal is lost and alert the system administrator.

AN. The NVMS shall provide the capability to rename all video and audio sources and NVRs.

AO. The NVMS shall record video and audio streams based on a recording schedule that can be defined individually for each video source. The schedule shall be created with the following parameters to include but not limited to:
1. Recording Mode
2. Continuous
3. Motion
4. Digital Inputs

5. Alarms
6. POS Transactions
7. License Plates
8. Time and Date Settings
9. Daily
10. Weekly

AP. The NVMS shall provide the ability to manually trigger recording.

AQ. The NVMS shall provide a pre-event and post-event recording option.

AR. The NVMS shall provide a reference frame recording option in the absence of events.

AS. The NVMS shall perform motion detection on each individual video source with adjustable sensitivity, threshold and detection zones.

AT. The NVMS shall provide the ability to record and maintain a primary and secondary video stream for a set amount of time before the primary stream is discarded as a means of increasing record time. This setting can be configured separately for each H.264 video source.

AU. The NVMS shall perform analytics event detection on each individual video stream sourced from a device possessing adaptive video analytics capabilities.

a. The NVMS shall allow users to connect individual video sources to analytics appliance channels.
b. The NVMS shall allow users to configure events based on classified object motion detection.
c. The NVMS shall allow configured analytics events to be used as alarm and rule triggers.
d. The NVMS shall allow users to mark analytics detection as a true or false positive and send this data to the analytics appliance or analytics camera. This data will be collected and sent on a per video source basis to improve the accuracy of the analytics enabled device.

AV. The NVMS shall provide the ability to set a maximum recorded video retention time for each video source.

AW. The NVMS shall perform dynamic bandwidth management to ensure that the total bandwidth does not overload the system.

AX. The NVMS shall authenticate users before granting access to the system. Access rights for each user can be defined individually for each user,

AY. The NVMS shall provide the ability to import members of Active Directory groups as users in the NVMS. Changes made to members in the Active Directory are automatically synced with the NVMS.

AZ. The NVMS shall optionally support using Windows credentials to authenticate users.

BA. The NVMS shall provide the ability to create and schedule alarms.

BB. The NVMS shall provide the ability to schedule backups of recorded video with associated events to a local folder or mapped network drive.

BC. The NVMS shall provide the ability to email users and system administrators when an event or system health error occurs.

BD. The NVMS shall provide the ability to schedule when email notifications are sent.

BE. The NVMS shall provide the ability to include camera images in email notifications.

BF. The NVMS shall maintain an event log for various – Server, Device, User, Alarm, POS related events

BG. The NVMS shall have the capability to schedule and execute any of the following actions in response to any of the events:
1. User Notification Actions
2. Display on-screen message
3. Send an email
4. Play a sound
5. Monitoring Actions
6. Start live streaming video
7. Create Bookmark
8. Open a saved view
9. Start live streaming on a virtual matrix monitor
10. Open a map on a virtual matrix monitor
11. Open a web page on a virtual monitor
12. Device Actions
13. Reboot camera
14. Trigger digital output
15. PTZ Actions
16. Go to Preset
17. Run a Pattern
18. Set Auxiliary
19. Clear Auxiliary
20. Alarm actions
21. Trigger an alarm
22. Acknowledge an alarm

BH. The NVMS shall provide the ability to create customized on-screen messages and email notifications.

BI. The NVMS shall combine and list all on-screen messages in one location and color code the importance of each message.

BJ. The NVMS shall provide a maintenance log and audit trail of all system errors and events.

BK. The NVMS shall report the status of all connected servers within a cluster and provide the option to export the information in PDF format.

BL. The NVMS shall provide the ability to receive transaction information from point-of-sale sources.

BM. The NVMS shall provide the ability to enable and configure PTZ control on the RS-485 interface of a video source.

BN. The NVMS shall support the following list of PTZ camera protocols it include but not limited to:
1. American Dynamics Sensormatic.
2. BO.AXSYS
3. AXSYS DCU
4. Ernitec ERNA
5. Honeywell Diamond
6. Kalatel ASCII
7. Pelco D
8. Pelco P
9. TEB Ligne
10. Vicon extended
11. Vicon normal
12. Videotec Legacy
13. Videotec MACRO

BO. The NVMS shall provide the ability to change the network settings for a video and audio source.

BP. The NVMS shall provide the ability to change image quality and image rate parameters for a video source without affecting the settings on the other video sources.

BQ. The NVMS shall provide the ability to enable a secondary stream for live viewing.

BR. The NVMS shall provide the ability to change the exposure, iris, IR filter, backlight compensation, gain, priority, sharpening, saturation, focus, and white balance settings for a video source.

BS. The NVMS shall provide the ability to change the image dimensions for a video source.

BT. The NVMS shall provide the ability to rotate the image 90°, 180° or 270° for a video source.

BU. The NVMS shall provide the ability to add privacy zones to a video source to block unwanted areas in the image field of view.

BV. The NVMS shall provide the ability to set a maximum recording duration for manually triggered recording for a video source.

BW. The NVMS shall provide the ability to change the input, output, gain and volume for an audio source.

BX. The NVMS shall provide for full-duplex two- way audio communication.

BY. The NVMS shall provide the ability to link any audio source to any video source.

BZ. The NVMS shall provide the ability to set a limit on the maximum bandwidth transmitted to the Client application from the Server application.

CA. The NVMS shall provide the ability to automatically log in to an NVR.

CB. The NVMS shall provide the ability to monitor user access to each server cluster.

CC. The NVMS shall provide the ability to override user access to an NVR.

CD. The NVMS shall provide the ability to automatically log out of an NVR when the application is left idle.

CE. The NVMS shall provide the ability to save and restore the window layout.

CF. The NVMS shall provide the ability to control the system using a PC keyboard or joystick.

CG. The NVMS shall provide the ability to import and export client settings such as maps, views, and web pages.

CG. The NVMS shall support live or recorded video monitoring of 1 to 36 video streams simultaneously on a single monitor with the following standard layouts:

1. Full Screen
2. 2 x 2
3. 3 x 3
4. 4 x 4
5. 5 x 5
6. 6 x 6
7. 1 + 5
8. 1 + 7
9. 1+ 12

10. 2 + 8

CH. The NVMS shall support live or recorded video monitoring in a customizable video display beyond the standard layouts.

CI. The NVMS shall support the ability to bias the displayed video to a higher frame rate or to a lower image resolution if the client network bandwidth or client processing power is insufficient to display the full frame rate and image resolution.

CJ. The NVMS shall support the ability to display the following list of image overlays including but not limited to:
1. Camera Name
2. Camera Location
3. Timestamp
4. Record Indicator
5. Motion Activity
6. License Plate

CK. The NVMS shall support an unlimited number of monitors for monitoring video and audio streams.

CL. The NVMS shall have the ability to share the application window display in a joint session with other users for collaborative investigations while viewing both live and recorded video.

CM. The NVMS shall support monitoring live and recorded video and audio streams simultaneously on the same monitor.

CN. The NVMS shall offer a Matrix Application Module to provide remote control of multiple monitor displays, including video walls, that can be controlled by an unlimited number of users with appropriate rights and permissions.

CO. The NVMS shall support viewing the same live or recorded video stream at different zoom levels and areas of interest.

CP. The NVMS shall support the ability to switch from live to recorded video on demand for an instant replay of recently recorded video.

CQ. The NVMS shall support the creation of unlimited views with unique layouts of video streams.

CR. The NVMS shall support the ability to full-screen a view.

CS. The NVMS shall support the ability to save views.

CT. The NVMS shall support the ability to cycle through views (guard tour) based on a specified interval.

CU. The NVMS shall display all video sources connected to the system.

CV. The NVMS shall support the ability to drag and drop a video source from a tree of video sources into a window for live or recorded video and audio monitoring.

CW. The NVMS shall support the ability to drag and drop a view from a tree of views into a window for live or recorded video and audio monitoring.

CX. The NVMS shall support the ability to configure how the tree of video sources and views is displayed.

CY. The NVMS shall support the ability to designate one or more regions in a window for displaying video directly linked to triggered alarms and rules.

CZ. The NVMS shall support the ability to acknowledge alarms from the designated video display area.

CA. The NVMS shall support the ability to manually trigger digital output.

DB. The NVMS shall support the ability to create a map that represents the physical location of cameras and other devices throughout the surveillance system. Maps shall be created from images stored in JPEG, BMP, PNG, or GIF image formats. Maps shall have the ability to contain links so as to create a hierarchy of interlinked maps.

DC. The NVMS shall support the ability to create an HTML-based map that has a link to a section of the entire image region.

DD. The NVMS shall support the ability to drag and drop a video source from a map into a window for live or recorded video and audio monitoring.

DE. The NVMS shall highlight a camera on a map when an alarm linked to the camera is triggered.

DF. The NVMS shall highlight a linked map that contains a camera when an alarm linked to the camera is triggered.

DG. The NVMS shall support the ability to save a link to a web page and view the web page in a window.

DH. The NVMS shall support digital zooming and panning on live and recorded video streams.

DI. The NVMS shall support controlling mechanical pan-tilt-zoom, iris, and focus as well as setting presets and patterns.

DJ. The NVMS shall provide the ability to name pan-tilt-zoom presets.

DK. The NVMS shall support the ability to create guard tours by combining a set number of presets that are run in sequence or random.

DL. The NVMS shall support the ability to center a PTZ camera's field of view by clicking anywhere on the video image.

DM. The NVMS shall support the ability to click and drag to define an area for the PTZ camera to optically zoom and center on.

DN. The NVMS shall support controlling mechanical pan-tilt-zoom camera on-screen display and auxiliary controls.

DO. The NVMS shall support locking PTZ controls.

DP. The NVMS shall support control of a mechanical pan-tilt-zoom camera with a USB joystick.

DQ. The NVMS shall support forward and reverse playback of recorded video and audio at variable speeds.

DR. The NVMS shall synchronously playback recorded video and audio from selected video sources.

DS. The NVMS shall support navigation of recorded video and audio via calendar, timeline, or events.

DT. The NVMS shall support a timeline that displays all connected video sources and the corresponding motion and recording events.

DU. The NVMS shall support a timeline that can display the entire time range down to one second of recorded video and audio.

DV. The NVMS shall have a quick access search for connected camera, encoders, sites, maps, saved views, web pages and virtual matrix monitors. It shall be possible to search all items by, but not limited to:
1. Name
2. Location
3. Logical ID
4. Serial Number
5. IP address

DW. The NVMS shall support creating bookmarks for recorded video and audio from multiple sources, displaying the bookmarks on the timeline, and searching for bookmarks.

DX. The NVMS shall support protecting a bookmark so the video and audio data is never overwritten.

DY. The NVMS shall support monitoring alarms.

DZ. The NVMS shall support the ability to assign alarms to users.

EA. The NVMS shall support the ability to acknowledge alarms.

EB. The NVMS shall support the ability to bookmark alarms.

EC. The NVMS shall support searching through bookmarks based on various search criteria including bookmark name, notes, and linked camera names.

ED. The NVMS shall support searching through recorded video and audio based on various search criteria including time, date, video source, and events.

EE. The NVMS shall support searching through recorded video based on motion in user defined areas (pixel search).

EF. The NVMS shall support searching through recorded video based on time, date, video source, and image region and have the results displayed as a series of thumbnail images.

EG. The NVMS shall support searching through recorded video based on alarm events.

EG. The NVMS shall support searching through recorded video based on point-of-sale transaction events.

EI. The NVMS shall support the ability to export recorded video in the following formats including but not limited to:
1. Native
2. JPEG
3. PNG
4. TIFF
5. AVI
6. WAV
7. PDF
8. Print

EJ. The NVMS shall support the ability to export recorded audio in WAV format.

EK. The NVMS shall support the ability to take a snapshot of a live or recorded image and export it from the system.

EL. The NVMS shall support the ability to export a live stream of images in the following formats including but not limited to:
1. JPEG
2. PNG
3. TIFF

EM. The NVMS shall support the ability to export video from multiple camera streams in Native format.

EN. The NVMS shall support reviewing video and audio that was exported in the Native format.

EO. The NVMS shall provide the camera properties and time zone for video exported in Native format.

EP. The NVMS shall support authenticating video that was exported in the Native format to validate that it was not tampered with.

EQ. The NVMS shall support converting video that was exported in the Native format to an industry standard format.

ER. The NVMS shall support reviewing video and audio stored in a backup.

ES. The NVMS shall support exporting of video in lower frame-rates than originally recorded.

ET. The NVMS shall support optionally exporting video representing a designated area of interest from within the camera's field of view.

EU. The NVMS shall support the navigation of recorded video and audio. Including but not limited to the following methods apart from calendar and events:
1. The NVMS shall support a timeline that displays all connected video sources and the corresponding motion and recording events.
2. The NVMS shall support a timeline that can display the entire time range down to one second of recorded video and audio.
3. The NVMS shall support a timeline that can synchronize video displayed on multiple tabs to the same point in time.

2.14 RACKS, CABINETS AND CONSOLE

A. CCTV cabinets to comprise free standing 19-inch racks inside enclosed cabinets Standards holes are to be provided for panel mounting of control equipment and cable distribution terminal boards, which are to be easily accessible for maintenance. Cabinets are to galvanized sheet steel box construction with joints welded on inside. Multi-formed mounting channels are to be standard gauge cold rolled steel, with secondary chassis providing infinite front-to-back adjustment. Base section is to be minimum 1.5 mm thick cold rolled steel. Blower panels are to be installed in base section of each cabinet to through bottom and back of racks. Approved manufacturers for 19 racks are: APW, Cannon, Infraplus, Rittal. Network Video Recorders are mounted in the telecom cabinets specified in section 16715 “Structured Cabling System”.

B. Central console design and components are to be modular design and contemporary styling subject to Architect approval, solid welded steel construction with concealed mounting screws, having laminated desk top and monitor/graphics panel turret housing, and containing the following:
   1. CCTV, access control & BMS Workstation
   2. System Controllers (CCTV Keyboards)
   3. Telephone set
   4. Auxiliary equipment.

C. Console is to have louvered side panels and interface styling throughout. Sections are 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 grey 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. Design and finish subject to architect approval.

PART 3 - EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

A. Install in accordance with manufacturer's instructions and to the approval of the Engineer. Mount equipment in alignment with other fixtures and fix firmly in place with all supports and fastenings secured.

B. Equipment is to be installed to prevent electro-static or other outside interference impairing system performance.

C. Equipment is to be installed to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made, but no changes are to be made without prior approval.

D. Make good surfaces of equipment damaged during installation, using touch-up paint provided by equipment manufacturer, to the satisfaction of the Engineer.

E. Routing of video signal cables (structured cabling), power and control cables is to be in separate raceways.

F. Equipment manufacturer is to provide an Engineer and Technician qualified in the operation of the system and equipment performance and the requirements of the specification, to assist the Engineer to test and verify the system performance.

G. Provide diagnostic equipment required performing system tests and measurements including function generator, Impedance Bridge, oscilloscope, frequency spectrum analyzer, chart recorder, digital voltmeter, dB meter and waveform monitor.

3.2 CABLING AND DISTRIBUTION SYSTEM

A. The infrastructure of the IP CCTV system shall be the structured cabling system specified in section 16715 "Telecommunication System".

3.3 RACEWAYS, BOXES AND FITTINGS

A. Refer to section 16118 "RACEWAYS, BOXES AND FITTINGS" for related products and field installation works.

B. Product selection and installation shall take into account the large bending radius of telecom cables, especially for CAT6A F/UTP cables serving embedded wall mounted telecom outlets and fiber optic cables.

3.4 SUPPORTING SYSTEMS AND RELATED ACCESSORIES

A. Refer to section 16139 "CABLE TRAYS" for related products and field installation works.

3.5 AS-BUILT DRAWINGS

A. The installation Contractor will be provided with 2 sets of drawings at the start of the project. One set will be designated as the central location to document all as-built information as it occurs throughout the project. The central set will be maintained by the Contractor's foreman on a daily basis, and will be available to the technical representative upon request during the course of the project. Anticipated variations from the build-to drawings may include such things as cable routing and actual outlet placement. No variations will be allowed to the planned termination positions of horizontal and backbone cables or grounding conductors unless approved in writing by the Owner.

B. The Contractor shall provide the central drawing set to the Owner at the conclusion of the project. The marked up drawing set will accurately depict the as-built status of the system including termination locations, cable routing, and all administration labeling for the cabling system. In addition, a narrative will be provided that describes any areas of difficulty encountered during the installation that could potentially cause problems to the IP CCTV system.

3.6 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 racks or cabinets. Isolate from power system and equipment grounding.

3.7 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.

3.8 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.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
   1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 32 hours' training.
   2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.10 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting settings, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to project site for this purpose.

SECTION 16850 – IPTV 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 IPTV system complete including satellites, antennas, head end switchers and distribution network comprising of cables, tap off units and outlets. The signal source of the system consists of:
   1. Three satellites earth-station system of the receive-only type (Hotbird, Nilesat and Arabsat)

B. Related Sections include the following: Division 16
   1. SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS
   2. SECTION 16715 - STRUCTURAL CABLING FOR DATA AND TELECOMMUNICATION SYSTEM & MAIN TELECOM ROOM
   3. SECTION 16740 - COMMUNICATIONS AND DATA-PROCESSING EQUIPMENT FOR NETWORK
   4. SECTION 16770 – PUBLIC ADDRESS AND AV EQUIPMENT

1.3 SUBMITTALS

A. Product Data: Include detailed manufacturer's specifications for each component specified. Include data on features, ratings, performance, catalogues and literature, sufficiently detailed for engineering purposes, and with full description of component and operating parameters.

B. Submittals are to include also:
   1. Reception distribution technique
   2. System expandability.
   3. Operating parameters and limitations, ambient conditions, heat dissipation, power requirements, etc.
   4. Recommended fiber optic and/or coaxial cable specifications and characteristics.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.
   1. Include dimensioned plan and elevation views of components and enclosures, and details of racks. Show access and workspace requirements.
   2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer installed and field-installed wiring. Wiring diagrams are to bear manufacturer's signature indicating that they have reviewed the drawings and that they are correct in respect to sizes, wiring and configuration and will operate in accordance with function, scope and intent of the specifications.
   3. Detailed system schematic diagram.
   4. Exact IPTV outlets' locations, layouts and mounting details.
   5. Configuration and construction details for operating console and layouts.
   6. Complete and detailed cable routing and layouts with calculation losses and signal levels.

D. Samples: Full size, for each outlet and finish plate, for colors and textures required.

E. Product Certificates: Signed by manufacturers of television equipment and components certifying that products furnished comply with requirements.

F. Field Test Reports: Indicate and interpret test results for compliance with performance requirements of installed systems.

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. Standards: System is to be in accordance to CCIR and/or EIA standards or other equal and approved standards.

1.5 COORDINATION

A. Coordinate layout and installation of television equipment and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: As listed below or approved equal
   1. TELEVES
   2. ARANTIA
   3. VDA
   4. GUESTEK
   5. QUADRIGA
   6. OTRUM

2.2 TELEVISION SYSTEMS

A. Refer to Section 16770 “Public Address & AV Equipment”

B. Components: Modular plug-in, heavy-duty, industrial- or commercial-grade units.

C. Equipment: Silicon-based, solid-state, integrated circuit devices.

D. Power Supply Characteristics: Devices shall be within specified parameters for ac supply voltages within the range of 240 V, 50Hz

E. Protect signal cables and connected components against transient-voltage surges by suppressors and absorbers designed specifically for the purpose.

2.3 EQUIPMENT

A. Identification of Signal Sources and Channels Distributed:
   1. Three satellite dishes of the receive-only type (Hotbird, Nilesat and Arabsat)

B. IPTV System Qualitative Performance Requirements: Reception quality of color-television program transmissions at each system outlet from each designated channel and source shall be equal to or superior than that obtained with performance checks specified in "Field Quality Control" Article.

C. IPTV System Quantitative Performance Requirements: Level and quality of signal at each outlet from each designated channel and source shall ensure
   1. Fluke performance test for Cat6A
   2. OTDR test for fiber optic cable
   3. Performance test of RG11 (loss attenuation dB level)

2.4 COMPONENTS

A. Head-End Equipment: Include IP streamers, aggregation switches, power supply units, and other equipment as required to provide specified performance.

B. Outlets:
   1. Wall Plates: Match materials and finish as per Architect/Interior Designer
   2. RJ45 Outlets

2.5 SIGNAL TRANSMISSION COMPONENTS

A. Cabling from Satellite to Head-End may be the following depending upon attenuation calculation to be done by Contractor:
   1. Satellite Antenna Cable: RG-11/U; cellular-polyethylene dielectric, tinned-copper braid shield with 100 percent shielding factor, No. 18 AWG solid copper conductor; and PVC jacket.
   2. 12 core Single Mode Fiber Optic Cable.

B. Backbone and Horizontal Cabling:
   1. Single Mode fiber optic cabling (Refer to Section 16715 Structured Cabling specifications)
   2. Cat6A cabling for horizontal distribution (Refer to Section 16715 Structured Cabling specifications)

C. Set Top Boxes (STB or SBB):
   1. Refer to Section 16770 “Public Address & AV Equipment”
   2. Remote controller: one for all including TV set and main functions accessible with a button directly.
   3. To be coordinated with TV set selection

D. Raceways for IPTV cabling and distribution are to be as described in Division 16 Section “Raceways and Boxes”.

2.6 SYSTEM FEATURES

A. The IPTV system shall ensure the following minimum features:
   1. PayTV support
   2. Support of several TV sets in a room
   3. Personal welcome screen / individual message to guests
   4. Wake-up service
   5. Management of standardized Hotel TV sets
   6. Nationalities: sorting of channels, RSS feed
   7. Interface with PMS (property management system)
   8. Option internet
   9. Option mobile connect
   10. Option redundancy
   11. Option info pack
   12. Video On Demand
   13. Parental Control
   14. Individual list of channel
   15. Option to implement further languages
   16. Live TV, radio, pause/play
   17. Catch up TV
   18. Personal Video Recorder
   19. Comply with Operator’s TV channel list

B. The system shall be based on Network Computer Terminal (NCT) or Set Back Box (SBB) solution both of which integrated with room televisions on a plug & play basis.

C. The IP TV system connectivity should be done through the IP network to a digital video distribution network for accessing live and on-demand content and to access other features and added value services.

D. The system shall provide a contemporary access to all the guest room at the same time. Due to typical problems and limitations of number of simultaneous users.

E. Channel Allocation Technology is not acceptable.

F. The Architecture of the system shall be open, based on an Intranet platform and shall use standard TCP / IP, HTTP, and JAVA Scripts protocols.

G. The in-room equipment shall consist of:

1. An open Architecture TV set provided with plug & play slot in the back cover or a consumer screen with SCART plug connection with Hotel Mode Feature: Menu access controllable, volume control, power on channel control, power on volume control and PC connection for longer viewing
2. The NCT or SBB shall support either a CAT 5E or CAT 6 network.
3. The interface between the NCT / SBB and the TV screen is a complete interface which would provide functions like banner management in both the interactive as well as channels menu.
4. A proprietary universal remote control is used to access the internet services with pre-defined links classified by category. The control of the TV functionality is achieved via single remote control.
5. A wireless keyboard supplied with each TV is using extensively access the internet and email service.
6. Compact flash interface with capability of the NCT / SBB for local storage. The NCT / SBB must be running a Linux Kernel.

H. The system provides the guest with an Internet WEB surfing facility with defined readability of Internet pages from the typical bed – TV distance and is scalable in future for doing PVR functions.

I. The system shall provide remote supervision facility to monitor system performance, fault analysis, software downloading, check-in, check-out status and also should use a single interface with PMS for high speed internet billing and interactive TV services etc.

J. Approved Brands for IPTV Media Solution are the following:
1. Triple TV, digital IP Television solution for delivering the full satellite channel line-up for TV's throughout the hotel using the IP network infrastructure and displayed on TV sets through IP set top boxes ('IPSTB') or PC's using the Triple play PC client.
2. Triple Choice, hotel guest portal for providing hotel information and services to the guest TV set via the IPSTB.
3. Triple Mux, an audio / video mixer solution for generating graphics, slides or videos over an audio stream i.e. a radio station or off air TV channel
4. Triple Sign, an IP based digital signage solution for delivering bespoke content to public are screens

2.7 GENERAL FACILITIES

A. The system shall be made with the following facilities:
1. Interactive pages shall be generated directly by the graphical processor of the Interactive terminal and the same shall be resident in the terminal (Channel Allocation technology shall not be used to provide graphics on the screen).
2. The interactive pages shall be made like a WEB like navigation style resident into the interactive terminal which allows the guest to navigate easily between the interactive pages using the arrow key buttons of the remote control (and not the numbers of the numeric pad).
3. The interactive pages shall come with multiple colors
4. Graphical capabilities: Each of the interactive-navigable shall be built using Picture definition: VGA 640 x 480 pixels (full screen).
5. Local memory: Each of the Interactive terminal shall have its own rewritable memory which can store as much as pages required for any hotel with graphical content.

2.8 FUNCTIONAL SPECIFICATION

A. Individual alphanumeric room number codes will be assigned to each TV Set Back Box.

B. Special access codes will be programmed for housekeeping and maintenance personnel.

C. Language selection will be flagged at check-in or user assigned in the guestroom. A choice of various European languages and Arabic shall be available.

D. All transactions are logged in secure auditable database.

E. All defaults are reset at check out

F. Alarm conditions are reported at central PC

G. The central PC shall continuously log the polled status of all system components and generate alarms upon system elements being found outside pre-configured control point settings.

H. The central PC shall be installed with secure remote access software and telephone modem such that the authorized service agent may dial in to the system to carry out software updates, regular system maintenance and fault diagnostics. Virtual hostess should be able to guide the guest through the Interactive Menu.

I. Virtual hostess should be able to welcome the guest and guide the guest through the Interactive menu or the services available. It responds to the remote control and explains the requested service or selected function.

2.9 STANDARD GUEST ROOM FUNCTIONS

A. Guest would access to the following functions of the system by use of the hand held infrared remote control OR wireless keyboard supplied with the open architecture TV sets.

B. The proposed system should have the capability to provide any of the following features if required by the client:
   1. Welcome Message
   2. Wake up.
   3. In-House Information Pages (The central PC contains a set off pre-configured templates for presentation of the information pages. This information shall be customized to suit the hotel‘s requirements. Also, the information pages consist of various Text formats with facility to insert photographic images as required to suit the hotel‘s requirements)
   4. View Bill (The guests can their bills and this service shall also provide the possibility for the guest to view the total amount of his bill (Basic) or to analyze the complete detailed Bill (extended))
   5. Centralized TV Tuning (The interactive TV system shall provide a centralized TV tuning facility to take control of all the TV channels distributed in the hotel)
   6. House Keeping
   7. Maintenance (By using a Service Menu, the Maintenance personnel shall be able to update the room status by using the guest remote control accessed with a user code. All the information related to the maintenance of the room can be customized by the Hotel and updated by the Maintenance personnel. Automatic reporting will be available on System Server and on a centralized TV)
   8. Bathroom loudspeaker (It shall be possible to connect an external loudspeaker to the television and control the volume of both the television and the external loudspeaker by use of the remote control)
   9. System Check-up (RH recommends that the IPTV system shall provide the
   10. facility from the System Server to check the real time status of each TV /Network Computer Terminal)

11. Room Service (The central PC shall contain a set of pre-configured templates for presentation of the room service pages. This information shall be customized to suit the hotel‘s individual requirement). Also, the system supplier shall coordinate with the Hotel‘s Food & Beverage department to collate the details regarding restaurant menu, pricing and ordering time etc. The information pages shall consist of various text formats with facility to insert photographic images prices as required to suit the hotel‘s individual requirement and should be able to print the guest request of a room service order to a printer either locally or on the network)
12. Banner Management (The system should have the facility to create banner information in the form of a scrolling banner to send information like – news, flash, greetings, advertisements, Birthday wishes, individual or group messages, etc)
13. Internet-Contemporary Access

C. Surfing the Internet to available for the guests, and the simplified remote control shall be enough to navigate through the most useful WEB sites.

D. The system shall also be able to access a specific Web site introducing its URL address from the WWW Pop Up menu.

E. The communication is done through TCP / IP and HTTP standard protocol running over the Ethernet Network.

F. All these functions shall be configured in a Pay x Day modality (price to be defined by the Hotel) or with free of charge modality. If the Pay x Day modality is selected, some defined WEB sites can be accessible free of charge and if required by the hotel a specific amount of time shall be available for free for the guest before the charges are requested to the guest and confirmed by the guest.

G. The guests before being charged, have to introduce their room number as confirmation. While surfing the Web it shall be possible to open picture in browser, where the TV program can be watched contemporary.

H. It shall be possible for the guests to access internet via the TV remote control and/or the Wireless keyboard.
1. E – Business / E – Shopping (optional) (Selecting the E – Shopping icon on the main menu, a certain number of Hot Links shall be shown. This optional service shall be included with E -Shopping advertisements, access to their websites for online ordering, local trading houses etc.)
2. XML applications (The IPTV system should support XML applications, where any developed application in the future can be run on the TV screens. Different XML based application can be added to the system and which can be useful for the guest i.e. currency converter, calculator etc. Also Room Management System interface Application (if applicable) can be run through the TV and which allow the guest to use all the control features which exit in the room management system)
3. Game facility.

2.10 ALL ELECTRONIC PRODUCTS

A. All system components shall be modular plug-in, heavy-duty, industrial- or commercial-grade units.

B. All equipment to be supplied under this Specification shall be new and shall be the current model of a standard product of a Manufacturer of record. A Manufacturer of record shall be defined as a company whose main occupation is the manufacture for sale of the items of equipment supplied. Equipment shall be silicon-based, solid-state, integrated circuit devices.

C. Specifications of equipment as set forth in this Specification are MINIMUM requirements, unless otherwise stated, and shall not be construed as limiting the overall quality, quantity or performance characteristics of items furnished in the IPTV System. When the Contractor

furnishes an item of equipment for which there is a specification contained herein, the item of equipment shall meet or exceed the specification for that item of equipment.

D. The total IPTV System shall be designed and installed so that the combination of equipment actually employed does not produce any undesirable visual or aural effects such as signal distortions, noise pulses, glitches, hum bars, transients, ghosting, etc.

E. Active component equipment shall consist of solid state components, be rated for continuous duty service, and comply with the requirements of FCC Docket No. 21006.

F. Shall operate on 120/240 VAC at 50/60 Hz.

G. Shall be capable of operating continuously for 12 hours over the external ambient temperature range of -5°C to +65°C (20% to 95% humidity, noncondensing) without permanent damage.

H. All programmed, software based microprocessor based control and DSP devices shall be powered by a UPS supply capable of providing 4 minimum hours backup.

2.11 IPTV SYSTEMS

A. Antennas and their supports shall withstand adverse local environmental conditions and 161 km/h (100 M/h) winds without damage.

B. Lightning Arrestor: The lightning arrestor shall be a grounding block assembly for grounding of the antenna coaxial lead-in cable shield. It shall be made of non-corrosive metal and shall be securely connected to the earth ground for lightning protection by a #6 AUG stranded copper conductor.

C. Antenna Tower: The tower shall be a heavy duty self-supported tower made of 32 mm (1 1/4 inches) minimum outside (OD) diameter, hot dip galvanized steel tubing. It shall be built on an equilateral triangle design with cross bracing throughout. It shall be mounted to withstand 161 km/h (100 M/h) winds with full load antennas installed. The tower shall be securely grounded to the earth ground.

D. Satellite Dishes:

1. All the antennas are mesh-type Satellite TVRO antennas with LNBs.
2. LNBF's operate at Ku band for the 1.8-meter antennae. Coordinate Satellite transponder with satellite service provider.
3. LNBF's operate at C band for the 3.6-meter antennae. Coordinate Satellite transponder with satellite service provider.

E. UHF/VHF Off-Air Antenna

1. Large Directional UHF/VHF/FM Antenna
2. Constructed of high-tensile aluminum
3. Includes mounting kit with 1524mm mast

F. DiSEqC Multiswitch

1. Frequency range: TERR 5-862 MHz (passive), 40-862 MHz (active), SAT 950-2300 MHz.
2. Insertion Loss TERR active (avg): 6dB
3. Insertion Loss TERR passive (avg): 30dB
4. Insertion Loss SAT (avg): 7dB

5. Isolation: 20dB min (between V/H polarizations), 20dB min (between L/H bands), 25dB min (between satellites)
6. Maximum Input Level: TERR 85 dBuV avg (active), TERR 110 dBuV avg (passive), SAT 85 dBuV avg
7. Maximum Output Level TERR active (avg): 79dBuV
8. Maximum Output Level TERR passive (avg): 80dBuV
9. Maximum Output Level SAT (avg): 78dBuV
10. Control: DiSEqC 2.0 (or 1.0)

G. DVB-T Receiver

1. Accepts at least one CA module (CAM). Contractor to provide required CA module as required per channels selected by Employer, if required
2. Dual SDI output with embedded de-compressed audio and VBI
3. Dual analog (PAL/NTSC) BNC outputs
4. Dual ASI transport stream outputs
5. Frame synchronization input
6. Remote control via SNMP or web page
7. Single alarm relay
8. Descrambling of MPEG-4 AVC via a CAM
9. CAM menu browsing via web browser
10. DVB-T OFDM input, compatible with 6, 7, 8 MHz bandwidth signals

H. Integrated Receiver Decoder

1. Four (4) input DVB-S QPSK satellite demodulator
2. Transport stream input with ASI connection
3. Transport stream output with ASI connection
4. DVB Common Interface CA support
5. Director single service decryption
6. Front panel and web browser control, with alarm relay
7. SCTE 35 controlled contact closures for ad-insertion signaling
8. DVB-S2 QPSK demodulation
9. Transport steam over IP output
10. Multi-service decryption via Pro CAMs
11. Ability to decrypt up to 10 channels or services off the same transponder transport stream at one time with the limit of a maximum of 24 PIDs. Final quantity of receivers to be determined as required per channel packages selected by Employer

I. HD/SD Video Processor/Streamers

1. The purpose of the streaming server is to encode live stream of video to be transmitted through the network directly to users or to local video servers for storage and future viewing.
2. The system shall be a rack-mount system running on an embedded operating system with no moving parts for reliability and low maintenance.
3. The system shall offer a mixture of compression/decompression techniques operating at a wide range of bit rates and video resolution.
4. The system shall combine ease-of-use with advanced features and top video quality, giving the Employer the ability to set up a TV-quality streaming solution.

5. The system shall be reliable with minimal down time and maintenance.
6. NEBS Level 3 certified chassis for telco environment installation
7. Self-managed 1:1 hot-standby redundancy configuration available, also n+m redundancy with control suite.
8. 2 built-in Gigabit Ethernet interfaces for traffic I/O
9. 2 built-in Fast Ethernet interfaces and Serial port for management
10. Up to 8 submodules for video processing and additional input and output interfacing
11. Up to 4 MPEG-4 AVC Ultra Compression encoders
12. Up to 4 MPEG-4 AVC Ultra Compression transcoders
13. Up to 8 MPEG-2 or MPEG-4 AVC encoders
14. Up to 16 ASI interfaces
15. Up to 8 ATM interfaces
16. Up to 36 MPEG-2 SD transrated streams
17. UP 8 MPEG-2 to MPEG-4 AVC transcoded streams. Final quantity of Video Processor/Streamers to be determined as required per channel packages selected by Employer.

J. Multi-format SD/HD Integrated Receiver Decoder

1. MPEG-2, SD, 4:2:0 decoding
2. MPEG-2, SD, 4:2:2 decoding
3. MPEG-2, HD, 4:2:0 decoding
4. 3 x HD-SDI, SD-SDI, or ASI Outputs
5. 1 x RGB or YPrPb analog video output
6. 1 x ASI input
7. 2 x balanced analog audio outputs
8. 2 x balanced digital audio outputs
9. 4 x unbalanced digital audio outputs
10. Frame synchronization input
11. RS-232 data output
12. RS-232/485 Control port
13. Alarm Relay
14. BISS Mode 1 & E support
15. Extensive VBI support

K. Audio and HD Video Monitor

1. 5.8” LCD video screen
2. NTSC/PAK Auto-Sensing
3. Self-powered speaker
4. Monitors and converts eight audio channels and one video channel simultaneously
5. 8 26-segment tri-colored LED bar graphs displaying VU and PPM
6. Complete magnetic shielding
7. Front panel summing of any combination of up to 8 channels to the left and/or right speakers
8. 16:9 aspect ratio

L. Middleware Application

1. The purpose of middleware is to connect applications, allowing them to exchange data. The middle is a software layer that lies between the operating system and the applications.
2. The software shall be designed in a way to reduce the dependence of a specific hardware platform. This feature shall allow **KAUST** to vary between different STB manufacturers over time without changing the software platform.
3. All software upgrades shall be included in the Contract, and shall be effective on the installed version as and when applicable.
4. The application platform shall be ported to the different hardware with minimal or no integration work necessary.
5. The solution shall be based on industry open standard technologies such as XML, XSL, HTML, Java, Java Script and others.
6. The system shall interoperate with equipment from major video streaming manufacturers.
7. Administration functions shall include, but not limited to, the followings:
   a. Easy access to user account details,
   b. Ability to set different rental period to be combined with price groups,
   c. Ability to build advertisement profiles and to insert video advertisements in the contents,
   d. Shall allow transaction profiling and reporting.
8. Administration components shall be easily integrated with existing infrastructure components such as accounting, and network management through open standard interfaces such a SNMP, SQL or XML.
9. The application software shall contain a set of pre-configured templates for presentation of the text information channels. Text may be entered in constrained on-screen boxes within those templates by the operators for each service and shall be easily updated as required. The templates shall be prepared by the system installer to suit **KAUST Hotel** requirements.
10. Central monitoring station of the system shall have indication of TV status like power on, data disconnection, video disconnection and any other foreseeable defect at the user end.
11. The PC shall be the latest model at the time of implementation and shall be from a recognized Manufacture of PCs. Purchase of the PC shall be delayed until the latest time possible without causing a delay in the schedule in order to ensure that it is state-of-the-art and is based on the latest proven technology.
12. Fully integrated solution including streaming pump and middleware to manage and deliver services on TV
13. Open solution that can be used with any IPTV set top box
14. Capable of full integration with world leading property management systems, such as Fidelio
15. Language pre-selection from the PMS or through server
16. Minimum languages provided: English and Arabic
17. DVD like-control for Video on Demand channels such as pause, stop, rewinding, and fast forward with variable speed
18. Support of multilingual transport streams
19. Support music jukebox with selection of individual tracks or random playback by categories
20. Live TV programs placed in categories in addition to Pay TV play outs
21. Pay TV, if required

22. Programs are played out at pre-scheduled times
23. Users can purchase a movie after a pre-determined free period
24. System shall provide a simple intuitive resident interface for purchasing
25. Warning page shall be displayed before purchase
26. Shall utilize the multicast feature of the TCP/IP Protocol
27. Possibility of on screen “real-time” viewing of bill
28. Remote monitoring/control of the IPTV set top box
29. Help menu
30. Welcome message
31. Personal message

M. Encoding station

1. Comprehensive metadata creation, editing and packaging
2. Automated VOD validation, packaging and propagation
3. Editor allows for transport stream editing of MPEG-2 SD and HD and MPEG-4 AVC SD and HD
4. MPEG Player Module for preview and QC
5. VTR shuttle control via RS-232/422
6. Manual, automatic, batch, schedule, time and rolling MPEG capture modes
7. Easy-to-use Windows-based interface

N. Video on Demand (VOD) system – server based

1. Can view movies/other content (both free and purchased) from a set of digitally stored content
2. DVD like control of the movie
3. Uses the Multicast feature of the TCP/IP protocol
4. System capacity within each Tower/Podium shall support at least 100 movies

O. TELEVISIONS

1. MANUFACTURERS
   a. Subject to compliance with requirements, manufacturers shall meet all specifications requirements and shall be approved by the Engineer.
2. Normal Televisions.
   a. Typical Television size shall be 42” diagonal except as otherwise noted.
   b. Aspect Ratio: 16:9
   c. Native Resolution: 1920 x 1080
   d. Brightness: 500cd/m2+
   e. Viewing Angle: 170 x 170
   f. Color Depth; 16.7m
   g. Lamp Life: 50,000 hours minimum
   h. Response Time: 8ms
   i. NTSC and ATSC Tuner
   j. Support formats: 1080p,1080i,720p,576p,480p,480i
   k. Speakers: 2@10 watt RMS
   l. Analog Audio: Mono/Stereo/SAP
   m. Digital Audio: Multi lingual
   n. Power: 100-120V, 60Hz, IEC male,
   o. Inputs: RF F connector female, RS-232 9 pin male D-SUB, RJ-45, (2) component, (1) s video, (1) composite, (2) HDMI, (1) PC RGB, (1) PC audio, (1) DVI.

p. Outputs: (1) composite audio/stereo, (1) digital sound output.
q. Auto power on, power management
r. Programmable source selection
s. Channel lock
t. Parental control V chip
u. Clone programmable
v. Black cabinet
w. Wall mount adjustable mount suitable for weight of television.

P. IPTV Servers minimum requirements (to be confirmed by relevant manufacturer/supplier):

1. General Server equipment requirements
   a. General Server:
      1) 19” (483mm) Rackmount – 2RU Server chassis
      2) Two Processors: Each Processor Intel Xeon 2.93 GHz 64-bit Quad-core
      3) Memory: 24GB RDIMM DDR3 SDRAM
      4) Disk: Support for Hot plug, Serial Attached SCSI, 2.5” 15KRPM Harddrives
      5) Accommodates up to eight (8) Small Form Factor hot-plug harddrives
      6) Raid Array Controller
      7) DVDRW Optical Drive
      8) Minimum 4 USB ports
      9) 10/100/1000 Ethernet Ports
      10) Fully Redundant hot plug fans
      11) Redundant 750 Watt, 100-240 VAC, 50/60Hz Power Supplies.

   b. Storage Drives
      1) 146GB, Serial Attached SCSI 15K rpm SFF (2.5-inch) Dual Port Enterprise Hard Drive
      2) Provide three (3) drives per server chassis

2. Database Server equipment requirements

   a. General Server:
      1) 19” (483 mm) Rackmount – 2RU Server chassis
      2) Two Processors: Each Processor Intel Xeon 2.93 GHz 64-bit Quad-core
      3) Memory: 24GB RDIMM DDR3 SDRAM
      4) Disk: Support for Hot plug, Serial Attached SCSI, 2.5” 15KRPM hard drives
      5) Accommodates up to twenty-four (24) Small Form Factor hot-plug hard drives
      6) Raid Array Controller
      7) DVDRW Optical Drive
      8) Minimum 4 USB ports
      9) 10/100/1000 Ethernet Ports
      10) Fully Redundant hot plug fans
      11) Redundant 750 Watt, 100-240 VAC, 50/60Hz Power Supplies.

   b. Storage Drives:
      1) 146GB, Serial Attached SCSI 15K rpm SFF (2.5-inch) Dual Port Enterprise Hard Drive
      2) Provide twenty-four (24) drives per server chassis

3. Blade Server equipment requirements:

   a. Blade Server Chassis:
      1) 19” (483 mm) Rackmount – 10RU Server chassis
      2) NEBS Certified

3) Device Bays: 16 Half-Height Blades, 8 Full Height Blades, with mixed configurations supported.
4) Fans: 10 Fans
5) 1 Gbps and 10 Gbps Network connectivity Support
6) 4Gb and 8Gb Fibre Channel Support
7) Redundant 2400 Watt, 100-240 VAC, 50/60Hz Power Supplies.

b. Server Blades:
1) Two Processors: Each Processor Intel Xeon 2.93 GHz 64-bit Quad-core
2) Memory: 24GB RDIMM DDR3 SDRAM
3) Disk: Support for Hot plug, Serial Attached SCSI, 2.5" 15KRPM Harddrives.
4) Dual Port 10Gbps Ethernet Interface
5) 10Gbps Ethernet modules
6) Dual 8Gbps Fibre Channel ports

c. Storage Drives:
1) 146GB, 6Gb/sec, Serial Attached SCSI
2) Single Track Seek Time: 0.14 ms
3) Average Seek Time: 2.58 ms
4) Rotational Speed: 15K rpm
5) Form Factor: Small Form Factor (2.5-inch)
6) Dimensions: 16.0 mm Height, 78.7 mm Width, 138.4 mm Depth
7) Provide two (2) drives per server blade

Q. IPTV Supervision Workstation minimum requirements (to be confirmed by relevant manufacturer/supplier):

1. Computer Workstation:
a. Small Form Factor (Maximum dimension 300mm x 90mm x 350mm)
b. Processor: 3.0 GHz 64-bit Quad-core
c. Memory: 8GB 1333MHz DDR3 SDRAM
d. Disk: 7200 RPM SATA 3.0 1TB Harddrive
e. 1333 MHz Front Side Bus
f. PCI Express x16 Slot
g. DVDRW Optical Drive
h. Minimum 4 USB ports
i. 10/100/1000 Ethernet Port
j. Ergonomic 103 keys multi-media keyboard
k. Stereo speaker sound bar attachable to display screen listed herein
l. Minimum 240 Watt, 100-240 VAC, 50/60Hz Power Supply.

2. Video Card (s):
a. 4 monitor support
b. PCI Express x16 compatible
c. Minimum 784MB DDR3 graphics memory
d. low profile half length card
e. DVI connectors supporting 1600 x 1200 resolution per display
f. RoHs and WEE compliant, support 4:3 and 16:9 aspect ratio

g. Supports configuration of four screen arranged horizontally

h. Vertically or combination of both orientations.

3. Display Screen:

a. LCD active matrix

b. 20-inch viewable size

c. 178-degree viewing angle

d. 4:3 aspect ratio

e. Black colored enclosure

f. Minimum of two USB 2.0 Ports

g. 1600 x 1200 DVI Native resolution

h. 32-bit color support

i. Minimum 160 MHz video bandwidth

j. DVI connector

k. 800:1 minimum contrast ratio

l. 120-240 VAC, 50/60Hz power supply.

4. Secure Keyboard/Mouse Switcher:

a. 2-channel supporting USB and PS/2 keyboard and mouse

b. Minimum 10 foot cables

c. Audio and Video ports are not required

d. Advanced H/W and S/W security

e. NIAP Common Criteria validated to EAL 4+

R. Peripheral Devices

1. Rack Mount IP-Based KVM Switch (LAN Accessible)

a. 8-Port PS2/USB KVM with 19” Rack Mounting Kit and all cabling for eight servers.

1) Keyboard and Mouse: PS2 Type Keyboard and Mouse

2) Video: Resolution XGA (1024 x 768) @ 75Hz and DVI or HD-15 connector

3) Connects to remote computers or over IP

4) Supports minimum of 4 simultaneous remote users and 8 servers / workstations.

5) Security system with login, computer access control and data encryption (Minimum 64 bit triple DES)

6) Scaling, scrolling, auto-size, and quad screen features

2. Rack Mount KVM Drawer (Rack Local Console)

a. Rack View Fold Forward - 1 Rack Unit

1) 17" TFT/LCD high-resolution monitor

2) Tactile keyboard with separate numeric keypad

3) Integrated trackball mouse

4) PS/2 and USB connections

5) Easy-glide 1 rack unit drawer mountable in a standard 19 inch rack

2.12 SET-TOP-BOX

A. The set-top box (STB) is the hardware and common software infrastructure component that is used at the end user premises to convert video, delivered as IP packets, into an uncompressed digital stream that can be directly turned into TV signal ready for display by a television set. The set-top box can also provide VCR like functionality, allowing the user to rewind, fast-forward, pause, slow down play, etc. by sending user command upstream via the channel.

B. The STB hardware shall typically consist of a high performance integrated general-purpose processor with built-in graphics and TV support, hardware based MPEG decoder, and video subsystem that produces television output.

C. The set-top boxes shall be standalone devices without integrated communication cards within the TV sets. All required communication cards shall be integrated within the set-top boxes, which shall communicate with any type of TV sets.

D. The set-top box shall support the popular basic functionality such as Digital TV, video on Demand (VoD), and Internet browsing. Adding any additional application or service shall require no extra hardware.

E. The STB software shall typically include an embedded operating system and application infrastructure components.

F. The system software shall be based on open standards operating systems, and navigation and control shall be via low cost web based protocols, or using established middleware.

G. The set-top box shall be software upgradeable and remotely manageable.

H. The STB shall be similar to a lock and key arrangement which permits only a single, authorized user access. To maintain this exclusive access, each lock and key combination shall be unique.

I. The STB shall be plug and play auto setup device configurable using DHCP and TFTP.

J. The STB shall have integrated IR receiver for IR remote control and keyboards (as an option). This IR receiver shall be easily adapted to support other IR devices should they be required.

K. The system shall include anti-flickering filter, square pixel conversion for optimized viewing of computer graphics on a television.

L. Functional Characteristics:

FUNCTIONS	CHARACTERISTICS
Input Voltage:	100 to 240 Volts AC
Power Line Frequency:	50 Hz ± 2.0 Hz
Operating Temperature:	-5 to +65degrees C
Humidity:	95% minimum rating

M. Input/Output Interfaces:

Minimum Interfaces requirement

RJ45 10/100baseT Ethernet (for network connection and link to a laptop or PC)

RF PAL or NTSC

HDMI

RGB

S-Video

VGA

Digital Audio

Stereo Audio

USB Ports (for optional I/O devices such as web cameras and hard disk drives)

Smart TV Port (for use in hospitality applications)

IR Receiver (for remote control & keyboard)

N. Streaming Media (as a minimum): MPEG-1, MPEG-2, MPEG-4, MP3, PAL & NTSC IETF RTSP for VoD services.

O. The STB shall be manageable (SNMP, HTTP, etc.) using the appropriate user management, operation management, and billing software.

P. The set-top box shall adapt well to the bottlenecks of various network structures and QoS management.

Q. The Contractor shall provide a verified compliance with leading video servers' Manufacturers.

R. The STB software and configuration should not be affected by a power outage and shall reside in a non-volatile memory.

2.13 INTERFACES

A. The system shall interface with the Fire Alarm System through the BMS system.

B. The system shall interface with **KAUST** data network.

C. The Contractor shall co-ordinate with **KAUST** define the scope of works for system interfacing and shall identify those areas requiring interface works by third party suppliers.

PART 3 - EXECUTION

3.1 INSTALLATION

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. Wiring Method: Install cables in raceways.

C. Pulling Cable: Do not exceed manufacturer's recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

E. Grounding: Provide signal circuit grounding (clean earth) recommended by manufacturer.

F. Equipment: install in accordance with manufacturer's instructions and to the approval of the Engineer. Mount equipment in alignment with other building fixtures and fix firmly in place with all supports and fastenings secured.

G. Interference Protection: equipment is to be installed to prevent electromagnetic, electrostatic or other outside interference impairing system performance.

H. Accessibility: equipment is to be installed to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made, but no changes are to be made without prior approval.

I. Make good surfaces of equipment damaged during installation, using touch-up paint provided by equipment manufacturer, to the satisfaction of the Engineer.

J. Routing of video signal cables, power and control cables, in general, is to be in separate raceways.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Basic Electrical Materials and Methods."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field assembled components and equipment installation and supervise pre-testing, testing, and adjusting of television equipment.

B. Inspection: Verify that units and controls are properly installed, connected, and labeled and that interconnecting wires and terminals are identified.

C. Record test results.

D. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

E. Test Equipment: provide diagnostic equipment required performing system tests and measurements including function generator, Impedance Bridge, oscilloscope, frequency spectrum analyzer, chart recorder, digital voltmeter, dB meter and wave form monitor.

3.4 CLEANING

A. Clean installed items using methods and materials recommended by manufacturer.

3.5 DEMONSTRATION

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

SECTION 16910 - DIGITAL, ADDRESSABLE FIRE ALARM SYSTEM.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. All Fire protection and audio drawings, Bill of Quantity, Design criteria and general provisions of the Contract, including General and Supplementary.

1.2 SUMMARY

A. This Section includes intelligent, interactive, analogue, addressable fire alarm systems with manual stations, detectors, signal equipment, controls, connection to voice evacuation (VE), emergency voice/alarm communication systems) and relative devices.

B. Related Sections include the following:
   1. Divisions 16 of the specifications.

1.3 DEFINITIONS

A. Definitions in NFPA 72 apply to fire alarm terms used in this Section.

1.4 SYSTEM DESCRIPTION

A. General: Non-coded, Interactive / Intelligent, addressable-analog system with manual and automatic alarm initiation; automatic sensitivity control of detectors; and multiplexed signal transmission dedicated to fire alarm service, VE and extinguishing agent release.

B. Connection and interface to KAUST fire alarm system with fiber optic cable connection through telecom entry room rack.

1.5 SUBMITTALS

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

B. Shop Drawings:
   1. Wiring Diagrams: Detail wiring and differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
   2. Battery: Sizing calculations.
   3. Floor Plans: Indicate final outlet locations and routings of raceway connections.
   4. Device Address List: Coordinate with final system programming.
   5. 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.
   6. Monitored input/output points schedule & sequence of operation.
   7. Details of graphics display panel

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.
5. Size and location of speakers and all audio equipment.

D. Operating Instructions: For mounting at the FACP and main audio rack.

E. Product Certificates: Signed by manufacturers of system components certifying that products furnished comply with requirements.

F. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.

G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Comply with NFPA 72

H. Maintenance Data: For fire alarm systems to include in maintenance manuals specified in Division 1. Comply with NFPA 72.

I. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 1 Section "Submittals," 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 Architect for review.

J. Certificate of Completion: Comply with NFPA 72.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the FACP manufacturer, ISO 9002 certified for both installation and maintenance of units required for this Project.

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. UL listing for NFPA compliant is a requirement.

C. Source Limitations: Obtain fire alarm system components through one source from a single manufacturer. Equipment must either be UL listed to NFPA requirements

D. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.

E. Comply with NFPA 72 for installation requirements and NFPA

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. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but not less than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but not less than one unit.

3. Optical Smoke Detectors, Heat Detectors, combined optical smoke and rate of rise detector and Flame Detectors: Quantity equal to 5 percent of amount of each type installed, but not less than one unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed (including bases with built-in sounder), but not less than one unit of each type.
5. Speakers and horns: Quantity equal to 10 percent of amount of each type installed, but not less than one unit of each type.
6. Keys and Tools: One extra set for access to locked and tamper proofed components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by **one** of the following **for fire alarm and detection** systems:
   1. Edwards Systems Technology, CA
   2. Notifier/Honeywell, USA
   3. Simplex, USA
   4. Esser of Germany

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

A. General: The fire detection systems shall comprise of main fire alarm control panels, optical smoke/heat sensor, heat sensor, optical smoke/heat sensor with integral sounder units, manual call points, electronic sounders, repeat panels, interface units, each with isolators for every 10 devices in a fire zone. Please refer the relevant fire detection and alarm drawings and schematics. The repeat panels, master panel and the graphics terminal shall be sited as shown on the drawings. All loop cabling and any other components and accessories deemed necessary for a safe, reliable and satisfactory system shall conform to the relevant and applicable requirements and recommendations of **NFPA 72, corresponding UL standards and the equipment manufacturer.**

B. Control of System: By the FACP.

C. System Supervision: Automatically detect and report open circuits, shorts, and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.

D. 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.

E. Noninterference: A signal on one zone shall not prevent the receipt of signals from other zones.

F. System Reset: All zones are manually reset-able from the FACP after initiating devices are restored to normal.

G. Flexibility: The system shall be fully programmed to accommodate fire alarm zones as indicated on the drawings and schematics. The system shall be configured to allow on site modifications with the minimum of disruption using the PC based software and built-in features to facilitate future changes or alterations to the buildings.

H. Transmission to Remote Alarm Receiving Stations: Automatically route alarm, supervisory, and trouble signals to a remote alarm station by means of a digital alarm communicator transmitter.

I. 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.

J. Loss of primary power at the FACP initiates a trouble signal at the FACP and the remote announciators. An emergency power light is illuminated at both locations when the system is operating on the secondary power supply.

K. The system shall be of safe soft addressable type i.e. all the devices on the loops of the FACP shall be:
   1. Allocated addresses automatically from the panel at the time of system power up on a numerically lowest unused value basis (algorithms)
   2. Given an address during commissioning, the value of which shall be stored in non-volatile memory, within the electronics module of the outstation. This value shall be read during loop allocation and provided it is valid shall be used to setup the outstations primary address.
   3. If the devices are inserted or removed all the existing devices shall keep the same address.

L. The panel shall allocate the address in strict sequential order when the loop is powered up to speed up commissioning and ensure that it is impossible for two devices to have the same address.

M. All devices shall be assigned up to 32 character alphanumeric label. In case of fire, fault or warning, the label of device sensing threshold shall appear on visual display unit of the panel.

N. Any correction in label shall be able to be carried out from the built-in keyboard of FACP.

O. Fire Detection and Alarm Systems, which rely on hard addressing techniques, are not acceptable.

P. Basic Alarm Performance Requirements: Unless otherwise indicated by **KAUST** security department, operation of an automatic alarm operation of one detector:
   1. Transmission of an audible (sounders, speakers) & visual (strobes) alarm in that zone.
   2. Notification-appliance operation.
   3. Identification at the FACP and graphics monitor of the zone originating the alarm. With a graphical display of the zone.
   4. Identification at the FACP and graphics monitor of the device originating the alarm.
   5. Recording of the event in the system memory.
   6. Recording of the event by the computer of the graphics monitor which shall also print the event log (provide serial or Ethernet interface with software).

Q. Basic Alarm Performance Requirements: Unless otherwise indicated by **the Engineer**, operation of one manual station, automatic alarm operation of two detectors, un-cleared or unacknowledged alarm of one detector, or operation of a manual agent release station initiates the following:
   1. Notification-appliance operation.
   2. Identification at the FACP and graphics monitor (of the separate computer) of the zone originating the alarm with a graphical display of the zone.
   3. Identification at the FACP and graphics monitor of the device originating the alarm.
   4. Transmission of an alarm signal to the remote alarm receiving stations.
   5. Unlocking of electric door locks (if any).
   6. Release of fire and smoke doors held open by magnetic door holders.
   7. Transmission of an audible (sounders, speakers) & visual (strobes) alarm in all zones.
   8. Shutdown of fans and other air-handling equipment serving the zone where the alarm was initiated.
   9. Closing of smoke dampers in air ducts of system serving the zone where the alarm was initiated.
   10. Recording of the event in the system memory.
   11. Recording of the event by a separate computer which shall print the event log. (provide serial or Ethernet interface with software).

12. Activate auto dialer to notify fire brigade.

R. Alarm Silencing, System Reset and Indication: Controlled by switches in the FACP and the remote announciator.
   1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
   2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
   3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.

S. 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, reading 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.

T. Removal of an alarm-initiating device or a notification appliance initiates the following:
   1. A "trouble" signal indication at the FACP and the announciator for the device or zone involved.
   2. Recording of the event by the system printer.
   3. Transmission of trouble signal to remote alarm receiving stations.

U. 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.

V. 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.

W. Topology: All system components and devices shall be connected to two-wire loop circuits (as shown in the typical schematics) with maximum 10 devices between isolators in a fire compartment. Removal or disconnection of any component from the loop shall not affect the functioning and performance of other components and the system.

X. Voice Evacuation (VE):
   1. There shall be a seamless software interface between the fire alarm between the fire detection and voice alarm paging system.

2.3 MANUAL PULL STATIONS

A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
   1. Manufactured as per NFPA requirements, UL listed.
   2. Double-action mechanism requires two actions, such as a push and a pull after breaking the glass, to initiate an alarm.
   3. Station Reset: Key or wrench operated; double pole, double throw; switch rated for the voltage and current at which it operates.
   4. Integral Addressable Module: Arranged to communicate manual-station status (normal, alarm, trouble) to the FACP.
   5. Built-in isolator.

2.4 COMBINED OPTICAL SMOKE AND RATE OF RISE DETECTORS (SENSORS)

A. General: Include the following features:
   1. Manufactured as per NFPA requirements, UL listed.
   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. Addressing is automatic (dip switches and similar shall not be accepted).
   5. Integral Visual-Indicating Light: LED type. Indicates detector has operated.
   6. Sensitivity: Can be tested and adjusted in-place after installation from control panel.
   7. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
   8. Remote Controllability: detectors are intelligent and interactive analog-addressable type, individually monitored at the FACP for calibration, sensitivity, analogue reading and alarm condition, and individually adjustable for sensitivity from the FACP.
   9. Automatic drift conpensation and control.
   10. In base isolator.
   11. EMI Protection 50V/m.
   12. Response time less than 7 seconds.

B. Combined Photoelectric Smoke & Rate Of Rise Detectors: Include the following features:
   1. Sensor: LED or infrared light source with matching silicon-cell receiver (or approved better technology).
   2. Detector Sensitivity: 0.006 grams of combustion product per cubic foot of air.
   3. Integral rate of rise Detector: actuated upon 8.3°C per minute (adjustable) temperature change setting. (for combined detectors).
   4. EMI Protection 50V/m.
   5. In base electronic sounders providing 85 dBA at 1 meter.

2.5 OTHER DETECTORS (SENSORS)

A. 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. Integral Addressable Module: Arranged to communicate detector status (detector reading, alarm, or trouble) to the FACP.
   4. In base isolator.

B. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 88 deg C.
   1. Mounting: Adapter plate for outlet box mounting.
   2. Mounting: Plug-in base, interchangeable with smoke detector bases.
   3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
   4. In base isolator.

C. Infra-Red Flame Detector.
   1. The infra-red flame detectors shall be capable of detecting infra-red radiation produced by flaming fire involving carbonaceous materials.
   2. The infra-red flame detectors shall be UL LISTED and approved.

   3. The infra-red flame detectors shall be able to detect a fuel fire of 0.1 square meter area from a distance of 30 meters for the following fuels:
      a. Petrol (gasoline).
      b. N-heptane.
      c. Kerosene.
      d. Diesel oil.
      e. Alcohol (I.M.S).

D. Beam Detectors (Sensors)
   1. The beam Sensors shall be addressable, loop powered; loop signaled with built-in short circuit isolator and shall detect fire by obscuration of an optical beam by smoke. It shall utilize a transmitter and receiver unit and be suitable for ranges of up to 100 meters. It shall be used in areas as indicated in the drawings. The traditional false alarm problems associated with the use of beam detection, such as birds, workmen and sunlight shall be overcome by the use of analogue detection.
   2. A method of automatic gain control shall be employed to minimize the effects to a built up of duct and dirt on the lens.
   3. LEDs shall be provided integral with the transmitter/receiver units to assist in the alignment set-up.
   4. The Beam sensors shall be NFPA requirements, UL listed.

E. Duct Detectors (Sensors)
   1. Duct Sensors shall be addressable, loop powered, loop signaled with a built-in short circuit isolator. They shall comprise a sampling unit with probes extending into a straight section of the mechanical ventilation ductwork. The duct sensor shall comprise optical Smoke/Heat sensing devices.

2.6 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. Mechanical Bells: Electric-vibrating, 24-V dc, under-dome type; with provision for housing the operating mechanism behind the bell. When operating, bells provide a sound-pressure level of 95 dB minimum, measured at 1 meter, from the bell. 8 inch size, unless otherwise indicated. Bells are weatherproof where indicated.

C. The addressable Alarm Electronic Sounders shall be loop wired and loop signaled and provided with built-in short circuit isolation and shall be sited in areas as shown in the schematics and the floor layout drawings. The sounders shall be configured via software to operate individually or in sectored groups, totally independent of the way they have been connected to the loops. The sounders shall have the synchronization feature to ensure that all the sounders give alert and evacuate tones that are totally in phase. Conventional Sounders that "free-run" and therefore be out of phase with each other will not be accepted. The sounders shall have an output of 100dBA at 1 meter with frequencies of 970 Hz and 910 Hz. Variety of sounds shall be available.

D. Visible Alarm Devices: Xenon strobe lights with clear or nominal white polycarbonate lens. Mount lens on an aluminum faceplate. The word "FIRE" is engraved in minimum 25 mm high letters on the lens.
   1. Rated Light Output: 110 candelas.
   2. Strobe Leads: Factory connected to screw terminals.

2.7 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door plate.
   1. Electromagnet: Requires no more than 3 W to develop 111 N holding force.
   2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.
   3. Rating: 24-V dc.

B. Material and Finish: Match door hardware.

2.8 CENTRAL FACP

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, phenol-resin nameplate with lettering not less than 25 mm high. Identify individual components and modules within cabinets with permanent labels.
   2. 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. Indicating Lights and System Controls: Individual LED devices identify zones transmitting signals. Zone lights distinguish between alarm and trouble signals, and indicate the type of device originating the signal. 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.
   4. LED test 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 the FACP and addressable system components, including annunciation, supervision, and control.
   1. Visual display unit capable of displaying at least 8 lines 40 characters backlit display.
   2. Built-in 40 character thermal printer operating when the access door is open. There shall also be an option to enable the printer when the door is closed.
   3. Built-in full qwerty keyboard. Labeling of devices shall be done from this keyboard. Also, any correction in label if required shall be done by this keyboard only.

H. Simple menu driven function keys with password protection shall allow users to an extensive range of software based features such as:
   1. Last 100 fire events.
   2. Last 255 system events.
   3. Current fault and warning logs.
   4. Analysis of analogue sensor information.
   5. Interrogation of sensor cleanliness.
   6. Loop map connections.
   7. Enable/ disable sensors, zones, sounders, interface unit channels.
   8. Fire plan configuration menus.
   9. Outstation label changes.
   10. Address allocation.
   11. Status of outstation.
   12. Status of all cards.
   13. Printer on, off, line feed and test facilities.
   14. Address allocation including soft addressing.

I. Graphics display capability by connection to a computer system by a serial or Ethernet connection (provide software and programming).

J. Instructions: Printed or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

K. VOLTAGE AND POWER SUPPLY: Main FACP is to provide 24 V d.c. to all zone alarm initiating and alarm signaling devices and is to be designed to operate from 220 V a.c., 50 Hz 2-wire, earthed power supply. Power supply is to be an integral part of the main fire alarm panel, switch mode solid state design, with built in transient protection (up to 6 kV), including UL recognized EMI filter, spark gaps and varistors. Additional power supply units are to be provided for the amplifiers. The power supply is to provide diagnostic LEDs to notify operator upon AC power and/or the control unit CPU failure.

L. Monitored output relays for security MDBs, HVAC, lifts, fire fighting panels, BMS, secondary fire alarm panels, fire doors, motorized dampers, motorized fuel valves, fuel pumps …etc as per the NFPA standards requirements and to the satisfaction of the **building's** security department. Outputs shall allow for segregated selective control per floor and/or area application.

M. Monitored input relays from fire pumps, fire fighting panels, secondary fire alarm panels, security MDBs, synchronizing panel, smoke pressurization & extraction fans, fire dampers & BMS.

N. Interface to paging system for broadcast of live messages. The operation of the alarm sounders and the voice evacuation speakers shall be coordinated such that voice messages are not blurred by alarm tones emanating from sounders.

O. RS 232/ RS 485 computer communication.

P. Inputs to BMS shall include but not limited to:
   1. Failure or disconnection of power supply.
   2. Failure of protective device.
   3. Valve tamper at five pumps.
   4. Flow switches at fire pumps.
   5. Fire pumps power loss or phase reversal.
   6. Generators start failure.
   7. Generators low fuel.
   8. Generators low oil pressure.
   9. Each stairwell pressurization fan that is running.
   10. Each smoke removal fan that is running (or high speed).

Q. In addition to the above, all other necessary controls, elements and accessories shall be included to provide a complete and efficient panel conforming to the requirements of NFPA standards.

2.9 EMERGENCY POWER SUPPLY

A. General: Components include stand-by sealed lead-acid battery, charger, and an automatic transfer switch.
   1. Battery Nominal Life Expectancy: 10 years, minimum.

B. Battery Capacity: 24 hours: including supply of sounders, electronic bells, warning signs, strobe lights, control signals, full alarm load for 30 minutes.
   1. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails.

C. 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.

D. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.10 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.

2.11 REPEAT PANELS

A. The Repeat Panel with built-in short circuit isolation shall be sited at the indicated locations. It shall provide system repeat facilities to repeat all of the liquid crystal display messages as well as the common indications. It shall have essential alarm controls, menu facilities and an optional printer allowing it to take the role of the main system indicator for the day to day running of the system. The Repeat Panel shall be loop driven and provided with an inbuilt isolator. The Repeat Panel shall be complete with built-in battery and charger to comply with NFPA standards and shall require 220V AC supply. The Repeat Panel shall be located as shown in the schematics.

2.12 GRAPHICS TERMINAL

A. The graphic visual display shall pictorially represent Fire, Fault and Emergency events on a visual display unit (VDU). The purpose of this facility shall be to provide the operator with the additional visual information over and above the text provided. All system events ie fire, fault and warning shall be automatically printed onto the graphics printer. Operation of the graphics terminal shall normally be by selection of the appropriate pages guided by a navigation system. However, it shall automatically track to the relevant initiating device for the first occurrence of each type of the event.

B. The graphics terminal shall provide the following:
   1. Events display/status bar giving a clear and concise view of the current events on the fire alarm system.
   2. Ability to control and change the following:

- Disable actions.
- Labels.
- Auxiliary text.

3. User Action buttons.
4. Historic data of all the system events.
5. Access levels/passwords to target specific levels of access to specific users.
6. Graphical representation of the site allowing the exact location of the fire alarm events, e.g. fires, faults etc.
7. Panel remote buzzer cancellation.
8. Event acknowledgement.
9. Clock synchronization with panels with local adjustment facility.
10. Touch screen support.

C. The terminal shall assign a number of different graphic pages to each fire event – from a site overview of building layout, through a floor layout, breaking the site down into increasing levels of detail. Number of graphic pages required shall be finally determined by the client/consultant. For tender assume 10 pages per floor, based on the drawings produced on AutoCAD by the Contractor.

2.13 NETWORK INTERFACE

A. The network interface provides for connection of a control panel to the panel's network. It includes an integral battery-backed power supply.

2.14 T-BREAKER UNIT

A. The T-breaker may be placed anywhere in a loop to provide connection for a spur or sub-loop. The T-breaker uses a single address of its own.

2.15 WIRES AND CABLES FOR SOUNDERS, BELLS, and CONTROL SIGNALS (including detectors and addressable devices)

A. Certified to have passed IEC 331 and 332 flame resistance and fire retardant tests or BS 7629: 1993 and BS 6387 or NEC 760 and UL 2464. The wiring is to be true class "A".

2.16 CONDUITS AND RACEWAYS

A. Flame retardant rigid PVC heavy gauge concrete embedded or steel conduits for surface mounted for Pirelli FP100 (locally manufactured conduits and boxes shall not be accepted). MICC or FP200 GOLD cables do not need PVC conduits. However, all connection blocks shall be fire resistant similar to “WAGO” installed in metallic red painted boxes.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Connect the FACP with a disconnect switch with lockable handle or cover.

B. Manual Pull Stations: Mount semi flush in recessed back boxes.

C. Ceiling-Mounted Smoke Detectors: Not less than 10 cm and not more than 5 meters from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 10 meters apart in any direction.

D. Wall-Mounted Smoke Detectors: At least 10 cm, but not more than 30 cm, below the ceiling.

E. Smoke Detectors near Air Registers: Install no closer than 150 cm.

F. Audible Alarm-Indicating Devices: Install not less than 25 cm below the ceiling (or false 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.

G. Visible Warning signs: Install above exit doors at least 15 cm above top of door frame.

H. FACP: Surface mount with tops of cabinets not more than 1830 mm above the finished floor.

3.2 WIRING INSTALLATION

A. Wiring Method: Install wiring in rigid PVC heavy gauge conduits except for fire resistant cables when unconcealed. 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 vertical cable risers to serve the fire alarm system (sounders bells and control devices) as indicated on riser diagram.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Basic Electrical Materials and Methods."

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

C. Install instructions frame in a location visible from the FACP.

D. 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.

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 drawings.
   4. Verify that the control units are 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, graphics (on separate computer), signal tones, and annunciator indications.
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. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets Specifications 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 Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 8 hours' training.
2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.8 ON-SITE ASSISTANCE

A. 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.

SECTION 16920 — IP ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Electrical Work generally is to be in accordance with the requirements of other sections of the specifications.

B. Integrated access control system with contactless proximity cards, readers, associated accessories and IP based & interconnected controllers. The system shall include also system server, workstation, software, licenses and interfaces as described thereafter.

C. Integration is required with IP CCTV System and Network Video Management Software (NVMS).

D. Power supply up to the door controllers, servers' racks and workstations is provided by others. (Refer to electrical documents).

E. Structured cabling system and active LAN equipment is provided by others.

1.2 SYSTEM DESCRIPTION

A. Works are to include a complete access control system including the following:
   1. Central Host Server (CHS), satellite workstations, system software and peripherals or, when indicated, a Programming keypad (PK).
   2. Access Control Door Controllers (DCs) with IP interfaces.
   3. Proximity card Readers.
   4. Proximity Cards.
   5. Door Hardware Accessories (contacts, locks,…etc).
   6. Parking barriers and related interfaces via dry contacts.
   7. Readiness for integrating parking ticketing machines (those machines are not part of actual scope).
   8. Interfacing with the fire alarm and parking management (if any) systems by dry contacts.
   9. System should be readily accessible and configurable from the remote Network Operation Center (NOC) via TCP/IP.
   10. Back-up power by chargers, inverters (if equipment does not operate on DC supply) and batteries.

B. The central panel shall be UL listed for burglar detection and access control. It shall be addressable and shall manage dry contacts from various detectors as well as access control modules and alarm outputs.

C. It shall be software programmable, and allow for the edition of entry reports if ever required.

1.3 SUBMITTALS

A. Submit full technical information for approval including manufacturer's catalogues for all system equipment and components, indicating the following:
   1. System operation, equipment specification, software features, listings and certifications.
   2. System expandability
   3. Operating parameters and limitations, ambient conditions, heat dissipation, power requirements etc.
   4. Manufacturer recommended cabling and wiring specifications and characteristics.

B. Equipment is to be tested for quality and operation at factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Engineer before dispatch to site.

C. Submit drawings for approval including, but not limited to, the following:
   1. Detailed system schematic diagrams
   2. Exact devices & controllers locations, layouts and mounting details
      Configuration and construction details of access control cabinet, operating consoles…etc.

1.4 SPARE PARTS

A. provide manufacturer's recommended spare parts for replacement and one year's maintenance including, but not limited to, the followings:
   1. Power supply: Quantity equal to 3 percent of amount of each type installed, but not less than one unit of each type.
   2. Door Lock: Quantity equal to 3 percent of amount of each type installed but not less than one unit of each type.
   3. Proximity card reader: not less than one unit of each type.
   4. Door controller: not less than one unit of each type.
   5. Door Contact: Quantity equal to 3 percent of amount of each type installed but not less than one unit of each type.
   6. Input/Output relay interface: Quantity equal to 3 percent of amount of each type installed but not less than one unit of each type.
   7. Proximity access control cards (for proximity readers used): Quantity equal to 10 percent of amount used, of each type.
   8. One unit of any single point of failure device that could inhibit the usage of the whole system.

1.5 APPROVED MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the public address System include, but are not limited to, the following:
   1. Honeywell building solution (USA).
   2. GE security(USA).
   3. Lenel (USA)
   4. Kantech (USA)
   5. Northern computers(Canada).
   6. Bosch (Germany)
   7. Napco(USA).
   8. Johnson controls (USA).
   9. DSC - Tyco (USA).
   10. HID (USA).
   11. Siemens (Germany).
   12. Substitution: or approved equal.

1.6 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: A written warranty, signed by Contractor and manufacturer, agreeing to replace any component of the access control system that do not meet requirements or that fail within the specified warranty period.
   1. Warranty Period: 2 years from date of Substantial Completion for any component of the system.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer approved by the manufacturer for both installation and maintenance of equipment required for this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in European EN, UL and IEEE Standards by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with relevant IEC and IEEE standards.

PART 2 - PRODUCTS

2.1 SYSTEM OPERATION AND MATERIAL

A. GENERAL: The purpose of the access control systems is to monitor and control access to the selected areas of the project 24 hours a day 7 days a week depending on the cardholder credentials.

B. Access through any such points is controlled through an electronic touch-less card reader (for proximity cards). The access control field devices shall be connected to a control panel housing the access control system controllers (security panels or door controllers as indicated on drawings).

C. Access control systems controllers :
   1. Single Point “ON-LINE/OFF-LINE” Controllers that can handle up to four readers in an ON-LINE and OFF-LINE mode in addition to input-output cards.
   2. Modular multi-Point “ON-LINE/OFF-LINE” Controllers that can handle up to 32 readers or input-output cards in an ON-LINE and OFF-LINE mode.

2.2 SYSTEM DESCRIPTION

A. A CHS (CHS) working as a server and serving multiple satellites; 1 workstation (satellite) in **the control room** connected to the access control system controllers via the Local Area Network (LAN) of the project. The workstation is also used for the IP CCTV and BMS system.

B. Complete integration with the IP CCTV System and Network Video Management Software (NVMS) referred to in section 16780.

C. The CHS shall be used to program each of the DCs (access system controllers), monitor the operation of each DC, log the activity data for future consultation and if necessary override the DCs to manually actuate the status of the inputs/outputs. The access to the different functions of the CHS shall be protected by different levels of passwords for different kinds of authorizations. The CHS shall also be used to program the following:
   1. zonal alarm interlock or cause to effect matrix (inputs at different controllers affect outputs on other controllers - such as freeing specific access points in case of fire or assault, ...)
   2. zonal anti-passback (where applicable) (cards read at the entrance of a zone covered by different controllers should be restrained from accessing the zone again before exiting from this zone first - to prevent using the same card by many persons at the same time).

D. The DCs shall be able to have similar functions for different areas covered by the system, or have different functions depending on the way they are used and programmed. For instance, the security information shall be monitored by the security officer in the control room, while the attendance of the employees who shall be using the system to enter the premises, shall be used by the personnel manager in the personnel department, etc.

E. At times where real time monitoring is not required, the system shall be able to work in an OFF-LINE mode where communication between the DCs and the CHS is restricted to the upload of the DCs’ buffers into the system.

2.3 SYSTEM OPERATION

A. When a cardholder badges his card, card data is transmitted to the access reader's controller (DC) which shall interpret the data and activate the release of the respective door magnetic or electric strike lock (or other interfaces to lifts or parking barriers…etc) in less than 200 msec if the access is authorized. In case the access is un-authorized, the DC shall activate an alarm relay, and transmit the information to the CHS.

B. The system shall allow the selective unlocking of the doors controlled by the access control system during emergencies, via inputs from the fire alarm system or operator (using a valid password).

C. Selected doors (refer to security drawings) have been monitored by balanced magnetic door contacts (without electronic locks). Those shall be programmed to raise an alarm when activated (door opened) except during fire conditions or the alarm being selectively disabled by the operator (due to maintenance operations for example). In all situations, the event shall be logged in the system.

D. The equipment center room shall be provided with 2 workstation PCs and one proximity card encoder capable of generating proximity access cards. Proximity cards shall be of predetermined time validity and the operator should be able to disable or modify their access privileges them at any time.

2.4 EMERGENCY SECURITY STRATEGY

A. An emergency situation triggered by the fire alarm system or by the actuation of any of the "Manual Release Devices" or "Malfunction Break Glass" units located on means of egress, shall un-lock the electric door locks as per NFPA 101 standard (Delayed-Egress Locks and Access-Controlled Egress Doors as indicated in NFPA 7.2.1.6.1 and 7.2.1.6.2 respectively).

2.5 SYSTEM RELIABILITY

A. The system shall be based on an "ON-LINE/OFF-LINE" stand-alone controllers and shall have a relatively small MTBF (mean time between failure) such that:
   1. The faults remain local. If a controller fails, the failure shall not prevent the rest of the system from being fully operational.
   2. A LAN communication failure shall only stop data transfer to and from the CHS but never prevent the controllers from being fully operational. The LAN communication failure shall be promptly detected by the CHS. Zonal interlocks are temporarily lost in this case.
   3. Any fault at the controller's level shall not liberate the access unless it was agreed that the system or the point should be Fail-Safe and not Fail-Secure so as to liberate the access such as in fire situations as indicated in the Emergency Security Strategy above, ...
   4. A relatively short power failure doesn't stop the controller's operation, (battery backup should be available at the controllers level and the CHS)

2.6 SATELLITE WORKSTATION

A. Satellite Workstations computer systems are also used for CCTV and BMS. Refer to section 16780 "VIDEO SURVEILLANCE" for their technical specifications.

2.7 CENTRAL HOST SERVERS

A. The server shall be a self contained, multi-tasking, high speed server, which shall be connected to a local (or wide area Network via appropriate routing) which would enable remote operators to access the same databases for programming the controllers and/or consulting the activities of these controllers. It shall also serve as a workstation.

B. The project includes 1 BMS, 1 shared CCTV & access control workstation, a CCTV management system server rack mounted in the low current room server cabinet and an access control system server also rack mounted in the low current room server cabinet with required software for the perfect operation of the access control management system including database systems.

C. Refer to section 16780 “VIDEO SURVEILLANCE” for the technical specifications of the shared BMS, access control & CCTV workstations.

2.8 CHS CAPACITY

A. The CHS in its smallest configuration should be capable of:
   1. Controlling and monitoring up to 150 readers through Ethernet LAN,
   2. Managing a database with a capacity of 2,000 card holders.
   3. Managing input and output points following a predetermined cause to effect matrix.

B. It shall be possible to expand the system further by upgrading the CHS.

2.9 CENTRAL HOST SERVER (CHS) HARDWARE

A. The systems shall operate on the Windows environment. The platform specification required is a rack mounted serverinstalled in the data center (DELL, IBM or HEWLET PACKARD) compatible with the following minimum specifications:
   1. Second Generation Quad core Core i7 Sandy Bridge processor, 3.4 GHz speed, 8MB Intel Smart cache, 8 processing threads
   2. Intel motherboard, triple channel DDR3 1066/1333/1600 MHz bus, 12 USB 2.0 ports and two e-SATA ports, 1 PCI slot, 2 PCI Express (x16 data), 1 PCI Express (x4 data), 2 PCI Express (x1 data)
   3. 8 GB RAM DDR3 1066/1333 MHz, 2 channels, 21 GB/s
   4. 1 TB storage min capacity, 7200 RPM (SATA II) HDDs in RAID 1 configuration.
   5. Graphics: Integrated Intel HD 3000 graphics
   6. Microsoft keyboard.
   7. Microsoft optical mouse with rotating wheel.
   8. 1.44 MB floppy disk drive.
   9. DVD+/-R/W (5x) dual layer drive.
   10. Operating System for Access Control Server: Microsoft Windows Server 2008R2, 64 bit version or later.
   11. Back-up software similar to Acronis solutions with system image (snap-shots) creation capability and facilities to re-deploy images to identical or different hardware on either physical or virtual machines.
   12. Gigabit Ethernet network interface card.
   13. RS232 Interface.

   N.B: The above mentioned computer system hardware specifications are adequate for 8 months from the specifications date. The contractor shall submit an equivalent time-upgraded specifications at the actual system commissioning time. Only branded computers shall be accepted (Dell, IBM, HP).

2.10 CHS PERIPHERALS

A. Laser printer, A4 size, 10ppm, grayscale.

B. Proximity card encoder (located in the “low current room”).

2.11 CHS SYSTEM CAPABILITY

C. The CHS shall provide the following functions as a minimum:
   1. Validate/invalidate cards in groups or one by one.
   2. Enable/disable readers (any type).
   3. Release or inhibit access points
   4. Allocate individual status; minimum of 25 groups with individual time programs.
   5. Obtain various listings
   6. Enable the printer to log exceptions only.
   7. Allow for a minimum of 8 password control levels.
   8. Pre-assign cards with clearly established and dated status level and validity period.

2.12 ACCESS DOOR CONTROLLER (DC, modular or standard unit)

A. Access Controllers (DC) shall be able to work in both ON-LINE and OFF-LINE mode should:
   1. be able to monitor the state of the access point (open or closed) during preset time frames, and detect locally any state of alarm
   2. be able to authorize locally the access to card holders with valid codes during their predetermined time zone,
   3. to report all abnormal activities at the card reader or at the monitored point via a data link or a dry contact closure,
   4. to store in its buffer all recent activities until they are transmitted to the central station,
   5. be down-loadable from the Central Host Server (CHS) with all the necessary information concerning:
   6. the card holders and the time zones they’ll be authorized to get through,
   7. the inputs and the time zones during which they’ll be shunted
   8. the outputs and the time zones during which they’ll be disabled
   9. beoverridable from the CHS such that activated outputs could be deactivated and vice-versa.
   10. have the anti-passback feature so as to inhibit multiple entries if not alternated with exits.
   11. Modular DCs shall be provided with their integration chassis complete with all management and communication interfaces (Ethernet LAN).

B. Each DC shall have an Ethernet RJ45 port with TCP/IP settings to allow communication with the CHS and other DCs.

C. Each DC shall have variable capacity features with a minimum of sixteen (16) spare input points and four (4) spare outputs (or as indicated on drawings, which-ever is higher). The DC local memory shall be of the non-volatile type with capability for access authorization data for a minimum of 4,000 individuals. Local memory shall be capable of being expanded to a minimum of 100 percent of its initial capacity. The DC shall be able to accommodate an expansion module that increases the number of outputs to eight (8).

D. Integral battery backup power and provisions for uploading and downloading data between each DC and CHS shall be provided.

E. DCs shall have an internal lithium battery to prevent loss of information when power is lost for at least 12 months period.

F. Modular chassis shall be mounted in 19” racks (SSN panels) common to access or as indicated on drawings.

G. DCs shall report to all other controllers located behind in case of LAN failure to force them to hold to their alarms in their buffers until communication is reestablished.
   1. Non-modular DCs are to be housed in lockable steel cabinets, with front access doors only, if wall-mounted. Cabinets are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 65 for outdoor installations, in accordance with IEC 529, and are to be factory designed and assembled.
   2. CONSTRUCTION: box, trim and doors, are to be electro-galvanized sheet steel of gauges not less than specified and in accordance with the Standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the Standards, but are not to be less than 100 mm on all sides. Enclosure is to have predesigned angles or threaded end studs to support and adjust mounting of interior cabinet assembly.
   3. 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.
   4. 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.
   5. FINISH: inner and outer surfaces of cabinet/boxes, trims, doors etc. are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, ageing and corrosion and of standard grey colour to the approval of the Engineer.
   6. DIRECTORIES: under glass, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors is specified. Directories are to be typed to identify cabinets and clearly indicate circuit number and description of circuit.
   7. OUTDOOR ENCLOSURES are to be heavy duty sheet steel cabinets, minimum 1.5 mm thick, fully weatherproofed (IP 65), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

2.13 DC's PERFORMANCE

1. Each DC shall serve as the collection point for monitoring and controlling devices in a particular security area. The DCs shall also provide power to devices down line.
2. The DCs shall be connected to all the Security System monitored points and readers (any type) to collect and transmit status information to the CHS for processing. The DCs shall buffer and retain status change information until transfer of data to the CHS is verified. The buffer size should accommodate at lest 1000 transactions.
3. DCs shall be capable of being configured from the CHS for operation via readers (any type) only, digital keypad only or readers (any type) and digital keypad in case digital keypad is available.
4. When an ID badge/keycard is presented at a card reader, the encoded information shall be compared with the stored data for authorized access. Access authorization decisions are to be made locally at the card or its associated DC.

2.14 CARD READERS

1. Card readers shall consist of a solid-state static sensor head that is compatible with only one (1) type of uniquely encoded ID badge/keycard and an electronic interface box. If required on drawings, card readers shall be equipped with digital keypads.
2. Card readers range shall be 10~14cm minimum unless otherwise mentioned on drawings. Long range readers range shall be 85~100cm minimum.

3. Card reader sensor head shall be housed in weatherproof enclosure equipped with a tamper switch. Mounting screws for surface mounting are to be provided inside the enclosure or, if exposed, are to be tamper-proof requiring a special tool for removal.
4. Card readers shall be provided with separate visual indications that an ID badge/keycard has been granted access or denied.
5. Card readers shall be provided in stainless steel body when indicated on drawings.
6. Esthetic design of the card readers shall be subject to the Engineer's approval.

2.15 READER TECHNOLOGY

A. Proximity: Where the readers would be equipped with antennas that could pick up a card at different ranges (from centimeters to meters) providing the best of all other technologies except for being the most expensive of all. This technology is best suited for rough environment and is particularly vandal and weather proof. Maintenance shall not be required.

2.16 AUTHORIZATION PROCEDURE

A. Authorization decisions include: 1. Unauthorized access requests and/or the presentation of an inactive, expired, lost, stolen, un-returned or an improperly encoded ID badge /keycard / pin-codes shall be reported to the CHS. Access shall not be granted.

B. At fire emergency exit doors (where required on drawings):
   1. The card reader or break-glass shall generate a command to temporarily change the status of the associated balanced magnetic switch to "ACCESS" to permit unalarmed entry/exit. The time duration of "ACCESS" shall reset and the "SECURE" status shall begin as soon as the door closes after authorized entry/exit. As indicated NFPA 101 standard (Delayed-Egress Locks and Access-Controlled Egress Doors as indicated in NFPA 7.2.1.6.1 and 7.2.1.6.2 respectively), the break-glass (referred to as MRD and MBG on drawings) or presence sensor shall directly disable the door locks and notify the DC.

C. At operational doors: 1. The card reader shall generate commands to release the associated electric strike or magnetic lock and temporarily change the status of the associated door status sensor to "ACCESS" to permit unalarmed entry. If the door is equipped with dual technology sensors (presence sensors), the sensor shall initiate the sequence described above. The time duration for "ACCESS" shall reset entry/exit.

D. At elevator cabs (if required on drawings): 1. The card reader shall enable the elevator call buttons from inside the cabin.

2.17 ACTUATION TIME

A. The time periods for activating a local locking device and accessing the associated intrusion detection device(s) shall be independently programmable. In the event two (2) or more individuals utilize the same card reader or exit push-button, each valid request shall reset the time duration for unlocking and "ACCESS" status to allow sufficient time for the unalarmed entry/exit of each subsequent individual.
   1. Failure of a portal to close within the preset ACCESS time shall be reported to the CHS.
   2. In the event a portal is not within a pre-determined programmable CHS time after an entry/exit request is granted, either locally via a card reader or exit push-button or remotely from an operator console, the portal equipment shall reset and the event shall be reported to the CHS.

2.18 DOOR HARDWARE ACCESSORIES

A. They are divided into locking Mechanisms (LM) and monitoring devices (MD).
   1. The locking Mechanisms (LM) are:
      a. The Electric Door Releases that can handle a limited break force (~150N), and are usually used indoors. There exist a large variety of devices to adapt to all kind of frames (wooden, metallic, aluminum, ...). Those are used in fail-secure mode.
      b. The Electro-Magnetic Locks that can handle large forces (~5kN) but can never work in Fail-Secure setups where any loss of power means an immediate release of the door. Those are used in fail-safe mode.

B. The monitoring devices (MD) are: 1. Balanced Magnetic Door Contacts that are similar to Standard Magnetic Door Contacts but besides detecting the absence of the magnetic field, they detect the presence of any other magnetic field. This feature prevents intruders from disabling the contact by applying a strong magnetic field from the outside to simulate the presence of the magnet on the door.

2.19 PROXIMITY ACCESS CONTROL READER PERFORMANCE

A. The card reader shall read the encoded data from the access card and/or transponder and transmit the data back to the access control panel (DCs), giving an audible and visual indication of a properly read card.

B. The proximity card reader shall provide the following:
   1. The card reader shall have a typical read range of 4" to 5.5" (10 - 14 cm). Long range readers range shall be 85~100cm minimum.
   2. The card reader shall be listed under UL 294 as an access control system unit accessory, and shall have FCC & CE Mark certifications.
   3. The card reader shall have separate terminal control points for two LEDs and an audible indicator.
   4. 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.
   5. The card reader shall have a card present line that will indicate that card data is ready to send for clock and data applications.
   6. The card reader shall have a re-present mode in which the card must be taken from the reader field before being read again; to eliminate multiple reads from a single card presentation.
   7. The card reader shall have a built in anti-passback (multiple read) delay of one second.
   8. The card reader shall an operating temperature of -10 to 50 degrees Celsius and an operating humidity of 5-95% noncondensing.
   9. The card reader shall communicate in a Wiegand protocol interface, and be compatible with all standard access control systems.

2.20 ACCESS CONTROL PROXIMITY CARDS

A. The access control proximity cards shall provide the following:
   1. The access card shall have a lifetime warranty.
   2. The access card shall have up to 84 programmable bits of Wiegand formatted information for universal compatibility with all Wiegand interface reader applications.
   3. The access card shall be "Passive" (non-battery operated) proximity technology.
   4. The access card shall have a permanent ink jet or laser engraved identification number printed onto it. The card numbering options shall be:

5. Sequential Matching - The internal identification numbers and the external ink jet numbers shall both be sequential and shall match (i.e. internal numbers 1-100, external ink jet numbers 1-100).
6. Sequential Non-Matching - the internal identification numbers and the external ink jet numbers will be sequential but they will not match (i.e. internal numbers 1-100, external ink jet numbers 200-300).
7. Random Non-Matching - the internal identification number shall be random numbers, the external ink jet numbers will be sequential, and the internal and external numbers will not match (i.e. internal numbers 2, 7, 13, 18, etc., external ink jet numbers 1-100).
8. No External Card Numbering - the internal identification numbers are either sequential or random, there are no external ink jet card numbers.
9. The access card shall be slot punched on the short edge of the card for a vertical/ portrait oriented photo, shall be offered with multicolor custom graphics, and be compatible with most self adhesive photo pouches and PVC labels for use with a direct print printer.
10. The access card shall have an operating temperature of -10 to 70 degrees Celsius and shall have an operating relative humidity of 5-95% noncondensing.
11. The read range of the access card shall be extremely consistent, and not be affected by body shielding or variable environmental conditions.
12. The access card shall be offered with over 137 billion unique codes.

2.21 DUAL TECHNOLOGY SENSORS (PRESENCE &MOVEMENT DETECTORS)

A. The dual technology sensors shall combine passive infrared (PIR) and microwave (MW) technologies. The device shall use Dielectric Resonant Stabilized Oscillator (DRSO) circuitry for microwave, along with Energy Frequency Analysis (EFA) and dual-element pyro-electric sensors.

B. The contractor shall select different microwave circuits to provide for large area coverage (about 70’ x 70’) or long-range coverage (about 100’ x 9 ’) depending on the application.

C. The dual technology sensors shall also provide the following:
   1. Microwave: Adjustable by potentiometer from 100% to 30%
   2. LED Indicators: One for PIR, one for MW, one for alarm or trouble (selectable).
   3. Mounting: Wall, ceiling (recessed or surface) or corner mounts.

D. Compliant to the requirements of NFPA 101 standard (Delayed-Egress Locks and Access-Controlled Egress Doors as indicated in NFPA 7.2.1.6.1 and 7.2.1.6.2 respectively) when used on means of egress.

2.22 MANUAL RELEASE DEVICE (MRD) AND MALFUNCTION BREAK-GLASS (MBG)

A. Are to have the following features:
   1. Comply with the requirements of the operation described in NFPA 101 standard (Delayed-Egress Locks and Access-Controlled Egress Doors as indicated in NFPA 7.2.1.6.1 and 7.2.1.6.2 respectively) including signage.
   2. Vandal proof stainless-steel body
   3. The unit shall incorporate a key operation facility for testing purposes and a specially designed film fitted over the glass to prevent fragmentation when broken.
   4. The unit shall incorporate an integral LED to activate upon breaking the glass/testing the unit with a special key.

2.23 EGRESS BUTTONS

A. Are to have the following features:
   1. Vandal Proof.
   2. Stainless Steel faceplate. Esthetic design subject to the Engineer's approval.
   3. Rating as per access controllers' manufacturer recommendations.
   4. Heavy-duty type with gold-plated contacts rated for five million operations, minimum.

2.24 FINGER PRINT MACHINE

A. Are to have the following features:
   1. Casing: Scratch-proof Plastics
   2. Finger Placing Angle: ±45°
   3. Failed Recognition Rate (FRR): Less than 0.01%
   4. False Acceptance Rate (FAR): Less than 0.0001%
   5. Identification Time: Less than 1s
   6. Identification Mode: 1:N / 1:1
   7. Operation Mode: Stand-alone
   8. Verification Mode: Fingerprint, PIN Code
   9. Capacity of Fingerprints: 3,000
   10. Capacity of Users: 1,000
   11. Capacity of Transactions: 50,000
   12. Communication Mode: RS232, RS485, TCP/IP, USB Drive
   13. USB Flash Drive Download: Yes
   14. Access Control Interface: Access Control / Wiegand
   15. Name Display: Yes
   16. Ring Inside: Yes
   17. Voice Indicator: Yes
   18. Power: 12V
   19. ESD Protection: Less than 15kV

2.25 BACK-UP BATTERIES AND CHARGERS

A. The access control system (provided with back-up batteries and chargers), upon a mains power failure, shall force the gate barriers to open and remain in the open position until the mains power is restored or the emergency generator is on-line. Each access control panel shall have its independent back-up power suitable for powering all connected devices for the indicated back-up time.

B. The back-up batteries of the access control system shall have the following specifications:
   1. The battery block shall include sealed leak-proof, stand-by, maintenance-free, stationary batteries. Other battery types shall not be accepted.
   2. The nominal operating time provided by the battery block shall be 3 hours, for 100% system utilization at the end of the discharge period.
   3. The battery block shall be extremely low gassing such that no special precautions are required.
   4. The service life of the battery block shall exceed 10 years at 20 °c.
   5. The battery block shall have a low self-discharge.
   6. The batteries post bushings shall be sealed against electrolyte and atmospheric oxygen.

C. The charging devices of the access control system shall have the following specifications:
   1. Microprocessor-controlled charging (IU characteristic)
      a. Battery charger: constant voltage, current limited type with electronic solid-state controller. Voltage shall be controlled to within 2% of setting at up to 10% mains supply variations.

b. Minimum charger efficiency: 85 percent.
c. Equalizing charge: automatically applied to battery every 90 days.

2. The charger shall be designed for a 90% recharge of a fully discharged battery set within 15 hours.
3. Temperature based with automatic boost charging circuit. The charger voltage shall be automatically adjusted with reference to ambient temperature for optimizing charging & battery life.

PART 3 - EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

A. Install in accordance with manufacturer's instructions and to the approval of the Engineer. Mount equipment in alignment with other fixtures and fix firmly in place with all supports and fastenings secured.

B. Equipment is to be installed to prevent electro-static or other outside interference impairing system performance.

C. Equipment is to be installed to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made, but no changes are to be made without prior approval.

D. Make good surfaces of equipment damaged during installation, using touch-up paint provided by equipment manufacturer, to the satisfaction of the Engineer.

E. Routing of access control cables (backbone of each door controller over the structured cabling), power and control cables is to be in separate raceways.

F. Equipment manufacturer is to provide an Engineer and Technician qualified in the operation of the system and equipment performance and the requirements of the specification, to assist the Engineer to test and verify the system performance.

G. Provide diagnostic equipment required performing system tests and measurements.

3.2 AS-BUILT DRAWINGS

A. The installation Contractor will be provided with 2 sets of drawings at the start of the project. One set will be designated as the central location to document all as-built information as it occurs throughout the project. The central set will be maintained by the Contractor's foreman on a daily basis, and will be available to the technical representative upon request during the course of the project. Anticipated variations from the build-to drawings may include such things as cable routing and actual outlet placement. No variations will be allowed to the planned termination positions of horizontal and backbone cables or grounding conductors unless approved in writing by the Owner.

B. The installation Contractor will be provided with 2 sets of drawings at the start of the project. One set will be designated as the central location to document all as-built information as it occurs throughout the project. The central set will be maintained by the Contractor's foreman on a daily basis, and will be available to the technical representative upon request during the course of the project. Anticipated variations from the build-to drawings may include such things as cable routing and actual outlet placement. No variations will be allowed to the planned termination positions of horizontal and backbone cables or grounding conductors unless approved in writing by the Owner.

3.3 CABLING AND DISTRIBUTION SYSTEM

A. The installation Contractor will be provided with 2 sets of drawings at the start of the project. One set will be designated as the central location to document all as-built information as it occurs throughout the project. The central set will be maintained by the Contractor's foreman on a daily basis, and will be available to the technical representative upon request during the course of the project. Anticipated variations from the build-to drawings may include such things as cable routing and actual outlet placement. No variations will be allowed to the planned termination positions of horizontal and backbone cables or grounding conductors unless approved in writing by the Owner.

3.4 RACEWAYS, BOXES AND FITTINGS

A. Refer to section 16118 "RACEWAYS, BOXES AND FITTINGS" for related products and field installation works.

3.5 SUPPORTING SYSTEMS AND RELATED ACCESSORIES

A. Refer to section 16139 "CABLE TRAYS" for related products and field installation works.

3.6 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 racks or cabinets. Isolate from power system and equipment grounding.

3.7 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.

3.8 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.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
   1. Revise training requirements in subparagraphs below to suit Project and system.
   2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 32 hours' training.
   3. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
   4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.10 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting settings, controls, schedules and sensitivities to suit actual occupied conditions. Provide up to three requested visits to project site for this purpose.

SECTION 16991 - BUILDER'S WORK

PART 1 - GENERAL

A. BUILDER'S WORK GENERALLY: materials and workmanship, unless otherwise specified, are to be in accordance with the relevant requirements of the Specification for Structural and Architectural work.

B. DESCRIPTION OF WORK: cable and duct trenches, equipment foundations, bases and supports, ducts and duct banks, manholes, handholes and earth pits, chases, holes and the like, sleeves, bolts, brackets and fixings including grouting.

C. COORDINATION: confirm locations and dimensions of all builder's work required for electrical work. Submit shop and construction drawings or other data to the Engineer for checking before proceeding with the work.

D. ROUTES FOR SERVICES BELOW GROUND: agree precise locations with the Engineer, set out clearly and accurately and locate with temporary maker posts.

PART 2 - PRODUCTS AND MATERIALS

2.1 COMPONENTS

A. POLYVINYL CHLORIDE (PVC) DUCTS for outdoor power and lighting cable installations are to be 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. Ducts are to be nominal size shown on the Drawings, with minimum wall thickness 3.2 mm for 100 mm ducts and 4.7 mm for 150 mm ducts.

B. DUCT SUPPORTS: 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. COVERS FOR TRENCHES in electrical rooms and the like, unless otherwise specified or shown on the Drawings, are to be flanged chequered steel plates with angle or channel-section frames, suitably reinforced to support anticipated loads, and finished with zinc chromate primer and two coats grey enamel.

D. COVERS FOR MANHOLES AND HANDHOLES: to BS 497, chequered cast iron or cast steel, recessed type, and of suitable duty for the particular application.

E. 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.

2.2 COMPOSITE CONSTRUCTION

A. AEQUIPMENT FOUNDATIONS AND BASES: reinforced concrete, as approved by the 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.

B. CONCRETE ENVELOPE FOR DUCT BANKS for power distribution systems and outdoor lighting cable installations crossing water, gas and sewage mains, under roadways and where required or shown on the Drawings, is to be reinforced concrete Class B using

sulphate- 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. Length of concrete envelope is to extend at least 300 mm beyond each side of crossing etc.

C. CABLE MANHOLES AND HANDHOLES: reinforced concrete Class B using sulphate-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.

PART 3 - WORKMANSHIP

3.1 GENERALLY

A. CABLE TRENCHES: width is to be as small as practicable with sides vertical. Remove mud, rock projections, boulders and hard sports 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.

B. DIRECTLY BURIED PVC CABLE DUCTS:

1. lay and join ducts to required line and level on stand bed, cover with stand and backfill trench to ground level with excavated soil, free from stones and other debris, well compacted in layers not exceeding 300 mm thick

2. lay approved concrete tiles to fully cover cable duct, extending minimum 50 mm beyond sides of duct and placed 300 mm below ground level

3. provide warning tape or galvanized steel mesh along duct runs at a depth 200 mm below ground level.

C. UNDERGROUND CABLE DUCT ASSEMBLIES:

1. from duct assembly to required line and level, using duct supports spaced to prevent sagging of ducts and breaking of couplings and watertight seals, and secured with cords (not tie wires) where necessary

2. provide 1% slope to duct banks for draining to exterior manhole, handhole or other location as instructed

3. join ducts using waterproof cement, to manufacturer's recommendations, to give waterproof and sandproof joint with at least 80 mm overlap

4. provide 3 mm galvanized steel wire inside empty ducts, for future pulling of cables, extending 1 m beyond duct banks at both ends securely fixed to wooden bungs sealing the ducts.

D. ENDS OF DUCTS: 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. Duct not ending in cable manholes or handholes are to be properly capped.

E. SEALING ENDS OF DUCTS: 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 vapour.

F. 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.

G. SUPPORT FRAMES FOR SWITCHGEAR located over cable trenches, where shown on the Drawings or required by equipment design, are to be installed prior to concreting.

H. DRILLING FOR ANCHOR BOLTS is to be carried out using appropriate electric drills and in approved positions.

I. HOLES AND CHASES IN SITU CONCRETE are to be cast in. Do not hardened concrete or drill holes larger than 10 mm diameter without prior approval.

J. HOLES AND CHASES IN PRECAST CONCRETE: do not cut or drill precast concrete without prior approval.

K. HOLES IN STRUCTURAL STEELWORK: do not cut or drill structural steelwork without prior approval.

L. 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
3. walls, 1/3 leaf thickness
4. Depth of horizontal chases : 1/6 wall or leaf thickness.

M. 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.
5. PREFORMED HOLES IN MASONRY: submit proposals for bridging over holes for ducts etc. Which exceed 460 mm width.

3.2 INSPECTION AND CLEANING

A. INSPECTION OF DUCT SYSTEMS: directly buried ducts and underground duct assemblies are to be inspected in the presence of the Engineer, before backfilling or concreting. Steel mandrel or other approved device, diameter equal to 90% 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. CLEAN DUCTS with stiff bristle brush pulled through each duct prior to pulling in cables.

SECTION 16992 - OPERATION AND MAINTENANCE (O&M) MANUALS TECHNICAL SPECIFICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General Provisions

B. Relevant Specification Sections

1.2 SUMMARY

A. This specification section includes requirements for preparing and submitting O&M Manuals for MEP services and Civil / Architectural items (as applicable).

1. In hard copy
2. In electronic copy

B. The specification also covers preparation of Emergency Manuals.

C. The warranty period and O&M Training shall not start prior to the submittal / approval of the O&M Manuals.

1.3 SUBMITTALS

A. Initial submittal: submit 1 number of draft copies of each manual at least 15 days before requesting inspection for Substantial Completion.

B. Final submittal: submit 2 copy (ies) in final form at least 15 days before requesting inspection for Substantial Completion.

C. Submit final electronic copy subsequent to the final approval of the hard copy in 2 copy(ies).

1.4 QUALITY ASSURANCE

A. The Operation and Maintenance (O&M) manuals shall be compiled by a specialised firm, with a minimum of ten (10) years experience in this field, and on similar projects. This firm shall have on its technical staff, full-time, specialised Technical Writers / Authors with several years experience on similar projects.

B. The contractor shall provide, at no cost to the O&M firm, the necessary information, drawings, catalogues, data, etc to the O&M firm and shall keep him informed of any changes / modifications which may affect the O&M Manuals contents.

PART 2 - GENERAL FORMAT REQUIREMENTS

2.1 GENERAL FORMAT

A. Language: Simple, direct, universally accepted terminology and nomenclature shall be used to facilitate comprehension.

B. Units of Measure: Units of measure shall be in Systems International d'Unites (SI units).

2.2 TABLE AND FIGURE NUMBERS

A. Tables and figures shall be numbered consecutively by section.

2.3 ILLUSTRATIONS, TABLES. AND DRAWINGS

A. Illustrations, tables, and drawings necessary for clarity shall be included. All illustrations, tables, and drawings shall be mentioned in the text.

B. Illustrations, tables, and drawings shall be numbered consecutively within each section in the order mentioned 'in the text'. Each illustration, table and drawing shall be placed as close as possible to the page of the text on which it is first mentioned or shall be placed at the end of the applicable section, if appropriate to facilitate use.

C. Illustrations, tables and drawings contained in the body of the manual shall be black and white.

2.4 BINDERS

A. Binders shall be rigid, white in colour and of heat resistant, loose leaf type, with four rings. Rings shall be round or D shaped, 64 mm to 75mm in height. Each binder shall be provided with sheet lifters installed and not contain more than 50mm (2") of material. Each binder shall be equipped with full-sized durable clear plastic insert pockets on the front and spine portions of the binder.

2.5 INSERT SHEETS (FRONT LOGO) AND SPINE INSERT

A. The insert sheet for the front pocket of the binder shall be of 160g/m2 stock minimum, printed in colour. The spine insert shall be of the same quality and colour as the front insert sheet. All printing shall be horizontal.

2.6 PAGE SIZE AND IMAGE AREAS

A. The size of the standard pages shall be ISO A4. Foldouts shall not exceed ISO A3.

B. Each page shall have the applicable revision number and date printed in each Division.

2.7 SECTION DIVIDERS AND TABS

A. Major sections of the manual shall be separated by dividers, 300g/m2 stock minimum, with tabs which shall be laminated and printed on two sides with binding edge reinforced. Tabs shall be specifically printed with section number and title.

2.8 PRINTING

A. All documents shall be printed clearly, without smudges, in black ink. Printing on both sides of the paper (duplex) is permitted.

2.9 PAPER STOCK

A. Text shall be printed on 100g/m2 stock. Paper shall be sufficiently opaque that printing does not show through the back side. Paper shall absorb ink in a manner that produces clear, crisp print.

PART 3 - STRUCTURE AND CONTENTS – MEP O&M MANUALS

3.1 HOW TO USE THE MANUAL

A. This initial section is a guide to the contents, structure and layout of the manual. It enables the reader to comprehend the scope and purpose of the document and to identify readily where specific information can be obtained. A block diagram of O&M Manual structure shall be included.

3.2 CONTRACTUAL AND LEGAL GUIDES

A. The contractual and legal records of the installation should include:

1. the name and address of the project;
2. details of ownership etc;
3. details of local and public authority consent;
4. details of the design teams, consultants, project contractors and associated subcontractors;
5. dates for the start of the project, for hand over (practical completion) and for the expiry of the defects liability period;
6. information on all guarantees affecting components, systems and plant items, together with expiry dates and names, addresses and telephone numbers of relevant contacts

B. For each item of plant and equipment installed within the building and contained in the list of services covered by O&M manual, copies of the following documents should also be provided, where applicable:

1. test certificates
2. manufacturers' guarantees and warranties;
3. insurance inspection reports;
4. safety and fire certificates
5. safety instructions

C. A clear statement shall be made in this section concerning those hazards and safety precautions of which the operators and maintainers of the installations need to be made aware.

This should include the following:

1. any known feature or operational characteristic of the equipment or systems installed which may produce a hazard;
2. any known hazards against which protection can be provided;
3. any mandatory requirements relating to safety;
4. any other safety precautions which should be observed;
5. any other relevant warnings

3.3 OVERALL PURPOSE

A. This section provides a general overview of the original design intent. It should include a summary for each engineering system installed, giving:

1. the parameters and conditions within which it has been designed to operate, including known hazards;
2. the type of each service (gas, electricity, water) required to operate the system:
3. the intended method of control

3.4 DESCRIPTION

A. This section provides a detailed description of each engineering system installed. It should include:

1. the system type (eg cold water supply)
2. system location and what it serves;
3. what the system depends upon in order to function;
4. design data, basic design parameters, basic assumptions made during design;
5. reasons for selecting particular plant;
6. expected service life (where available)
7. planned operational efficiency

3.5 EQUIPMENT SCHEDULE

A. The type, model number and serial number of all component items within the system should be listed, together with the names of their respective manufacturers or suppliers.

3.6 PARTS IDENTIFICATION AND RECOMMENDED SPARES

A. This should comprise a parts identification list detailing and identifying replaceable assemblies, sub-assemblies and components. It should include suppliers' recommendations for both spares and 'running spares' (ie parts required for scheduled replacement due to wear or deterioration).

3.7 COMMISSIONING DATA

A. The results of all commissioning work and associated tests shall be included or referred to. This shall include:

1. measured data;
2. measurement points
3. test equipment used;
4. calibration certificate details;
5. a statement of whether design requirements were achieved.

3.8 OPERATION

A. Instructions shall be given for the safe and efficient operation, under both normal and emergency conditions, of each engineering system installed. These will be in addition to manufacturers' literature for plant items and should include:

1. a recommended strategy for operation and control;
2. an outline of the general operating mode;
3. control data (location, effect, object, sequence, limits of capability, modes, set points);
4. procedures and sequences for start-up, running and shut-down, under both normal and emergency conditions;
5. interlocks between plant items;
6. operating procedures for stand-by plant;
7. precautions necessary to overcome known hazards;
8. the means by which any potentially hazardous plant may be made safe;
9. forms for recording plant running hours, energy consumption and energy costs.
10. Sequence of Operation (as applicable)

3.9 MAINTENANCE

A. **Maintenance instructions**: The recommendations and instructions for maintenance must be detailed for each item of plant and equipment installed. Instructions should be given on each of the following, as appropriate:

1. the isolation and return to service of plant and equipment;
2. adjustments, calibration and testing;
3. dismantling and re-assembly;
4. the exchange of components and assemblies;
5. dealing with hazards which may arise during maintenance;
6. the nature of deterioration and the defects to be looked for;
7. special tools, test equipment and ancillary services.

B. **Maintenance schedules:** Maintenance schedules should be provided for all the preventive maintenance tasks identified above. These should be based on both manufacturers' recommendations and other authoritative sources and should include:-

1. inspections
2. examinations
3. tests
4. adjustments
5. calibration
6. lubrication
7. periodic overhaul
8. The frequency of each task may be expressed as specific time intervals, running hours or completed operations, as appropriate. Collectively, the schedules will form a complete maintenance cycle, repeated throughout the working life of the installations.

C. **Fault finding:** Procedures for the logical diagnosis and correction of faults should be provided.

D. **Lubrication:** A schedule of all plant equipment requiring lubrication should be provided together with manufacturers' recommendations on the type of lubricant and the method and frequency of application.

3.10 DISPOSAL INSTRUCTIONS

A. Where relevant, information should be provided detailing:

1. any known dangers likely to arise during the disposal
2. methods for safely disposing of equipment
3. sources from which further advice can be obtained

3.11 NAMES AND ADDRESSES OF MANUFACTURERS

A. Contact details including telephone, fax and e-mail address of all manufacturers and suppliers of equipment listed in the manual should be provided.

3.12 INDEX OF PLANS AND DRAWINGS

A. An index should be provided of all 'as-built' drawings. However, the as-built drawings shall be included in the electronic version of the O&M Manuals.

3.13 EMERGENCY INFORMATION

A. This should include names and contact details of the appropriate contacts in the event of fire, theft or burglary, and gas, electricity or water failure/leaks.

3.14 MANUFACTURERS' LITERATURE

A. A complete set of all manufacturers' literature should be provided for the plant and equipment installed and assembled for each building services system. All literature shall be annotated and extra materials shall be removed or boxed out neatly.

3.15 ELECTRONIC VERSION

A. Upon notification from the Consultant that the final review is complete and that the O&M Manuals are completely satisfactory the Contractor shall prepare and submit to the Consultant the final Manuals in an Electronic Format that meets the following requirements:

B. Electronic Operations and Maintenance Manuals shall be in English Language.

C. Electronic Operations and Maintenance Manuals shall be platform independent i.e. they shall be fully functional on Windows, Macintosh, Android, iOS computers and mobile devices.

D. Electronic Operations and Maintenance Manuals shall NOT require the client/owner to enter into any short or long term, proprietary software agreements or purchases.

E. Electronic Operations and Maintenance Manuals shall be fully functional both online and offline.

F. Electronic Operations and Maintenance Manuals shall require minimal user training (maximum of ½ day) with all necessary training costs included in the contractor's fixed price.

G. Normal working hours technical support for Electronic Operations and Maintenance Manuals for a period of two (2) years following Substantial Performance shall included in the contractor's fixed price.

H. Electronic Operations and Maintenance Manuals shall provide the ability to present in a consistent layout, search, distribute electronically and print information asset formats including, but not be limited to, the following;

1. PDF documents/files
2. Word documents/files
3. Excel documents/files
4. HTML documents/files
5. CAD Drawings/files
6. Digital models
7. Image files
8. Video files

I. Electronic Operations and Maintenance Manuals shall provide the ability for all digital content to be fully searched by key word.

J. Electronic Operations and Maintenance Manuals shall provide the ability for all documents or drawings capable of being read or printed page by page.

K. Electronic Operations and Maintenance Manuals and Drawings sections shall generally be organized by discipline to include, but not be limited to the following:

1. Architectural & Civil
2. Mechanical
3. BMS
4. Electrical
5. Fire Alarm and Suppression Systems
6. LEED
7. As Built Drawings

L. Each issue of the entire Electronic Operations and Maintenance Manuals shall be issued on a single; client approved hand held tablet device or other client approved electronic delivery method, eg CD, disk. Electronic Operations and Maintenance Manuals that require multiple digital devices/media are not acceptable.

3.16 O&M TRAINING

A. The O&M Training shall not start unless the O&M Manuals have been completed and approved.

3.17 EMERGENCY MANUALS

A. Content: Manual shall contain a separate section for each of the following-

1. Type of emergency.
2. Emergency instructions.
3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, instructions and procedures for each system, subsystem, piece of equipment, and component shall be included:

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.
8. Chemical release or spill.

C. Emergency Instructions

D. Warnings, trouble indications, error messages and similar codes and signals shall be described. Responsibilities of Employer's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties shall be included.

E. Emergency Procedures

F. The following shall be included, as applicable:

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

3.18 CIVIL AND ARCHITECTURAL MANUALS

A. Content: Manual shall be organised into a separate section for each product, material, and finish indicated. Include product information, maintenance procedures, repair materials and sources, and warranties, as described below.

B. Source Information: Each product shall be included in manual, identified by product name and arranged to match manual's table of contents. Each product shall be listed by list name, address, and telephone number of manufacturer or supplier and maintenance service agent, and cross-reference section number and title in Project Specification.

C. Product Information: The following shall be included, as applicable:-

1. Product name and model number.

2. Manufacturer's name, address, telephone and fax numbers, e-mail and web site addresses.
3. Size, color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Manufacturer's written recommendations and the following shall be included, as applicable:

1. Schedule for routine cleaning and maintenance, with standard time allotments.
2. Inspection procedures.
3. Types of cleaning agents to be used and methods of cleaning.
4. List of cleaning agents and methods of cleaning detrimental to product.
5. For operable components and assemblies, include:-
   a. service and lubrication requirements.
   b. aligning, adjusting and checking instructions.
6. Repair and replacement instructions.

E. Warranties: Copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds shall be included. Procedures to follow and required notifications for warranty claims shall also be included.

F. Schedule: Complete information shall be included in the Civil and Architectural manual on products, materials and finishes specified in the relevant specification section.