
Rehabilitation of Mufti Hassan Khaled Garden Beirut - Lebanon

TENDER DOCUMENTS

Technical Specifications

Part 4 of 4
Electrical Installations

August 2024

TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

- SECTION 16010 - GENERAL ELECTRICAL REQUIREMENTS
 - SECTION 16025 - BUILDER'S WORK
 - SECTION 16035 - PAINTING AND ANTI CORROSION TREATMENTS
 - SECTION 16060 - EARTHING SYSTEM
 - SECTION 16075 - ELECTRICAL IDENTIFICATION
 - SECTION 16080 - ELECTRICAL TESTING AND COMMISSIONING
 - SECTION 16081 - ELECTRICAL TESTING
 - SECTION 16110 - CONDUITS AND WIREWAYS
 - SECTION 16120 - WIRES, CABLES AND FEEDERS
 - SECTION 16140 - WIRING DEVICES
 - SECTION 16262 - PHOTOVOLTAIC CELLS
 - SECTION 16413 - TRANSFER SWITCHES (CHANGE-OVER SWITCHES)
 - SECTION 16442 - PANELBOARDS AND SWITCHBOARDS
 - SECTION 16443 - MOTOR CONTROL CENTERS
 - SECTION 16500 - LIGHTING INSTALLATIONS
 - SECTION 16525 - OUTDOOR AND ROAD LIGHTING INSTALLATIONS
 - SECTION 16530 - EMERGENCY LIGHTING
 - SECTION 16721 - STANDALONE FIRE ALARM SYSTEM
 - SECTION 16740 - VOICE AND DATA DISTRIBUTION SYSTEM INSTALLATION
 - SECTION 16785 - VIDEO SURVEILLANCE SYSTEM (CCTV)
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SECTION 16010

GENERAL ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

A. Generalities:

1. The Contractor must provide complete installations from the power supply terminals indicated on the drawings. The scope of work includes supply, installation of material and equipment as described in the specifications and/or shown on the drawings. Associated civil works including supporting structure are also the responsibility of the Contractor.

B. General Conditions and Requirements:

1. Work shall be carried out in accordance with the latest issue of the IEC publications.
2. Equipment and material are to be new and manufactured in compliance with the relevant recommendations of the International Electro-technical Commission (IEC) or approved equivalent standards.
3. Locations shown on the drawings indicate the approximate location of apparatus. Exact and final locations are to be coordinated with all other trades.
4. Work must be carried out in a neat and efficient manner in accordance with the specifications. Installations are to be complete ready for operation and fully coordinated with all other works.
5. Necessary items/accessories for operation of the systems are to be provided even if not mentioned in the specification/or shown on the drawings.
6. Wiring layout shown on drawings is to be used only as a guide. Electrical drawings must be checked against all other trades drawings.

C. General Design Conditions:

1. Power will be delivered to the site by relevant local authority at 380 / 220 V, 3-phase, 4-wire, 50 Hz, or at 220 V, single-phase, 2-wire, 50 Hz. An earthing system should be provided.
2. Equipment shall be selected for continuous and trouble free service under climatic conditions of equipment location.

D. Contractor Responsibility:

1. The Contractor shall be responsible of the work covered in this division including the supply, transport, storage, installation, testing and delivering in good running conditions the electrical installations. The installation of all items shall be as specified and shown on drawings, catalogues.

- E. Coordination of Work:
1. The Contractor shall be responsible for coordinating the work of the electrical installations with that of other trades. He shall prevent interference's and conflicts and shall be the sole responsible for damages to work of other trades, already completed.

1.3 PERFORMANCE AND STANDARDS

- A. Site Tests:
1. Acceptance tests should be carried in accordance with the regulations and standards. Equipment and labor for testing are to be provided by the Contractor.
 2. A visual inspection to check proper installation, connections and nameplate data must be carried on before testing.
 3. Lighting and power circuits, motors, etc., must be subjected to an installation resistance test with a Megger of at least 1000 Volts operating voltage. Communications and security systems must also be subjected to a resistance test.
 4. A continuity test to all major feeders and circuits must de done.
- B. Manuals:
1. Complete 2 sets of instruction manuals must be provided. These should cover operation, maintenance and spare parts list of all equipment and systems.
- C. As-Built Drawings:
1. Complete sets of as-built drawings must be provided, including:
 - a. Two hardcopies.
 - b. One transparent copy.
 - c. One soft copy.
- D. Manufacturer's Warranty:
1. Five-year warranty for materials, products, equipment, etc. specified in these electrical specifications must be provided.
- E. Contractor's Guarantee:
1. The Contractor shall guarantee his works for the duration of one year from the date of the completion certificate.
 2. If during guarantee period any equipment or material proves defective or any of systems fails to function properly, equipment is to be replaced and defects and malfunctions corrected as directed by the Engineer.
 3. If during guarantee period any piece of equipment is replaced or rebuilt, the guarantee period for this equipment is to be extended for a new period equal to the original guarantee period.
- F. Maintenance and Operation:
1. The Contractor shall provide necessary skills and labor to assure proper operation and shall provide regular and preventive maintenance required for equipment and controls during guarantee period, on a continuous 24 hours basis. He has to act promptly to correct problems arising in operation of equipment or system.

2. The Contractor has to provide the Employer with monthly inspection certificates of equipment, record findings on a check list and certify that each piece of equipment has been examined, is operating as intended and has been properly maintained as recommended by manufacturer.
3. The Contractor has to check all controls monthly to ascertain that they function as designed.

1.4 SUBMITTALS

- A. Shop Drawings:
 1. The Contractor is responsible to prepare the following sets of shop drawings and ask for approval before any construction:
 - a. Two hardcopies.
 - b. One transparent copy.
 - c. One soft copy.
 2. These drawings are to show that the design concept is understood.
- B. The Contractor has to submit priced lists of recommended spare parts for one-year operation, after substantial completion.
- C. Documents relative to equipment to be supplied and installed must be submitted for approval. Therefore, no equipment shall be installed before getting prior approval.
- D. For approval, the Contractor has to submit detailed manufacturer's specifications, original catalogue cuts and drawings of equipment and materials to be used.
- E. The Employer reserves the right to operate operable defective equipment, during guarantee period, until its repair or replacement. Spare parts shall be supplied and shall cover the items recommended by the manufacturer for two years operation.

1.5 TRAINING

- A. The Contractor shall, at no additional cost, demonstrate to operating personnel the functions and operation of all equipment before handing over. The operating personnel must be trained to perform necessary adjustments to equipment, appliances and effect routine maintenance.

PART 2 PRODUCTS

Not Applicable

PART 3 EXECUTION

Not Applicable

END OF SECTION

SECTION 16025

BUILDER'S WORK

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Materials and workmanship, unless otherwise specified, are to be in accordance with the relevant requirements of the Specification for Structural and Architectural work.
- B. Scope of work is to include 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 grounding.
- C. 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. For routes of services below ground, agree precise locations with the Engineer, set out clearly and accurately and locate with temporary marker posts.
- E. Unless otherwise specified in the Particular Specification all cutting of holes and chases in brickwork, concrete or other building materials, channeling of joints and the excavation of trenches for external cables, together with all the subsequent making good relaying of covers, filling in and resurfacing of trenches. The Contractor must include for the fixing of conduits etc., the boring for and fitting of all plugs, bolts and other fixings, the final trimming and adjustment for depth for accessory boxes, and the supply and laying of protective tiles. The cost of all unnecessary cutting away and making good occasioned by the faulty marking out and/or incorrect instructions being given by the Contractor shall be borne by him. Chases in plaster, brickwork and concrete must be sufficient deep to give 6mm clearance to all conduits and fastenings introduced. The chases must be neatly executed and be of minimum width.

PART 2 PRODUCTS

2.1 COMPONENTS

- A. Polyvinyl chloride (PVC) ducts for outdoor power and lighting cable installations at road crossings 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 6m or 3m lengths, with one end of each length tapered. Ducts are to be nominal size shown on the Drawings, with minimum wall thickness 3.2mm for 100mm ducts and 4.7mm for 150mm ducts.

- B. Duct supports are to be pre-formed, non-metallic of approved type. Supports containing metal are to have the metal non-continuous and not forming a magnetic loop in any manner.
- C. Covers for manholes/hand holes are to be to BS 497, ductile iron, recessed and ready to receive the required type of sidewalk tiles, and of suitable duty for the particular application. Contractor is to submit samples for the Engineer's approval before proceeding with the works.
- D. 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 & lead anchors are not acceptable unless approved for light duty installations.
- E. Duct spacers are to be easily assembled of the heavy duty type design. Spacers are to be designed to limit slip between themselves or the ducts in the formation, while the formation is being assembled, or while the concrete encasement is being cast.
- F. Duct spacers are to be suitable for multiple columns placement; inter connectable; or at least must have matching surfaces that can be easily matched to adjacent surfaces.
- G. Duct spacers are to be preferably delivered to site in basic sizes that can be joined together to support any number of ducts. Duct spacers are to be made of un-plasticized, polyvinyl chloride (PVC) or an approved alternative. Duct spacers are to provide a uniform separation of the ducts within the formation in the trench (both vertically and horizontally).

2.2 COMPOSITE CONSTRUCTION

- A. Equipment foundations and bases are to be 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 envelop 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 using sulphate-resisting Portland cement. Reinforcement is to consist of 12mm diameter longitudinal bars at approximately 300mm centers along bottom and sides of duct bank with 10mm diameter U-shaped transversal bars at 400mm centers. Length of concrete envelop is to extend at least 300mm beyond each side of crossing etc.
- C. Cable manholes and handholes are to be reinforced concrete 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.
- D. Provide loading details for all fixing types. For equipment requiring plinths/inertia blocks, provide all loading details on the builders work drawings. Use largest size of bolt, screw or other fixing permitted by diameter of hole in item to be fixed. Obtain Engineer's approval for all fasteners, fixings and install samples.

- E. For greasing of fixings ensure all bolts, screws or other fixings used are greased or lubricated in accordance with manufacturer's instructions.
- F. Obtain Engineer's approval for all fasteners, fixings and provide samples.

PART 3 EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

- A. Width of cable trench shall be as small as practicable with sides vertical. Remove mud, rock projections, boulders and hard spots from trench bottom and trim level. Inform the Engineer in advance to give him reasonable opportunity to inspect trench for each section of the work.
- B. Directly Buried PVC Cable Ducts:
 - 1. Lay and join ducts to required line and level on sand bed, cover with sand and backfill trench to ground level with excavated soil, free from stones and other debris, well compacted in layers not exceeding 300mm thick.
 - 2. Lay approved concrete tiles to fully cover cable duct, extending minimum 50mm beyond sides of duct and placed 300mm below ground level.
 - 3. Provide warning tape or galvanized steel mesh along duct runs at a depth 200mm below ground level.
- C. Underground Cable Duct Assemblies:
 - 1. Form 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 80mm overlap.
 - 4. Provide 3mm galvanized steel wire inside empty ducts, for future pulling of cables, extending 1m beyond duct banks at both ends and securely fixed to wooden bungs sealing the duct.
- D. Ducts ending in cable manholes or handholes are to be neatly cut and reamed and set behind chamfered precast concrete duct end blocks or terminated with appropriate bell-mouth bushing set in concrete wall. Ducts not ending in cable manholes or handholes are to be properly capped.
- E. Conduits and ducts, active or spare, at entry into building or manhole, are to be completely sealed with approved plastic moulds or wooden bungs to prevent entry of rodents, gas and vapor.
- 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 cut hardened concrete or drill holes larger than 10mm diameter without prior approval.
- J. For holes and chases in precast concrete, do not cut or drill precast concrete without prior approval.
- K. For holes in structural steelwork do not cut or drill steelwork without prior approval.
- L. Holes and chases in masonry must not exceed:
 - 1. Size of Holes: 300mm square.
 - 2. Depth of Vertical Chases: 1/3 wall thickness, or in cavity walls 1/3 leaf thickness.
 - 3. Depth of Horizontal Chases: 1/6 wall or leaf thickness
- 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. 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.
- N. Performed holes in masonry, submit proposals for bridging over holes for ducts etc, which exceed 460mm width.
- O. 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 500mm 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.
- P. Clean ducts with stiff bristle brush pulled through each duct prior to pulling in cable.
- Q. Comply with BS 3974 Part 1, or equivalent European/American Standards for fixings. Ensure that fixings such as expanding anchors are tested for tensile loading in accordance with BS 5080 or equivalent.
- R. Use plugs of suitable size and length for fixings. Use plastic or soft metal non-deteriorating plugs to suit application. Do not use wood plugs. Ensure that when screw is in place, threaded length is in plug. Ensure plugs used for screw fixing are set-in to correct depth prior to final tightening.
- S. Where cast-in fixings are permitted, mark out and set fixings in accordance with manufacturer's instructions.
- T. Shot Fired Fixings: Obtain approval prior to using shot fired type fixings.
- U. Self Adhesive Fixings: Obtain approval prior to using self adhesive type fixings.

- V. Proprietary Channel Inserts: Provide proprietary channel inserts for casting-in where indicated.
- W. Drilling: Drill holes squarely. Use drills of requisite size and depth, and appropriate to fabric. Do not flame-cut holes in metal work.
- X. Proprietary Fixings: Use only proprietary fixings and comply with manufacturer's instructions for all fixings such as self expanding anchors, chemical anchors, rails.
- Y. Fixing to Reinforced Concrete: Take precautions to avoid fixing through reinforcement.
- Z. Fixing to Hollow Stud/Tile/Block Walls: Fix equipment, brackets and supports where there is access at rear of wall, by drilling hole through wall and fixing with bolt, back-plate, washer and loose nut. For each of type of fixings obtain approval of sample fixing from the Engineer, prior to proceeding with work.
- AA. Fix equipment, brackets and supports where there is no access at rear of wall, drill hole and use screw anchor type fixing or gravity type toggle fixing.
- BB. Fixing to Concrete, Brickwork or Block Work:
1. Fix equipment, brackets and supports using approved fixings.
 2. Drill holes and fix using one of the following approved methods.
 3. Fix equipment, brackets and supports as follows:
 - a. Use wood screws in plugs.
 - b. Use shot fired fixing.
 4. Drill holes and fix using:
 - a. Steel bolts of grouted bolt type.
 - b. Expanding bolt type fixing.
 - c. Resin bolts.
 - d. Studs.
- CC. Fixing to Metal Work: Fix equipment, brackets and supports by drilling holes and fixing using one of the following approved methods.
1. Self-tapping screws.
 2. Gravity type toggle fixing.
 3. Spring type toggle fixing.
 4. Set screws or bolts complete with washers, shake proof washers and loose nuts.
- DD. Fixing equipment, brackets and supports by drilling or flame cutting holes in or welding to metal structures is not permitted without Engineers written approval. Proprietary girder clamps shall be used for suspending pipes, equipment or ducts from steel structure. Ensure the Girder clamps are provided with axial restraints to prevent accidental slipping of Girder clamps due to horizontal thrusts.
- EE. Provide manufacturer's information on recommended fixing. Obtain approval for any fixing to structure steel work and concrete structures. Generally use proprietary fixings to structural steelwork and concrete structures.

END OF SECTION

SECTION 16035

PAINTING AND ANTI CORROSION TREATMENTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Section includes surface preparation and application of paints and anti corrosion treatments for electrical products, materials and equipment.
- B. Related Sections:
 - 1. Section 09900 - Painting.
 - 2. Division 16 - Electrical.

1.3 GENERAL REQUIREMENTS

- A. Where particular methods of finish and painting are not specified, ensure following requirements are met:
 - 1. Protect all metal work, plant, equipment, pipelines, ductlines, ancillaries, brackets and supports against corrosion and oxidization.
 - 2. Provide ferrous metals, machined or otherwise with protective coatings at manufacturer's works.
 - 3. All electrical containment elements like tray, trunking, supports, etc., exposed to public view like car park etc., shall be applied with primer and painted to a color of Engineer's choice.
 - 4. Ensure all items requiring on-site decorative finishes are provided primed to suit base material and required finish.
- B. Anticorrosive and decorative paints systems shall be from one of the approved manufacturers. Contractor shall make a proposal, for the painting and anticorrosive treatments for various items of work (which are not treated as such by the manufacturer) for approval.

1.4 DAMAGED FINISHES

- A. Following delivery to site, storage on site and installation, make good any damage to finishes, by cleaning, degreasing and re-furbishing before installation is taken over.

1.5 PAINTING REQUIREMENTS

A. Anticorrosive Coating and Painting to Surfaces:

Surface	Anticorrosive Coating and Painting
1. All un-insulated steel pipework installed in conditioned space within the building and within ceiling voids.	Two coats of red oxide primer. In addition apply two coats of synthetic enamel paint, color to Engineer's choice for exposed to view pipes.
2. Un-insulated steel pipes installed outside the building on roof and in the basements.	Two coats of two-pack epoxy paint on all pipework, color to Engineer's approval.
3. All galvanized steel pipes surfaces exposed to view, un-insulated	Two coats of etching primer followed by two coats of approved synthetic paint, color to Engineer's choice (for fire services color shall be red).
4. All un-insulated PVC pipe work surface exposed to sunlight, on roof	Two coats of UV resistant white paint.
5. Supports exposed to view in car parks, roof, plant rooms.	Galvanized and painted.
6. Supports in ceiling void	One coat of red oxide primer and two coats of black enamel.
7. Support, brackets, hangers in roofs and other exposed locations.	Mild steel brackets, angles, channels and hangers, all galvanized after manufacture

B. Equipment and all pipework ancillaries shall be provided with factory applied paint.

PART 2 PRODUCTS

2.1 MATERIALS

A. Use the following materials for corrosion protection and painting:

1. Red Oxide priming paint for bare iron and steelwork.
2. Zinc Chromate priming paint for non-ferrous metals.
3. Calcium Plumbate priming paint to BS 3698 for galvanized steel.
4. Undercoating paint for previously primed or painted surfaces before the application of finishing coats.
5. Gloss finishing paint for previously primed or painted/undercoated surfaces.
6. Epoxy resin paint for specialist coatings requiring resistance to acids, alkalis, oils, solvents, abrasion or high humidity.
7. Cold galvanizing paint for making good damage to previously galvanized surfaces and protection to galvanized materials modified during installation.
8. Zinc-rich metallic to BS 4652 for bare iron and steelwork where electrical conductivity has to be assured.
9. Bitumen based coating for cold application to BS 3416 protection to iron and steel, particularly pipelines and fittings for use in contact with potable water.
10. Bitumen based coatings for cold application to BS 6949 not to be used in contact with potable water.
11. Tar based epoxy coatings on all cast iron/ductile iron manhole covers, gratings, gully traps, etc., in car park areas, external unpaved areas.

2.2 PAINT QUALITY

- A. Ensure paints used are of quality and type to suit application and that primers have good adhesion, covering power, rust-inhibiting and grain filling properties; gloss finishing paints are of machine finish grade having high adhesion and high resistance to solvents, mineral oils, cutting oils, detergents, chipping and impact damage.

2.3 HEAT RESISTANT PAINT

- A. Use heat resistant paints for applications to surfaces over 80°C.

PART 3 EXECUTION

3.1 GENERAL

- A. Contractor shall propose paint corrosion protection system for all services applications from one of the acceptable paint manufacturers, for approval for only the approved paint system.
- B. Ensure paints are applied to manufacturer's instructions and to BS 6150.
- C. Install work in accordance with approved standards, as per manufacturer's recommendations, to the satisfaction of the Engineer, and with full coordination with local relevant authorities.

3.2 PAINTING

- A. Ferrous sheet metal work or structural support elements which are not galvanized shall be cleaned to remove all grease and rust and have a protective coat of paint or other approved material applied before dispatch from works. Other ferrous materials shall receive a protective coating at works, or alternatively, be treated in accordance with the manufacturer's approved corrosion resisting metal finishing process. Any deterioration or damage to manufacturer's protective coating during transportation, storage and following installation shall be made good to the satisfaction of the Engineer. Damaged areas shall be made good as if they were bare metal.
- B. The Contractor shall be responsible for painting thermal insulation where indicated.
- C. The surface of all ferrous metal work including pipework, brackets, hangers, steelwork, etc., (excluding ductwork), which are not protected by galvanizing shall be cleaned to remove all grease and rust and then given one coat of primer and finished with two coats of approved quality non-metallic paint of a color agreed with the Engineer. The surfaces of all ferrous pipework which are to be insulated shall be given one coat of primer. Where surfaces will be subjected to temperatures above 100°C. the finishing coat(s) shall be heat resisting paint and the primer omitted.
- D. All services exposed to view shall be painted by 2 coats of enamel paint. Color to Engineer's approval.

- E. All exposed to view pipework shall be cleaned to remove all grease and rust and then given one coat of primer and finished with two coats of approved quality non-metallic paint to a color agreed with the Engineer.
- F. Pipework and ductwork services shall be correctly identified in order to facilitate the use of approved paint of the correct color to comply with BS 1710 and the Engineer's instructions.

3.3 WEATHER AND OTHER CONDITIONS

- A. Do not apply paints where weather, temperature, humidity or other conditions may have a damaging effect upon finish or paint.

3.4 CLEANING AND PREPARING SURFACES FOR PAINTING

- A. Ensure metal surfaces are thoroughly cleaned, all mill and weld scale removed and finally degreased.
- B. Clean steel surfaces in accordance with BS EN ISO 8503
- C. Prepare surfaces for painting in accordance with BS EN ISO 4618.

3.5 APPLICATION OFF-SITE

- A. Wherever possible ensure paint finishes applied by manufacturers are spray applied.

3.6 FIELD APPLICATION

- A. Apply paint evenly and ensure finish shows no excessive brush marks, grinning, runs, sagging or other application defects.

3.7 HOT DIPPED GALVANIZED SURFACES

- A. Galvanizing shall be applied by the hot dipped process. The preparation for galvanizing and the galvanizing process shall not adversely affect the mechanical properties of the material being coated.
- B. All drilling, punching, cutting, bending, welding and removal of burrs shall be completed before galvanizing.
- C. Surfaces in contact with oil shall neither be galvanized nor cadmium plated, unless finished with an oil resisting varnish.
- D. The average thickness of the zinc coating shall be equivalent to not less than 0.6 kg/m² of zinc for all surfaces, except steel wires.
- E. The thickness of the zinc coating for steel wires shall be in accordance with a national or international standard and shall be approved by the Engineer.

3.8 SITE REPAIRS OF GALVANIZED SURFACES

- A. Repair damage to galvanized components due to installation process, i.e. following cutting, drilling or welding, by applying 2 no. substantial coats of approved cold galvanizing coat.

3.9 PROTECTION OF BRIGHT MACHINE PARTS

- A. Apply a protective coating to all bright machine parts before dispatch from works.
- B. Do not remove protective coatings unless required for installation, testing or commissioning purposes and in such cases reinstate upon completion.
- C. Repair any damaged protective coating or bright machined part, or where necessary replace damaged component.
- D. Use and apply metal coatings in accordance with manufacturer's instructions.
- E. Complete where possible all welding, drilling, bending and other work before metal coating.

PART 4 MEASUREMENTS AND PAY ITEMS

4.1 MEASUREMENT AND PAYMENT

- A. Painting and Anti Corrosion Treatments:
 - 1. Basis of Measurement: No separate measurement shall be made for painting and anti corrosion treatments of all electrical products, materials and equipment, and the work thereof shall be considered as subsidiary works and deemed included elsewhere in other related items.
 - 2. Basis of Payment: No separate payment shall be made for painting and anti corrosion treatments of all electrical products, materials and equipment, which rate shall be deemed included elsewhere in other related items.

END OF SECTION

SECTION 16060
EARTHING SYSTEM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Supply and install equipment required to connect to earth all electrical equipment and installations in compliance with the relevant clauses of the IEC Regulations and based on the TN earthing system.
- B. Work will include without limitation:
1. Main earth system.
 2. Test links.
 3. Earthing bars.
 4. Generators earth system (including earth of the generator neutral).
 5. Main earthing conductors from earthing bar to the main distribution board.
 6. Earthing of enclosures and shielding of electrical systems and equipments.
 7. Earthing of exposed conductive parts existing inside equipment rooms.
 8. Bonding conductors to all extraneous conductive parts of the building.
- C. Earthing installations shall conform to IEC publications 364-3 and 364-4-41.

1.3 SUBMITTALS

- A. The following data (but not limited to) shall be submitted for approval:
1. Manufacturer's catalogue cuts for all accessories.
 2. Shop drawings coordinated with all other trades showing exact location of earthing bars, details of installation, exact routing of protective and bonding conductors with cross sectional area.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

- A. FURSE (ENGLAND)
- B. WALLIS (ENGLAND)
- C. COPPERWELD (USA)
- D. OBO-BETTERMAN (GERMANY)
- E. Or other equal approved.

2.2 MATERIALS

- A. Electrical earth system consists of one or more earth pits at the ground floor level providing an earthing connection point with less or equal than five ohms' resistance to the general mass of the earth for power earthing and less or equal than one ohms resistance for low current system.
- B. Concrete earth pit is to contain one directly driven 1.8m rod with cable conductor on top. Diameter of the rod should not be less than 17mm.
- C. Earth rod is to be of high strength steel alloy core with molten welded copper stranded cable 70mm², buried 700mm below ground and at least 700mm distant from concrete structure.
- D. Permanent earthing connections are to be made by exothermic welding process.
- E. Materials used for earthing are to be copper or approved copper alloys specially manufactured for the purpose. Electrical continuity is to be of durable construction providing an independent fault current return path of low resistance to the site earth.
- F. Earthing and protective conductors shall be 1000V, PVC insulated multi-stranded cable. PVC cable insulation shall be continuous and intermediate jointing is not permitted.
- G. Non current-carrying metal parts such as metal conduits, raceways, outlet boxes, cabinets, enclosure doors, etc., must be earthen.
- H. Water mains pipe, on street side, is to be connected to site earth.
- I. Cross- sections of supply phase conductors less or equal than 16 mm² shall have equal protective conductor size cross-section.
- J. Conductor size is to be cross section half that of main supply phase conductors for sections greater than 16 mm².
- K. Conductor size should be in accordance with the Regulations and in no case less than 2.5mm².

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install work in accordance with approved standards, as per manufacturer's recommendations, and to the satisfaction of the Engineer.
- B. Earthing installation shall be protected from mechanical damage and corrosion.

- C. Electrical continuity is to be of durable construction providing an independent fault current return path of low resistance to earth.

END OF SECTION

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Section includes identification methods for electrical equipment and components.
- B. Related Sections:
 - 1. Section 16035 - Painting and Anti Corrosion Treatments

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data:
 - 1. Submit manufacturer's catalog literature for each product required.
 - 2. Submit electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location and function.
- C. Samples:
 - 1. Submit two samples of each type of applicable identification products.
 - 2. Submit two nameplates, 100 x 100 mm in size illustrating materials and engraving quality.
- D. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures and installation.

PART 2 PRODUCTS

2.1 LABELS AND NOTICES

- A. Apply identification labels and notices in accordance with BS 7671 (IEE Wiring Regulations), Clause 514 to all electrical cables, plant and equipment including components of mechanical systems. Also install caution and other labels required by relevant local authorities' regulations, and as deemed necessary by the Engineer.
- B. Fit labels and notices as shown on schedules and drawings.
- C. BS 7671 Labels and Notices:
 - 1. Identification of protective devices.
 - 2. Diagrams, charts or tables to comply with Clause 514-09.
 - 3. Warning notices, voltages in excess of 250 Volts.

4. Periodic inspection and test notices.
5. Residual current device notices.
6. Earth electrode safety electrical connection label.
7. Bonding conductor connector point to extraneous conductive parts label.
8. Earth free local equipotential bonding areas warning notice.
9. Electrical separation areas warning notice.
10. Outdoor equipment socket outlet notice.
11. Control equipment, including circuit breakers, fuse switches, isolators and fuse boards.
12. All cables with cable number, destination and source shall be provided.
13. In panel boards all cables shall be ferruled.
14. Cable trays, trunking and conduits to be identified with appropriate number corresponding to the shop drawing numbering and service identification.
15. All equipment shall be clearly and permanently labeled, to the approval of the Engineer, in English. Where labels are provided for making clear the method of operation of apparatus, they shall be concise and preferably diagrammatic in form.
16. Labels shall be of the engraved trifoliate type and to the approval of the Engineer.
17. Labels for similar equipment shall be uniform appearance and size, and all labels shall be fixed by screws.
18. Each item of equipment shall be marked with its function, manufacturer's name or trademark and the code or type number, together with the batch or serial number.
19. Danger notices have red lettering on a white background. Generally, lettering for danger notices shall be 100mm high and all other lettering 6mm high.
20. The Contractor shall submit a schedule of labels for approval by the Engineer before engraving is carried out.
21. Also see elsewhere in the specification.

2.2 MATERIALS

- A. Use materials for labels and notices with a predicted life equal to or greater than the design life of the electrical cables, plant, equipment or installation to which it refers.
- B. External:
 1. Engraved thermosetting plastic laminate.
 2. Rigid plastic, hot press printed.
 3. Printed pressure sensitive labels
 4. Brass, materials and engraving.
 5. Stainless steel engraved
 6. The contractor shall submit the sample based on the requirement as noted above and obtain approval from the Engineer prior to installation. The Engineer shall reserve the right to approve the material as noted above based on the suitability of the location and application.
- C. Internal:
 1. Engraved thermosetting plastic laminate.
 2. Screen printed thermosetting rigid plastic
 3. Screen printed flexible plastic
 4. Flexible plastic with manuscript lettering

5. Rigid plastic, hot press printed.
6. Printed pressure sensitive adhesive labels to BS 4781.
7. Aluminum or aluminum alloy, general lettering pressed, particular lettering engraved.
8. Aluminum or aluminum alloy, lettering embossed.
9. Stainless steel, engraved
10. The contractor shall submit the sample based on the requirement as noted above and obtain approval from the Engineer prior to installation. The Engineer shall reserve the right to approve the material as noted above based on the suitability of the location and application.

D. Color:

1. Background White or Red
2. Lettering Red or White.
3. Provide submittal detailing the color, material, etc.
4. All materials shall be from an approved manufacturer. No locally fabricated, printed items shall be accepted. All items shall be given a guarantee for the life of the systems and shall be included in the submittal.

2.3 FIXING INTERNALLY

- A. Fix labels and notices using materials compatible with label or notice and surface to which it is fixed by screws into tapped hole or bolted complete with washer nut and locking device.

2.4 ARRANGEMENT

- A. Obtain approval prior to manufacture, with regard to style, color, lettering, size and position of all labels and notices.
- B. Provide sample showing style, color, lettering and size, for approval.

2.5 LETTERING AND SIZE OF LABELS AND NOTICES

- A. Ensure that all lettering and symbols comply with the requirements laid out in BS 7671 (IEE Wiring Regulations), paragraph 514 and BS 5378. Use Table 6 of BS 5378 for height of lettering where not otherwise indicated. Ensure labels and notices of adequate size for the lettering required, and allow a minimum margin around all lettering of one line space vertically and two letter spacing horizontally.
- B. Font: Helvetica Medium or as approved by the Engineer.
- C. Size: To the approval of the Engineer.
- D. All lettering for the control equipment, including circuit breakers, fuse switches, isolators and fuse boards, shall be provided with beveled laminated plastic or ivorine labels suitably engraved with indelible characters (not less than 5mm high) indicating the use of the equipment and its reference numbers.
- E. For all other labels viz cable tray, service identification, etc., shall have lettering not less than 50mm high depending upon the size of the tray/trunking, etc. Provide sample for approval before installation.

2.6 CONDUCTOR ARRANGEMENT

- A. Arrange circuit polarity so that phases read in phase rotation order followed by the neutral, if any, from top to bottom in horizontal conductor layouts and left to right in vertical conductor layouts. Ensure flat horizontal arrays have leading phase to the left and neutral to the right from left to right when viewed from supply point. Arrange phase or live pole of two wire apparatus at top or left hand and neutral and earth both at bottom or right hand side. In all cases, ensure conductor arrangements defined are when viewed from front face of all equipment and terminating facilities. Apply identification markers in accordance with BS 7671 (IEE Wiring Regulations), Clause 514 to all conductor termination points.

2.7 SAFETY SIGNS

- A. Label all electrical plant and equipment using safety sign A.2.8 of BS 5378, Part 1 where voltages above ELV exist.
- B. Provide with each safety sign A.2.8 supplementary or text signs complying with BS 5378, Part 3.
- C. Label all electrical plant and equipment with the labels specified in the appropriate British Standards for that plant or equipment. Identify each substation and main switch room with safety sign A.2.8 to BS 5378, Part 1 with supplementary signs to BS 5378 Part 3, notices and signs required by BS 5306 for any fire extinguishing system and notice giving details of the following:
 1. Name of the Substation or switch room.
 2. The presence of Medium and Low Voltages.
 3. Administrative instructions for access.
 4. Location and method of contacting controlling authority.
 5. Actions to be taken in an emergency.
 6. In all switch rooms and/or substations, a laminated notice shall be provided and hung in a conspicuous place. The notice shall give full instructions for the method of treating persons suffering from electrical shock. All schematic diagrams including those for change over switches shall be glazed and framed to the Engineer's approval.

2.8 PLANT AND EQUIPMENT LABELS

- A. Fit labels on all items of plant, equipment, switches, etc., include the following information: service controlled, circuit reference, voltage, type of supply and phase etc., circuit protection type and rating.

2.9 MAINTENANCE NOTICES

- A. Fix notices giving warning of, and instructions on, any special maintenance procedures to plant and equipment.

2.10 COLOR CORRECTED LIGHT FITTINGS

- A. Fix a warning or identification disc to light fittings containing color corrected fluorescent tubes or other color corrected light sources to ensure that maintenance staff install the correct lamps.

2.11 MOTORS AND STARTERS LABELS

- A. Fit identification labels to all motors, starters and starter panels. Ensure positive identification of respective motors and starters. Provide motors with non-corrodible labels attached adjacent to each bearing giving details of the lubricant to be used. Mark direction of normal rotation on motor casing. Provide labels to identify motor equipment fitted with surge suppressors and thermistors stating that insulation test voltages must not be applied to thermistors and thermistor control units. Ensure labeling is compatible with schematic and wiring diagrams, and complies with BS 4999, Part 108.
- B. Motors arranged for automatic restart shall have label of durable material permanently fixed to them in prominent position and having, in clearly inscribed characters and in English and Arabic, the legend: "DANGER. THIS ELECTRICAL MOTOR IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING. ISOLATE BEFORE INSPECTION".

2.12 ENGRAVED ACCESSORY PLATES

- A. Engrave switch plates like for cooker, dryer, washing machine, dishwasher, etc, spur units, pushes and special plates for fire alarm system etc. Use 6mm high letters with engraving colored red.

2.13 SWITCHGEAR

- A. Fit labels on switchgear as required by BS 7671 and BS EN 60439 to indicate duty of unit, its voltage, phase and current rating, protective device rating, size of conductor involved, and all other necessary details.
- B. Use an agreed serial coding system, provide at the switch a key to the coding system.
- C. Switch panels, distribution boards and similar distribution units shall, unless specified otherwise, be designated in accordance with the reference letters or numbers used in the Particular Specification and/or shown on the drawings.
- D. All distribution boards shall be provided with a type written circuit chart (which has been approved by the local Electrical Authority) mounted on a aluminum sheet and given a transparent Perspex coat (not less than 0.8mm thick), fixed by screws to the inside of the front cover.
- E. Duplicate copies of each circuit list shall be filed into separate A4 size twin ring loose leaf binders and handed over as directed by the Engineer.
- F. The list shall give the following particulars of each circuit:
 - 1. Apparatus connected and location.
 - 2. Connected load in watts.
 - 3. Cable size.
 - 4. MCB rating.
 - 5. Phase, if a single phase circuit from a TP and N fuse board.
 - 6. The rating and circuit identification of each fuse shall be marked adjacent to the fuse base.

7. All outdoor switchgear shall be clearly and permanently identified by number plates and phase discs of appropriate color.
8. On AC systems the phase sequences shall be maintained throughout the installation and all phase connections shall be in the order Red, Yellow, Blue from top to bottom and/or left to right. Neutral connections, links and/or busbars shall always be located above, below or to the side, not between the phase connections, links or busbars.
9. The particular phase connected to circuit breaker banks and busbars shall be clearly indicated by marking with the appropriate color.

2.14 DISTRIBUTION BOARDS

- A. On each distribution board, identify every outgoing way with a renewable circuit chart in a transparent plastic envelope permanently fitted inside distribution board cover. Clearly indicate in typed script, circuit identification number, cable size, fuse or circuit breaker rating and a description of item supplied and area supplied by circuit.

2.15 SCHEMATIC DIAGRAMS

- A. Provide a purpose made schematic diagram permanently fixed showing the connections of the equipment and plant.
- B. Locations:
 1. At main switchgear.
 2. At sub-main switchgear.
 3. At control gear.
 4. Fixed to plant and equipment.
 5. The schematic diagram shall be located at any of the locations, as noted above, or at appropriate places near to the equipment as per the site conditions.
- C. Materials:
 1. Printed paper, transparent cover and framing
 2. Engraved thermosetting plastic laminate
 3. Printed paper, encapsulated
 4. All material shall be as appropriate based on the location and size. The items noted above are for reference only.
 5. In all switch rooms the Contractor shall provide and install a framed and glazed schematic diagram in accordance with relevant local authorities' regulations, indicating the distribution arrangement of the installation. The frame shall be fabricated from standard section hard-drawn aluminum.

2.16 SPECIAL PURPOSE EARTHING

- A. Fit labels to special purpose earthing conductors and connection points, describing their purposes and any instructions necessary for their operation and maintenance.
 1. IT equipment "Clean Earths".
 2. Telecommunications functional earths.

2.17 INDICATOR LAMPS AND PUSH BUTTONS FOR POWER SYSTEMS

- A. Use indicator lamp and push button colors in accordance with BS EN 60073.
- B. Indicator lamp: Red, danger or alarm; yellow, caution; green, safety.
- C. Push buttons: Red, emergency action; red, stop or off; yellow, intervention; green, start or on.
- D. Illuminated push buttons - To the approval of the Engineer.

2.18 CONDUIT AND TRUNKING COLOR CODING

- A. In areas of mechanical plant or voids accommodating mechanical services, or where otherwise indicated, identify electrical conduits and ducts in accordance with BS 1710. Apply color orange to BS 4800 by:
 - 1. painting over whole length of the service.
 - 2. applying an adhesive tape type wrap around services over a length of 150mm.
 - 3. No local tape shall be acceptable.
- B. Place identification colors at bulkheads, wall penetrations and any other place where identification is necessary.
- C. The service bands shall be kept at equal intervals of 6 mts for the full length of the conduit/trunking which are at accessible areas. In the event that the intervals are occurring after an access panel, the contractor shall provide suitable band at the access panel opening area also in addition to the other areas as noted.
- D. The conduit and trunking number shall also be marked besides the color band.

2.19 CABLE IDENTIFICATION

- A. Provide all cables, other than final sub-circuit wiring enclosed in conduits or trunking, with labels fixed at each end of cable either side of wall and floor penetrations at approximately 12m intervals at convenient inspection points by means of:
 - 1. galvanized wire binder, to BS 1052
 - 2. non-releasable plastic straps
 - 3. releasable plastic straps
- B. Ensure labels show the following information
 - 1. Reference number of cable.
 - 2. Points of termination.
 - 3. Size and number of conductors.
 - 4. Type of cable and date installed.
 - 5. Operating voltage of cable.
 - 6. All cable ends shall be marked to identify the cable connection. Identification labels for all cables shall give the cable an approved reference number.
 - 7. All cables shall have a label fixed to them below each cable joints, also where the cable passes through ducts and trenches at each exit from or entry to such ducts and trenches and where the cable enters a room or building. The label shall indicate the cable potential and destination as well as the cable number.

2.20 TERMINAL MARKING AND CONDUCTOR IDENTIFICATION

- A. Provide for switchgear and control gear elements whose terminals are marked as per BS 5472 (EN 50005) and BS 6272 (EN 50042). Use a unique reference to identify each element in the switchgear or control gear. Mark on or adjacent to each element its reference. Identify each terminal for connection to external wiring or cabling using a reference system complying with BS 5559 (EN 60445) based on the element reference and the appropriate element terminal reference.
- B. Adjacent to terminals.
- C. Use lettered or numbered ferrules or sleeves to BS 3858 to mark each auxiliary conductor or control cable core with the identity of the terminal to which it is connected and the reference of plant or equipment to which it is connected and the identity of the terminal at the remote end. Ensure that main circuit conductors are identified in accordance with BS 7671 (IEE Wiring Regulations) paragraph 514-06. Ensure that all identification of terminals and conductors is recorded and included on record drawings and in operation and maintenance documentation.

2.21 UNDERGROUND CABLE IDENTIFICATION

- A. Identify external underground cable routes by means of approved markers along their length at distances not exceeding 30m and where a change of direction occurs on such routes. Provide cables markers with a brass plate or impress concrete to clearly indicate the reference of group of cables or reference number of cable and operating voltage of cable.
- B. Provide key to any reference system used at switchgear.
- C. Mark and protect direct buried cables with detectable warning tapes yellow printed black "DANGER ELECTRIC CABLES", or printed to indicate other relevant other services.

2.22 CABLE CONDUCTOR COLOR CODING

- A. Identify cable conductors in accordance with BS 7671 (IEE Wiring Regulations) paragraph 514, note that a lighting sub-circuit switch wire is a phase conductor in a single phase circuit.
- B. Single phase final sub-circuit phase wiring coded to match phase used.
- C. On AC systems the phase sequences shall be maintained throughout the installation and all phase connections shall be in the order Red, Yellow, Blue from top to bottom and/or left to right. Neutral connections, links and/or busbars shall always be located above, below or to the side, not between the phase connections, links or busbars.
- D. The particular phase connected to circuit breaker banks and busbars shall be clearly indicated by marking with the appropriate color.

2.23 CABLE JOINTING AND TERMINATION

- A. Connect all cables in the installation so that the correct sequence of phase rotation is maintained throughout. Where straight through joints are approved on low voltage cables, whether power cables or control or auxiliary cables, joint conductors strictly in accordance with their color or numeric coding. Where such joints are approved on mineral insulated or other non-coded conductor cables, identify each core at the joint and make the joint core to core.

2.24 CABLE SHEATH IDENTIFICATION - INTERNALLY

- A. Use to identify colored cables sheaths for various services as follows:
 - 1. Fire alarm, red.
 - 2. Clock circuits, brown.
 - 3. Telecommunications, grey/beige.
 - 4. Data as system suppliers requirements.
 - 5. Control, black.
 - 6. LV, black.
 - 7. LV mineral insulated, orange.
 - 8. MV red.
- B. Code cables for various services using alphanumeric symbols as follows:
 - 1. Code letters preceding cable reference.
 - 2. Fire alarm, FA.
 - 3. Clock, CL.
 - 4. Telecommunications, T.
 - 5. Data, D.
 - 6. Control, C.
 - 7. Low voltage, LV.
 - 8. Extra low voltage, ELV.
 - 9. LV Essential circuits E.
 - 10. Medium voltage, HV.

2.25 CABLE SHEATH IDENTIFICATION - EXTERNALLY

- A. Identify cable sheaths for various services, as follows:
 - 1. MV Red; LV Black; telecommunications and data, Grey.

2.26 ADDITIONAL SAFETY SIGNS

- A. Provide at locations shown or as appropriate safety signs to BS 5378 with dimensions as Tables 5 and 6 of Part 2. Modular height (a), 75mm.
- B. Application for Main Switch and Electrical Plant Room Access Doors: BS 5378 Appendix A, complete with supplementary signs as shown.
 - 1. Part 1, A.1.4., A.1.3, with supplementary sign 'Authorized persons only'.
 - 2. Part 3, A.3.8.
- C. Application for Use with Permit to Work Systems: BS 5378 Appendix A, complete with supplementary signs as shown.

1. Part 3, A.1.3. Printed on rigid plastic, with hanging loop, with supplementary wording 'Do not operate. Work in progress'.
- D. Application for Use at Each Emergency Stop: BS 5378 Appendix A, complete with supplementary signs as shown.
1. Part 3, A.4.5. With supplementary sign 'Emergency stop push-button'.

PART 3 EXECUTION

3.1 INSTALLATIONS

- A. Install work in accordance with approved standards, as per manufacturer's recommendations, to the satisfaction of the Engineer, and with full coordination with local relevant authorities.

PART 4 MEASUREMENTS AND PAY ITEMS

4.1 MEASUREMENT AND PAYMENT

- A. Electrical Identification:
1. Basis of Measurement: No separate measurement shall be made for electrical identification of all electrical products, materials and equipment, and the work thereof shall be considered as subsidiary works and deemed included elsewhere in other related items.
 2. Basis of Payment: No separate payment shall be made for electrical identification of all electrical products, materials and equipment, which rate shall be deemed included elsewhere in other related items.

END OF SECTION

SECTION 16080

ELECTRICAL TESTING AND COMMISSIONING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 GENERAL

- A. A specialist testing and commissioning specialist engineer shall be appointed to programme, oversee, co-ordinate and record all the testing and commissioning of the electrical systems. The specialist test engineer shall co-ordinate with those elements undertaken by the mechanical services commissioning engineer and other specialist suppliers of low current systems. The electrical commissioning engineer shall allow for liaising and attendance and providing all necessary test and general data information at the correct times.
- B. Testing and commissioning shall be carried out in accordance with the following phases:
 - 1. Off-Site Tests: Tests carried out on items of equipment at manufacturer's works or elsewhere to ensure compliance with the requirements of specifications and/or relevant British Standards and Codes of Practice.
 - 2. Pre-Commissioning Site Tests: Tests on equipment and systems to ensure correct and safe installation and operation in accordance with the applicable standards.
 - 3. Commissioning: The process of energizing equipment and systems and setting them to full working order and verifying the performance to specified requirements under no-load conditions.
 - 4. Performance Testing: The measuring and recording of the performance of the commissioned installation under load conditions.
- C. All the electrical systems, whether mentioned in this section or not, shall be subject to testing and commissioning.

1.3 INSPECTION AND TEST PROCEDURE

- A. All electrical equipment shall be inspected and tested by the Contractor in accordance with BS 7671 (IEE Regulations) and other applicable standards, particularly section 713 and all tests shall be witnessed by the Employer, and recorded on test record sheets of an approved format at manufacturers facility. The inspection procedures and witnessing, etc., should be carried out without any extra cost to the Employer.
- B. It should be noted that electronic components may sustain serious damage as a result of certain accepted electrical installation test procedures. Conductors and other circuit components shall be tested prior to them being connected to electronic components. Electronic equipment to be tested in accordance with the manufacturer's instructions.

- C. The presence of electronic components shall be noted clearly on the circuit cards and in operating and maintenance manuals with an indication that testing procedures may result in damage.
- D. The Contractor shall submit a testing and commissioning programme, which is fully coordinated with testing of other related systems and equipment to the Employer within 30 days of contract award. The Contractor shall give fourteen (14)-day notice, in writing, of the date on which any testing or commissioning will be carried out, who shall ensure that all preliminary setting up and adjustments have been carried out prior to the day of the test.
- E. The Contractor shall provide all labor, materials, power, fuel, stores, apparatus and properly calibrated and certified instruments for carrying out tests of the plant, materials, work or workmanship in accordance with the Contract, on the site and/or at the place of manufacture.
- F. The Contractor shall submit test results to Employer on a certificate of approved type.
- G. The Employer or his representative shall witness all testing and sign the test certificates at site or at manufacturer facility.

1.4 SUPPLY CHARACTERISTICS

- A. Obtain information called for in BS 7671 about supply characteristics from Supplier, other than where to be measured as part of testing procedure.

1.5 DESIGN INFORMATION

- A. Obtain all design assumptions, calculations and any other information to enable compliance with BS 7671 to be verified.

1.6 TESTING

- A. Incorporated Equipment Characteristics:
 - 1. Obtain and use information from manufacturers of equipment provided.
 - 2. Use information provided, for equipment supplied by others and incorporated into installation.
- B. Prospective Short Circuit Current (IP):
 - 1. Determine values of IP by calculation and confirm by measurement as agreed with the Employer, unless other means are indicated. Determine IP at all necessary points within installation for maximum and minimum conditions to confirm correct equipment selections.
 - 2. Obtain from supply authority written confirmation of maximum and minimum values of IP at origin of installation. Adjust subsequent measured values of IP accordingly.
- C. Initial Verification:
 - 1. Carry out detailed inspection to verify the requirements of BS 7671 Section 712 in the order given in Clause 712-01-03 for New Installation or Altered or Added Installation as appropriate.

- D. Test Equipment and Consumables:
1. Provide test equipment and consumables to complete tests satisfactorily, and to retest any failed installations following corrective measures.
 2. Test equipment quality assurance requirements to BS EN 30012-1.
- E. Pre-Commissioning Testing: Carry out the following tests in the same order as published; the tests required by BS 7671 Section 713.
1. Continuity of Final Circuit Conductors.
 2. Continuity of Protective Conductors.
 3. Earth Electrode Resistance.
 4. Insulation Resistance.
 5. Insulation of Site-Built Assemblies.
 6. Electrical Separation of Circuits.
 7. Protection Against Direct Contact by Barriers or Enclosures.
 8. Phase sequence and Polarity.
 9. Earth Fault Loop Impedance.
 10. Earth Bonding of Conductive Parts.
 11. Operation of Residual Current Operated Protective Devices.
 12. Prospective Short Circuit Current.
 13. Surface Temperature Measurements under Load Conditions.
 14. Type Tests According to Specified Short Circuit Currents.
 15. Routine Works Tests.
 16. Functional Tests.
- F. Continuity of Circuit and Protective Conductors:
1. Confirm continuity. Use ac source or dc source.
 2. Test and confirm the electrical continuity of conduits, trunking and cable trays/ladders before installing cables.
- G. Earth Electrode Resistance:
1. To measure the resistance of an earth electrode, the test method shall be as described in BS 7430: 1991, Section 3, Part 16. Where it is not practicable to drive auxiliary earth test electrodes into the general earth mass then any known good earth may be utilized subject to agreement with the Employer.
 2. Combined resistance of earth electrodes is to be measured during dry season and checked against specified resistance.
 3. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the Employer promptly; include recommendations to reduce it.
 4. Electrical continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.
- H. Insulation Resistance:
1. Every test described in BS 7671 (IEE Regulations) Section 713-04 shall be made and proven satisfactory before the installation is permanently connected to the supply. A dc voltage not less than twice the normal voltage of the circuit concerned (rms value for an ac supply) shall be applied for the measurement of insulation resistance, provided that the test voltage need not exceed 500 V dc for installations rated up to 500 V or 1000 V dc for installations rated above 500 V up to 1000 V (All in accordance with BS 7671 IEE Regulation 713-04-04).

2. When measured between all the conductors connected to any one phase or pole of the supply and, in turn all conductors connected to each other phase or pole, the insulation resistance shall be not less than 1 Mega-Ohm. Wherever practicable, so that all parts of the wiring may be tested, all lamps shall be removed and all current using equipment shall be disconnected and all local switches controlling lamps or other equipment shall be closed.
 3. Where the removal of lamps or the disconnection of current using equipment is impracticable the local switches controlling such lamps and/or equipment shall be open. Particular attention shall be given to the presence of electronic devices connected in the installation and such devices shall be isolated so that they are not damaged by the test voltage in accordance with BS 7671 IEE Regulation 713-04-02.
 4. Where equipment is disconnected as prescribed in the BS 7671 IEE Regulations and the equipment has exposed conductive parts, the equipment shall be tested in accordance with BS 7671 IEE Regulation 713-04-06.
- I. Insulation of Site-Built Assemblies:
1. The protection against direct contact is intended to be afforded by insulation applied to live parts during erection in accordance with Regulation 412-02, it shall be verified that the insulation is capable of withstanding, without breakdown or flashover, an applied voltage test equivalent to that specified in the British Standard for similar factory-built equipment, as required by BS 7671 IEE Regulation 713-05-01.
 2. Where protection against indirect contact is provided by supplementary insulation applied to equipment during erection in accordance with BS7671 (IEE Regulation) 413-03 it shall be verified by test in accordance with IEE Regulation 713-05-02.
- J. Electrical Separation of Circuits:
1. Where BS 7671 (IEE Regulation) 413-06 and 491-12 applies, the electrical separation of the separated circuit shall be inspected and/or tested in accordance with IEE Regulation 713-06.
- K. Protection against Direct Contact by Barriers or Enclosures:
1. Where protection against direct contact is intended to be afforded by barriers or enclosures provided during erection in accordance with BS7671 (IEE Regulations) 412-03, it shall be verified by test that the enclosures or barriers afford a degree of protection not less than IP2X or IP4X as appropriate, where those regulations so require as per IEE Regulation 713-07-01.
- L. Phase Rotation and Polarity:
1. A test of phase rotation of three phase circuits and polarity of single phase circuits shall be made and it shall be verified that all 3-pole circuit breakers have the correct phase sequence, and that single pole control devices are connected in the phase conductor only, and that center contact bayonet and Edison type screw lamp holders in circuits having an earthed neutral conductor, have their outer or screwed contacts connected to that conductor, and that wiring has been correctly connected to socket outlets in accordance with IEE Regulation 713-09-01.

- M. Earth Fault Loop Impedance (ZS):
1. Earth fault loop impedance of all circuits is to be measured and checked against calculated impedance figures. Use a 5 A 50 Hz test current. Measure and record source impedance (ZE). If alternative LV supply arrangements are available, measure ZS when using supply with highest impedance.
 2. Measure ZS with main equipotential bonding conductors connected. Do not summate values of several parts of each loop.
- N. Earth Bonding of Conductive Parts:
1. Verify all necessary bonding of exposed and extraneous metalwork has been carried in accordance with BS 7671.
 2. Test conductive parts simultaneously accessible with exposed conductive parts of extraneous conductive parts. Establish that they are either not an extraneous conductive part, or that they are reliably connected by metal to main equipotential bonding.
 3. Confirm conductive parts, which are not extraneous conductive parts are separated from earth by an impedance greater than 50,000 ohms.
 4. Confirm other conductive parts are bonded to equipotential zone earth bar by an impedance not exceeding 0.1 ohms.
- O. Operation of Residual Current Operated Protective Devices:
1. Operation of residual current protective devices is to be checked. Test and verify the correct operation of all residual current operated devices.
- P. Prospective Short Circuit Current (IP):
1. Determine values of IP by measurement, unless other means are indicated. Determine IP at all necessary points within installation to confirm correct equipment selections.
 2. Obtain from supply undertaker written confirmation of maximum and minimum values of IP at origin of installation. Adjust subsequent measured values of IP accordingly.
- Q. Surface Temperature Measurements:
1. After commissioning and the project is fully functional under normal load conditions, surface temperature measurements shall be made of all switchboards, panels and bus-bar trunking. The tests shall be conducted with an approved thermo-graphic imaging meter.
- R. Type Test Certificates:
1. Submit type test certificates for all equipment manufactured to standards, which allow manufacture of type tested assemblies.
- S. Routine Works Tests:
1. Carry out routine works tests as agreed with the Employer for all equipment manufactured to standards, which require such tests to be made.
- T. Settings and Adjustments:
1. Check correct are within maximum and minimum specified tripping times.

- U. Generators (if Applicable):
1. Perform works tests on generators and provide test certificates. Comply with BS 7698 or BS EN 60034-3 as appropriate.
 2. Equipment: Inspect equipment upon delivery to Site and report any loss or damage to the Employer.
 3. Earthing resistance tests are to be carried out to verify specified requirements.
 4. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 5. 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 and pressure measurements at various locations, and in accordance with an approved plan under conditions equal to worst site ambient conditions.
 6. Tests shall include the following:
 - a. Full load test for 8 hours continuous.
 - b. Insulation measurement.
 - c. Functional tests for voltage sensing, automatic start and synchronization, transfer of load and load sharing as applicable.
 - d. Operation of engine shutdown and alarm signaling and indication, under simulated fault conditions.
 - e. Measurement of vibration transmission to building structure.
 - f. Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
 - g. Fuel tank testing.
 - h. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 7. Load Banks: If actual loads are not made available at time of acceptance, provide load banks to carry out complete test cycle of system under loading and switching conditions necessary to prove compliance with Specification.
 8. Piping System: Using carbon dioxide or nitrogen from pressurized cylinder, test each system to 1.5 times normal operating pressure. Do not subject equipment, apparatus or to pressure exceeding prescribed test pressure obtained from nameplate data or from manufacturers' published data. Apply tests before connecting piping to equipment. Remove or disconnect and blank off relief valves, instruments and devices that might be damaged by test pressure. Maintain test pressure on system for 24 hours during which time there is to be no noticeable drop in pressure. Check for leaks using soap solution. Isolate source of pressure during testing.
 9. Coordinate tests with tests for transfer switches and run them concurrently.
 10. Retest: Correct defects identified by tests and observations and retest until specified requirements are met.
 11. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

12. Test instruments shall have been calibrated within last 12 months, traceable to applicable standards, and adequate for making positive observation of test results. Make calibration records available for examination on request.
13. Commissioning:
 - a. Battery Equalization: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - b. Equipment to be certified by manufacturer or authorized representative, as inspected, tested, and commissioned.
14. Cleaning: On completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.
15. Demonstration: Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators as specified below:
 - a. Coordinate this training with that for transfer switches.
 - b. Train the Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 - c. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
 - d. Schedule training with the Employer, with at least 7-day advance notice.
 - e. Minimum Instruction Period: 8 hours.

V. LV Switchgear:

1. Perform work tests on LV switchgear in accordance with BS EN 60439-1 and provide test certificates. Inspect equipment upon delivery to Site and report any damage to the Employer.
2. Inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.
3. Adjusting: Set field-adjustable switches and circuit breaker trip ranges.
4. Cleaning: On completion of installation, inspect interior and exterior of main and distribution boards and system components. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish. Clean components internally using methods and materials recommended by manufacturer.
5. Prior to energization of circuitry, check all accessible connections to manufacturer's torque tightening specification.
6. Pre-commissioning Test Procedure:
 - a. Submit short circuit calculations and coordinated relay settings based on applicable standards from medium voltage incomer to final load.
 - b. Verify the protective device and relay settings given on the drawings, are appropriate for final system configuration and parameters based on system study. Where discrepancies are found, recommend final settings for approval before making final adjustments.
 - c. Load unbalance to be based on Supply Authority values.
 - d. Load shedding program to be developed by identifying the nonessential loads for generator or turbine loading.

7. After installation and before energizing, carry out all visual and mechanical inspection and electrical tests required by the governing codes and any other tests the Employer may require to check compliance of installation with the Specification, including, but not limited to, the following:
 - a. Insulation resistance tests for each main distribution board bus, component, connecting supply, feeder, and control circuit, using a 1000 V insulation tester (2000 Mega-Ohm range), check insulation resistance between phases, between phases and earth /enclosure and between neutral and earth.
 - b. Continuity tests of each circuit.
 - c. Operational tests.
 8. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 9. All testing shall be witnessed by the manufacturer and certified as acceptable.
 10. Main and Control Circuits:
 - a. Primary Injection Tests: Provide portable test equipment to test time-delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.
 - b. Instantaneous Trip Elements: Test by high current primary injection, using high-current primary injection test-sets and reports all readings.
 - c. Routine tests on site are to be carried out on every main distribution board in accordance with the Standard specified (IEC 60439 or BS EN 60439-1) for FBAs assembled from standardized components outside the works of the manufacturer.
 - d. Manufacturer /authorized representative shall install and certify "equipment ready for energization"
 - e. Inspections and Tests for Power Factor Correction Capacitors: Inspect and test component features, functions, operations, and protective devices according to manufacturer's instructions. Adjust system for optimum automatic power-factor correction as per Supply Authority Regulations.
 - f. Correct defects identified by tests and observations and retest until specified requirements are met.
- W. HV Power Transformers (If Applicable):
1. Perform works tests on HV power transformers in accordance with BS EN 60076 and provide test certificates.
 2. Perform all routine tests.
- X. LV Buried Cables:
1. Test continuity and insulation of buried cables immediately after back-filling.
 2. Test continuity and insulation of buried cables prior to energizing.
- Y. LV Cables:
1. Cable tests are to be carried out as per requirements of the Regulations and Standards, witness and certified by manufacturer's authorized representative.
 2. Test continuity and insulation of all cables immediately after installation.
 3. Test continuity and insulation of all cables prior to making connections.
 4. Cables shall be subjected to the test voltage as laid down in the appropriate British Standard.

5. The Contractor shall be responsible for 'ringing through' and testing all cables before finally making off ends and connecting up. The correct phase rotation of motors, etc., shall be the responsibility of the Contractor. Phase rotation tests will be carried out in the presence of the Employer and if found necessary, connections shall be changed for the correct sequence.
6. After commissioning, and the project is fully functional under normal load conditions voltage drop measurements shall be made and recorded as directed by the Employer. Any significant deviations from the calculations shall be immediately investigated and remedial measures taken.
7. Test Equipment: Provide megger testers of various ranges as applicable, and HV test equipment as necessary for testing MV installations. Use 500V megger on installations with nominal voltage up to 500V, and 1000V megger on installations with nominal voltage over 500V up to 1000V. Equipment of test shall have calibration certificate not older than 6 months on date of test.
8. Insulation resistance tests for LV power and lighting installations is to be carried out in accordance with BS 7671:2001, Clause 713-04.
9. Insulation resistance for control and signal cables is to be minimum 10000 Mega-Ohm-km for PE insulated cables and 100 Mega-Ohm-km for PVC insulated cables, all measured core-core and core-earth, in accordance with the Regulations.
10. Prior to energization of circuitry, check installed wires and cables with mega-Ohm meter to determine insulation resistance levels to ensure requirements are fulfilled.
11. Prior to energization, test wires and cables for electrical continuity and for short-circuits.
12. The Works tests shall include all routine electronic, electrical and mechanical tests when relevant in accordance with the appropriate IEC Standard, and in addition any tests called for by Supply authority, Owner and the Specification to ensure that the individual plant or equipment being supplied meets the requirements of the Specification.
13. Acceptance tests during inspection by the Employer in the works of manufacturer, shall comprise all the routine tests specified for the items, under inspection on samples, which will be selected by the Employer. In addition, any of the specified type tests may be required to be carried out in his presence, if satisfactory evidence of carrying out such tests is not available.
14. However, these tests need not be repeated if the manufacturer submits satisfactory tests reports, certificate, acceptable to the Employer, on tests conducted previously on identical cables.
15. Auxiliary Power and Control Cables:
 - a. Routine Tests: In accordance with IEC 60227, or BS 6346:1969, or BS 5467 and subject to approval of the Employer.
 - b. Tests at Site: Voltage test to BS 6346 Appendix B6, or alternatively cables may be tested with a 2000 V Megger insulation tester.
16. Tests at Manufacturer's Works: In the presence of the Employer, the cables shall be tested as specified below:
 - a. Provide Type test certificates for each type and size of cable during first consignment inspection of that particular cable. All the type tests specified in IEC 60502-1 as applicable to XLPE insulated cables of 0.6/1.0 kV rated voltage shall be carried out. Type of tests shall include both electrical and non-electrical tests.

- b. Routine tests shall be conducted on one sample per 10 km length of cable but limited to a minimum of 2 cable drums and maximum of 8 cable drums per consignment of each type and size of cable. All the routine tests specified in IEC 60502-1 as applicable to 0.6/1.0 kV, XLPE insulated cables shall be carried out.
- c. Special tests shall be conducted on one sample per 10 km length of cable but limited to minimum 2 samples and maximum 4 samples per consignment of each type and size of cable.
 - 1) All the special tests specified in IEC 60502-1 as applicable to XLPE insulated 0.6/1.0 kV cables shall be carried out.
 - 2) In addition to the above special tests armor wire test for armored cables shall be carried out on samples of galvanized steel armor wires for tensile strength in accordance with BS EN 1057: Part 1, uniformity of mass of zinc coating in accordance with BS EN 10244: Part 2 and for armor resistance in accordance approved standards.

Z. Lightning Protection Installations:

- 1. Carry out site testing and inspection and provide test certificates for lightning protection installations in accordance with BS 6651.
- 2. Materials used shall be certified; certification shall be submitted in original.

1.7 CALIBRATION

- A. Provide current certificates of calibration for all instruments used during test procedures. Record particular instrument identity on record sheets.

1.8 COMMISSIONING TEST PROCEDURE

- A. After completion of the pre-commissioning testing the next phase of commissioning, which includes energizing the systems and performing live operational and performance testing shall be commenced according to a programme agreed by the Employer.
- B. The sequence of energizing and testing shall be as follows, each succeeding step shall only be carried out when the preceding tests have been satisfactorily completed and recorded to the Employer's satisfaction. Where required portable load banks shall be used to simulate full load conditions.
 - 1. Provide attendance during the energizing of the incoming supply by the supply authority, which should be done with the main LV incoming circuit breakers locked in the OFF position. After the supply is energized test the incoming voltage and phase sequence with a calibrated test meter and confirm the circuit breaker instruments give accurate readings. Perform functional checks on the circuit breakers to ensure all controls and interlocks are fully functional.
 - 2. After satisfactory testing of the main LV incoming circuit breakers, each Main LV switchboard may be energized in turn, with all outgoing switches and bus-couplers in the open position. Test the busbar voltage and phase sequence with a calibrated test meter and perform functional tests on instruments and control devices.

3. Each outgoing circuit shall be individually energized with the isolator/circuit breaker at the remote end in the open position. Test the circuit voltage and phase sequence with a calibrated test meter.
4. The sub-panels/distribution boards/equipment fed by each main panel outgoing circuit shall be individually energized with all outgoing switches/circuit breakers in the open position. Test the busbar voltage and phase sequence with a calibrated test meter. Following this each outgoing final circuit shall be individually energized with the isolator/circuit breaker at the remote end in the open position. Test the circuit voltage and phase sequence with a calibrated test meter and perform functional tests on any instruments and control devices.
5. Test incoming voltage and phase sequence at the remote end of each final circuit or at equipment, which is fed from this circuit. Test and commission lighting and small power systems including ELCB's, etc.
6. After completion of the commissioning tests on the LV distribution, lighting and small power systems begin the next phase of commissioning the other sub-systems and/or equipment including mechanical and low current systems. This step shall be done in coordination with the mechanical commissioning engineer and any other specialist involved with other systems.

1.9 POST COMMISSIONING TEST PROCEDURE

- A. Following complete commissioning of all the electrical, low current and mechanical systems with all systems fully operational to establish normal full load conditions, conduct the following performance tests.
- B. Monitor and record the voltages, load currents, kW, kVA on all transformers, switchboards, distribution boards and MCC's under full load conditions and account for any significant deviations from the design calculations.
- C. Monitor and record surface temperatures of switchboards, distribution boards, MCC's, motor starters and busbars and verify these are within design limits.
- D. Monitor and record the harmonic currents and voltages at the main incoming LV circuit breakers and verify these are within the specified limits.

1.10 CERTIFICATION AND REPORTING

- A. Provide a complete set of Inspection and test Certificates and calculations in accordance with BS 7671 Appendix 6 and as required for the testing and commissioning of all specialist sub-systems.

1.11 OTHER TESTS OF SPECIALIST INSTALLATIONS

- A. Carry out site testing, inspection and commissioning and provide test certificates for the following systems.
 1. Street lighting.
 2. Lighting/emergency lighting systems.
 3. Telecommunications.
- B. Provide testing formats for all other systems and obtain Employer's approval.

- C. Lighting/Emergency Lighting Installations:
1. Carry out site testing and inspection and provide test certificates for emergency lighting installations in accordance with BS 5266.
 2. Visual inspection is to include inspection of condition of each piece of equipment, quality of workmanship, alignment, perpendicularity, labeling and the like, all in conformance with the specification. Replace damaged fixtures and components.
 3. Insulation resistance and continuity tests are to be carried out on each circuit and piece of equipment before energization, with circuit breakers in the open position and lamps not installed.
 4. Operational tests are to be carried out on all circuit breakers and control gear, with lamps installed, including recording voltage at terminals of ballasts on final columns of each circuit and at distribution panel or the like.
 5. Performance tests are to be carried out after 100 hours normal operation, and are to include measurement of lighting and uniformity levels on required illuminated surfaces.
 6. Other tests are to be carried out as required by the Employer to verify conformity with the Specifications.
 7. Results of tests are to be recorded on site and signed by witnessing parties.
 8. Provide calibrated instruments to make and record test results. Calibration should be valid for 1 year after taking-over (handing over) the works.
 9. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:
 - a. Measure light intensities at night to confirm specific illumination performance as indicated. Use calibrated photometers.
 - b. Check intensity and uniformity of illumination.
 - c. Check excessively noisy ballasts.
 - d. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation. Verify normal transfer to battery source and retransfer to normal.
 - e. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.
 - f. Corrosive Fixtures: Replace during warranty period or effect liability period whichever is later.
 10. Electrical Data: Measure power factor, current and voltage at start for installations with discharge lamps.
 11. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results. Lighting fixture manufacturer/authorized representative to inspect, witness site test and certify the results of tests report.
 12. Cleaning and Adjusting:
 - a. Clean units after installation. Use methods and materials recommended by manufacturer.
 - b. Adjust luminaires and luminaires with adjustable lamp positions to provide required light distributions and intensities.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

Not Applicable.

END OF SECTION

SECTION 16081
ELECTRICAL TESTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SUMMARY

- A. Provide labor, materials, temporary wiring, testing equipment, technical supervision and services, and perform operations required for testing of electrical equipment and installations and related work as specified herein and as shown on the drawings.
- B. Work Included: The work shall include, but not be limited to, the following:
 - 1. Preliminary inspections and tests.
 - 2. Electrical acceptance tests.
 - 3. Operational tests.
- C. Related Work Specified Elsewhere.
 - 1. Section 16010 - General Electrical Requirements.

1.3 DESCRIPTION

- A. Preliminary testing and visual inspections shall be conducted prior to acceptance and operational tests to avoid delays.
- B. Electrical acceptance tests shall be conducted to assure that electrical materials, and their installations are in accordance with contract documents, regulatory agencies, applicable codes and standards listed herein, and that they may be energized.
- C. Operational tests shall be conducted to assure capability of equipment and systems to perform as specified and designed.

1.4 QUALITY ASSURANCE

- A. Testing and testing equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.
- B. Contractor shall furnish testing equipment as required. Testing equipment, meters and instruments shall have been properly calibrated and certified within six (6) months prior to testing and shall be in satisfactory condition to perform its functions.
- C. Contractor shall provide an appropriate and stable source of electrical power to the test locations.
- D. Perform tests in the presence of the Employer's Representative.

- E. Electrical equipment and installation shall meet acceptance and operational tests. Promptly repair or replace defective work and repeat the tests until the particular system and component parts thereof receive the approval of the Engineer. Any damages resulting from tests shall be repaired and/or damaged materials replaced, to the satisfaction of the Engineer.
- F. It is essential that certain trades and manufacturer's technical representatives be present during the testing. These representatives shall include:
 - 1. Electrical subcontractor who is thoroughly familiar with the project as to its intent, what equipment has been provided and how it is supposed to operate.
 - 2. Supplier of equipment particularly where packaged equipment has been provided.
 - 3. Manufacturer's representative who is thoroughly familiar with the operation of the equipment.

1.5 SCHEDULING

- A. Scheduling of tests shall be as approved by the Engineer.
- B. Schedule tests so that equipment can be energized immediately after completing the tests and approval of the reports.

1.6 SUBMITTALS

- A. Submit the following in accordance with the requirements specified under "Submittals" in Section 16010.
- B. Submit two (2) copies of test reports including actual readings and corrected readings after each test period.
- C. Submit four (4) bound copies of final approved test reports at the completion of tests.
- D. Test reports shall be signed by the persons performing the tests and the witnesses to the tests.
- E. Include copies of the final approved test reports in the maintenance manuals.

PART 2 PRODUCTS

- A. Not Applicable

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. 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. Equipment shall be thoroughly cleaned prior to testing. Vacuum the interiors of cubicles and remove foreign material. Insulators, bushings and bus supports shall be wiped clean with a lint free cloth.
- D. Preliminary tests and visual inspections of the electrical installation including verification checks of factory wiring shall be conducted prior to electrical acceptance and operational tests to avoid delays, and to assure that equipment and installations are free of faulty conditions prior to the application of test voltages.
- E. Where the equipment or system under test is interrelated with and depends upon other equipment, systems and/or controls for proper operation, functioning and performance, the latter shall be operated simultaneously with the equipment or system under test.
- F. Test fuses for continuity.

3.3 APPLICATION

- A. Equipment that can be paralleled under any conditions including interlock defeat shall be tested for proper phasing using hot-phase hot-stick or other approved methods. This includes, but is not limited to, primary selector switches, automatic transfer switches, tie breakers and busses, etc. at medium and low voltage levels.
- B. Full load currents of feeders serving single-phase loads shall be measured to assure an equal load balance on each phase. Branch circuits shall be reconnected if necessary to achieve this balance.

3.4 TESTS

- A. Low Voltage Wires and Cables:
 - 1. Wires and cables shall be tested for continuity, freedom from short circuits and grounds and meggered to assure adequate insulation resistances for each conductor.
- B. Switchboards:
 - 1. Test electrical and mechanical interlock systems for proper operation and sequencing.
 - 2. Test earth connections as specified under "Earthing System".
 - 3. Perform ratio and polarity tests on instrument current and potential transformers.
 - 4. Test disconnect switches.
 - 5. Tests of relays associated with the distribution system shall include the following:

6. Control and instrument switch test shall include the following:
 - a. Inspect contacts and shunts, cleaning contacts if required.
 - b. Operate switch and note that design functions are performed in proper sequence.
 7. Ammeters shall be tested as follows:
 - a. Check connections from current transformers for AC shunts for DC to ammeters.
 - b. Check ammeter scale with current transformer ratio for AC and shunt millivolt rating for DC.
 - c. Set pointer on zero scale with no load.
 8. Wattmeter and watthour meter tests shall include the following:
 - a. Check with current transformer and potential transformers ratio.
 - b. Set wattmeter pointer on zero scale with no load.
 - c. Check rotation on watthour meter.
 9. Tests of instrument transformers shall include the following:
 - a. Physically check polarity mark orientation on CTs and PTs with three line diagram on the drawings and with manufacturer's drawings.
 - b. Check CT and PT polarity markings.
 10. Electrical controls shall be tested by trial operation of control equipment after wiring is completed to see that each interlock and control function operates according to the manufacturer's operating instructions.
- C. Lighting Switches: Test lighting switches for correct operation as directed by the Engineer.
- D. Lighting Fixtures: Verify proper operation of lighting fixtures.
- E. UPS:
1. All routine tests specified in IEC 146-4 must be carried out, together with tests listed below, both at the factory testing and on site.
 - a. Synchronization.
 - b. Rates stored energy.
 - c. Rates restored energy.
 - d. Overload capacity.
 - e. Restart.
 - f. Audible noise.
 - g. Earth fault test.
 - h. Full load test.
 2. Factory and on-site test
 - a. Checking and verifying
 - 1) Output voltages.
 - 2) Output frequency.
 - 3) Output current.
 - 4) Harmonic output and total harmonic distortion (THD).
 - 5) Ripple factor.
 - 6) Operation of controls, alarm.
- F. Fire Alarm System:
1. Provide the services of a factory-authorized service representative to supervise the field system pretesting, testing, adjustment and programming.

2. Pretesting: Upon completing installation of the system, align and adjust the system and perform pretesting. Determine, through pretesting, the conformance of the system to the requirements of the drawings and specifications. Correct deficiencies by replacing malfunctioning or damaged items with new items and retest until satisfactory performance and conditions are achieved.
 3. Testing: Perform electrical and mechanical tests required by the equipment manufacturer's certification form. In addition, measure and adjust each of the ionization detectors to the maximum stable sensitivity setting. All testing shall be as directed by the Engineer.
- G. Extra Low Voltage Systems:
1. The complete installation shall be inspected to ensure the work has been carried out satisfactory manner and that the methods comply with the manufacturer's recommendations.
 2. A functional test of the installation shall be made to ensure that the installation will give satisfactory service under all conditions likely to be experienced.
- H. As Built Drawings: After completion of the tests and adjustments listed above, submit the following information to the Engineer:
1. "As-built" conduit layout diagrams including wire color code and/or tag number.
 2. "As-built" wiring diagrams.
 3. Detailed catalog data on installed system components.
 4. Copy of the test report.

END OF SECTION

SECTION 16110

CONDUITS AND WIREWAYS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Work is deemed to include:
 1. Heavy gauge PVC rigid conduits.
 2. Heavy gauge steel conduits and flexible steel conduits.
 3. Cable trays and cable ladders.
 4. Mounting fitting, fixing, etc.
 5. Cutting and jointing, bending, etc.
 6. Junction boxes, expansion joints connectors, etc.
 7. Components for earth continuity.

1.3 SUBMITTALS

- A. The following data (but not limited to) shall be submitted for approval:
 1. Manufacturers catalogue with specifications.
 2. Samples.
 3. Shop drawings showing the exact routing of conduits, cable trays, boxes and accessories with their types and dimensions.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

- A. PVC Rigid Conduits:
 1. DIETZEL (AUSTRIA)
 2. UNIVOLT (AUSTRIA)
 3. DECODUCT (UAE)
 4. Or other equal approved.
- B. Steel Conduits:
 1. WHEATHLAND (USA)
 2. Or other equal approved.
- C. Cable Trays and Cable Ladders:
 1. SWIFTS (ENGLAND)
 2. MECAFABLON (FRANCE)
 3. CES (FRANCE)
 4. KRIEG & ZIVY (FRANCE)
 5. Or other equal approved.

2.2 RIGID HEAVY GAUGE PVC CONDUITS AND FITTINGS

- A. All PVC conduits shall be Rigid Conduits complying with BS 6099-2-2 / IEC 614-2-2 heavy gauge in all respects, and may be used where ambient temperatures do not exceed 75°C.
- B. All conduit fittings shall confirm to BS 6099-2-2 / IEC 614-2-2 Standards and BS 4607 Part 5.
- C. They shall be of the Heavy Duty, high impact type, non-hygroscopic self-extinguishing and suitable for installation, storage or transport at extreme temperatures.
- D. They shall be so designed that a reliable watertight joint can be made between conduit and fittings. Vinyl solvent cement shall be used for permanent joints and a cement of non-hardening type shall be used for expansion couplers (for surface installations).
- E. No conduit shall be less than 20mm diameter.
- F. The rigid PVC conduits for embedded installation shall be manufactured and tested in accordance with IEC 423; 614-1 and 614-2-2 and European Norm EN-500 86-2-1.
- G. They shall be made of polyvinyl chloride having the following characteristics:
 - Temperature resistance: min - 15°C and max 60°C.
 - Compressive strength: 1250 N.
 - Mechanical impact strength: 6 J (IK07).
 - External approved diameter 20mm, 25mm, 32mm and 40mm.
- H. The methods used for making conduit bends, conduit joints, fixing conduit to boxes without spouts, also the tools and materials to be used, shall be as recommended by the conduit manufacturer. Special adapters for use in joining rigid PVC conduits in metric sizes to conduit fittings in imperial sizes shall also be of rigid PVC.
- I. All conduit boxes shall be of rigid PVC with dimensions suitable for fixing switches, sockets, etc..., as specified elsewhere and shall be provided with tapped brass inserts for fixing screws and provision for an earthing terminal.
- J. Where conduit boxes are used for the suspension of lighting fittings; they shall be provided with external metal fixing lugs riveted to the brass inserts. (This requirement applies to both surface mounted and concealed boxes).
- K. Conduit boxes shall be of the circular pattern with appropriate spout entries and 50.8mm accessory fixing centers.
- L. All connections and terminations shall be by means of a manufacturer's standard adapter.

- M. All boxes shall have brass thread inserts for the fixing of accessories or covers. However, care must be taken in the support of totally enclosed lighting fittings. Where excessive temperatures are likely to occur special insulated boxes shall be used, i.e. of a pattern specifically designated by the manufacturer to improve weight-loading characteristics at high temperatures.
- N. All tees shall be made using conduit tee boxes. Tangential entry boxes shall be used where appropriate. Multiple conduits may necessitate the use of large U.P.V.C. adaptable boxes for junctions.
- O. All saddles shall be of the spacer bar type and from the same manufacturer as that of the conduit which they are being used to secure.
- P. A tapped earth terminal shall be provided in every conduit box.
- Q. All wall mounted accessory boxes shall have one adjustable fixing lug to facilitate final leveling of accessories. In order to facilitate interchangeability and to eliminate problems of differential manufacturing tolerances, it is essential that all PVC conduit and appropriate accessories covered by these specifications shall be obtained from the same manufacturer.
- R. Flexible conduits of same material are to be used for connection to motors and to fixtures installed in false ceiling.

2.3 RIGID HEAVY GAUGE STEEL CONDUITS AND FITTINGS

- A. Conduits and fittings shall be of heavy gauge drawn and welded steel, screwed galvanized and not less than 20 mm external diameter.
- B. Conduits shall be free from rust patches or mechanical damage and shall be adequate protected from damage whilst stored on site. All exposed threads, die marks and other abrasions shall be painted with two coats of an approved metallic paint immediately the conduit is installed.
- C. Steel conduits and fittings shall comply with BS 4568 part 2.
- D. Application:
 - 1. In mechanical rooms, pump room and electrical rooms (if exposed installations).
 - 2. In exposed area subject to physical damage.
 - 3. In areas under renovation.

2.4 FLEXIBLE STEEL CONDUITS

- A. Flexible conduits and assemblies are to be made from galvanized steel to BS 731.
- B. Where exposed to moisture conditions, conduits are to have PVC sheath.
- C. Application: For final connection of the rigid steel conduit to the terminal boxes of machines and/or where vibration is likely to occur.

2.5 CABLE TRAYS

- A. Heavy-duty cable trays shall be of the return flange type slotted and perforated. Trays shall be Hot-dip galvanized after perforation protected by two pack epoxy finish, minimum 1.5mm thick (galvanizing in accordance with BS 729). Trays shall be jointed with flange coupling strops that virtually make the flanges continuous. These shall be secured in place with nuts and bolts.
- B. All cable tray runs shall be continuous and constructed of bends, tees, elbows, adjustable connectors, reducers, risers and other accessories that are purpose made of same materials and finishes as cable tray and by the same manufacturer of cable tray.
- C. Cable tray shall have adequate mechanical strength for the load to be carried and shall have provision for the addition of a minimum of 20% of the initial installed cable and/or load. The deflection shall not exceed that recommended by the manufacturers.
- D. The cable trays shall have engraving marks of the serial and identification numbers.
- E. Cable tray with cover: The cover shall be made of same materials and finishes and by the same manufacturer of cable tray.

2.6 CABLE LADDER

- A. Cable ladder shall be constructed in mild steel galvanized after perforation and protected with a two pack epoxy finish (galvanizing in accordance with BS729).
- B. All cable ladders shall have sufficient strength and space allowance to accommodate the future installation of an addition of 25% of the initially installed load.
- C. Cable ladders shall not be used with greater loading or spans than those recommended by the manufacturers.
- D. All bends, tees or other accessories shall be purpose made by the manufacturer of the cable ladder.
- E. Application: Vertical mounting for installation of cable in shaft.

PART 3 EXECUTION

3.1 INSTALLATION - CONDUITS

- A. The installation and capacity of the conduits shall be in accordance with the IEE Wiring Regulations.
- B. The installation shall be neat and tidy.
- C. Means shall be provided to prevent condensed or entrapped moisture remaining within the conduit system.
- D. The conduit system, joint boxes, loop boxes etc. shall be firmly supported.

- E. The system shall be clean and free of sharp edges, burrs etc.
- F. Due allowance shall be made for expansion and contraction.
- G. PVC rigid conduit to be formed on site. Prefabricated conduits shall not be accepted.
- H. Standard circular or looping in boxes shall be installed at intersections. Small circular channel type inspection fittings will not be approved.
- I. Cables connected to different category circuits shall not be run thru a common box.
- J. Standard conduit boxes shall be installed at all lighting points and shall be substantially fixed so as to be supported independent of the conduit system. Conduits shall terminate directly into fixed lighting fittings having provision for direct conduit entry.
- K. Conduit shall be installed at least 100 mm clear of, and preferably above, pipes and any other services.
- L. Under no circumstances shall accessories of one conduit system type be used with another type (e.g. black accessories may not be used with galvanized conduit).
- M. Not more than two right angle bends shall be allowed in any surface mounted conduit run without provision of an inspection fitting for drawing in purposes between them.
- N. Surface mounted Conduits shall not be dismantled for wiring, and must be capable of being wired complete without draw wires being installed during erection.
- O. Sleeves for cable must be filled with a fire retardant compound to prevent fire spread from one compartment to another.
- P. Conduits specified to run on the surface shall be fixed by means of galvanized distance saddles to allow a 5mm space between the surface and the conduit.
- Q. Spacing of saddles for supporting of surface mounted PVC conduits is not to be greater than:

<u>Conduits size (mm)</u>	<u>Maximum spacing of supports (m)</u>
20	0.60
25-50	0.75
63-75	0.90
90-125	1.00

- R. Spacing of saddles for supporting of surface mounted steel conduits is not to be greater than:

<u>Conduits size (mm)</u>	<u>Maximum spacing of supports (m)</u>
20	3.00
25	3.60
32-38	4.25
50-63	5.00
75 & larger	6.00

- S. Sizes of conduits not shown on the drawings are to be selected in accordance with the regulations and in relation to number and size of conductors as shown in table below:

Number of Conductors Relating to Exterior Diameters of Conduits									
A	B			C			D		
	20	25	32	20	25	32	20	25	32
1.5	7	7	7	7	7	7	6	7	7
2.5	7	7	7	6	7	7	4	7	7
4.0	5	7	7	4	7	7	3	6	7
6.0	4	7	7	3	6	7	0	4	7
10	0	4	7	0	3	6	0	0	4
A: Section of Conductors (mm ²)									
B: Straight Run									
C: Run with One Bend									
D: Run with Two Bends									
Minimum size of conduit is to be 20mm (external diameter), unless otherwise stated.									

3.2 INSTALLATION - CABLE TRAYS AND CABLE LADDERS

- A. Install cable tray level and plumb according to manufacturer's written instructions,
- B. Coordination Drawings, original design, and referenced standards.
- C. Remove burrs and sharp edges from cable trays.
- D. Fasten cable tray supports securely to building structure as specified in Division 16 Section "Basic Electrical Materials and Methods," unless otherwise indicated.
- E. Locate and install supports according to BS/EN Code and IEE regulations.
- F. Design supports, including fastenings to the structure, to carry the greater of the calculated load multiplied by a safety factor of 4 or the calculated load plus 200 lb (90 kg).
- G. Make connections to equipment with flanged fittings fastened to cable tray and to equipment.
- H. Support cable tray independently of fittings. Do not carry weight of cable tray on equipment enclosure.
- I. Install expansion connectors where cable tray crosses a building expansion joint and in cable tray runs that exceed 90 feet (27m). Space connectors and set gaps according to BS/EN Code and IEE regulations.
- J. Make changes in direction and elevation using standard fittings.
- K. Make cable tray connections using standard fittings.
- L. Locate cable tray above piping, unless accessibility to cable tray is required or unless otherwise indicated.

- M. Sleeves for Future Cables: Install capped sleeves for future cables through fire stopping sealed cable tray penetrations of fire and smoke barriers.
- N. Workspace: Install cable trays with sufficient space to permit access for installing cables.
- O. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels.
- P. Install covers after installation of cable is completed.
- Q. Locate cable tray above piping, unless accessibility to cable tray is required or unless otherwise indicated. Cable trays and ladders are to be earthen at maximum spacing of 30m, by a cable of 16mm² section.

3.3 WARNING SIGNS

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

3.4 FIELD QUALITY CONTROL

- A. Earthing: Test cable trays to ensure electrical continuity of bonding and earthing connections.
- B. Anchorage: Test pullout resistance for toggle bolts and powder-driven threaded studs for each type and size of anchorage material.
 - Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales, required for reliable testing.
 - Obtain Architect's approval before transmitting loads to the structure. Test to 90% of rated proof load for fastener.
- C. Replace malfunctioning units.

3.5 CLEANING

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

3.6 PROTECTION

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

Completion.

- Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

3.7 SHOP AND CONSTRUCTION DRAWINGS

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

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

B. Coordination Drawings: Include floor drawings and sections drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural and mechanical elements.

C. Design Calculations: Verify loading capacities for supports.

END OF SECTION

SECTION 16120

WIRES, CABLES AND FEEDERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Work is deemed to include:
 - 1. Low voltage power cables.
 - 2. Branch circuit wiring.
 - 3. Control cables.
 - 4. Telephone and data cables.
 - 5. Electrical submersible cables.
 - 6. Termination and identification requirements.
- B. The Contractor shall be responsible for all off loading and handling of cable on site and shall ensure that cables are delivered to site on drums properly protected against mechanical damage.
- C. The Contractor shall be responsible for finally checking the sizes of all cables to suit the load. The sizes of the cables and conductors shall take into account voltage drops, fault levels, over current setting of relays, route length, derating factors, method of laying and ambient conditions.

1.3 SUBMITTALS

- A. The following data (but not limited to) shall be submitted for approval:
 - 1. Full details, catalogues and manufacturer data.
 - 2. Samples.
 - 3. Shop drawings showing exact routing of feeders, sub-feeders, number and size of conductors in conduits, details of supports, details of connection, etc.
 - 4. List of feeders & sub-feeders with their sizes, route length, voltage drops, etc.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

- A. LIBAN CABLES (LEBANON)
- B. BICC (ENGLAND)
- C. PIRELLI (FRANCE)
- D. Or other equal approved.

2.2 MATERIALS

- A. Cables shall have stranded copper conductors for sections 4mm² for power cables and 1.5mm² for control cables.
- B. Cables shall be manufactured to IEC 502.
- C. Cable cores shall be color coded for identification.
 - 1. "Red", "Yellow" and "Blue" shall be used for phase conductors.
 - 2. "Black" for neutral.
 - 3. "Green / Yellow" for earth conductors.
- D. Single conductor wires and cables for wiring and conduits are to have high conductivity, electrolytic annealed copper conductors insulated with PVC flame retardant, rated 450/750 V to IEC 227 and suitable for conductor temperature of 70°C.
- E. PVC insulated cables are to have high conductivity electrolytic annealed copper conductors insulated with PVC flame retardant suitable for conductor temperature of 70°C, bedded with suitable filler and sheathed with PVC. Cables are rated 0.6/1 kV.
- F. Fire resistant power cables are to have plain annealed copper stranded conductors, insulated with a mineral ceramic fire resistant tapes and a 90°C, cross-linked insulation, bedded with an extruded of steel wires and sheathed with a low smoke free halogen sheath. Fire resistant cables shall be rated 0.6 / 1 kV French Norm CR1 Category or in accordance to BS 6387 Cat C W Z.
- G. Control cables are to be multicore, PVC insulated and sheathed, rated 0.6/1 kV. Insulated conductors are to be numbered.
- H. Sheathed and insulated flexible cords shall be 300/500V rated to IEC 227 and shall only be used for lighting pendants.
- I. The minimum cross sectional area of conductors in flexible cords shall be 0.75mm² and the length not exceeding 400mm.
- J. Two pair telephone cables for wiring to telephone outlets shall be twisted PVC insulated and PVC sheathed 0.6mm diameter. Data transmission cables shall be 4 pairs unshielded twisted pairs (UTP) category 6. RJ45 voice/data outlets horizontal cabling shall be UTP cat 6 unless otherwise shown on drawings.
- K. Electrical Submersible Cables:
 - 1. General: Submersible non-clog pumps, each equipped with submersible electric motor. Furnish a power and signal hypalon jacketed type SPC cable.
 - 2. Cable Entry Seal:
 - a. Design cable entry water seal of single cylindrical elastomer grommet, flanked by stainless steel washers, with close tolerance fit against cable outside diameter and entry inside diameter and compressed by entry body containing strain relief function, separate from function of sealing cable.
 - b. Bear assembly against shoulder in pump top.

- c. Separate cable entry junction chamber and motor by stator lead sealing gland or terminal board that isolates motor interior from foreign material gaining access through pump top.

2.3 SINGLE CORE PVC INSULATED AND SHEATHED CABLES

- A. This type of cable shall be 600/1000V grade, complying with BS 6346 and shall have stranded conductors of plain annealed copper wires.
- B. The conductor shall be PVC insulated.
- C. Over the insulated conductor an outer protecting layer of extruded PVC layer shall be applied.

2.4 SINGLE CORE XLPE INSULATED AND PVC SHEATHED CABLES

- A. This type of cable shall be 600/1000V grade, complying with BS 5467 and shall have stranded conductors of plain annealed copper wires.
- B. The conductor shall be XLPE insulated.
- C. Over the insulated conductor an outer protecting layer of extruded PVC layer shall be applied.

2.5 MULTICORE PVC/PVC 600/1000 V NON-ARMoured CABLES

- A. This type of cable shall be 600/1000V grade complying with BS 6346. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be PVC insulated and the cores insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. A black outer protecting layer of extruded PVC shall be applied over the bedded cables.

2.6 MULTICORE PVC/SWA/PVC 600/1000V ARMoured CABLES

- A. This type of cable shall be 600/1000 grade complying with BS 6346, multicore. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be PVC insulated and the cores insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. Over the bedding is helically applied a layer of galvanized steel wires in such a way to form a continuous metallic protecting cover.

- E. Over the armored cable, an outer black protection layer of extruded PVC shall be applied.
- F. A single core cable shall have aluminum wire armor.

2.7 MULTICORE XLPE/PVC 600/1000V NON-ARMOURED CABLES

- A. This type of cable shall be 600/1000V grade complying with BS 5467, multicore. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be XLPE insulated and the core insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. A black outer protecting layer of extended PVC shall be applied over the bedded cables.

2.8 MULTICORE XLPE/SWA/PVC 600/1000V ARMOURED CABLES

- A. This type of cable shall be 600/1000 grade complying with BS 5467, multicore. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be XLPE insulated and the cores insulation shall be colored for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. Over the bedding is helically applied a layer of galvanized steel wires in such a way to form a continuous metallic protecting cover.
- E. Over the armored cable, an outer black protection layer of extruded PVC shall be applied.
- F. A single core cable shall have aluminum wire armor.

2.9 SINGLE CORE PVC CABLES

- A. Cables shall comply with BS 6004, IEC 60227 and be rated at 450/750V.
- B. The insulation shall be PVC phase colored.

2.10 SIGNAL AND INSTRUMENTATION CABLES

- A. Instrumentation cables unless otherwise indicated, shall be rated 300/500 V and comply with BS 5308 type 2.
- B. Cables shall be PVC or polyethylene insulated twisted pair with individual or collective metallic foil screen, tape bound with extruded PVC bedding, galvanized

steel wire armouring and coloured overall PVC sheath. Conductors shall be multistrand copper, 24/0.2 mm (0.75 mm²) or as indicated.

1. Collection screened cables shall be used only with measuring transmitters and analogue controllers (4-20 m Adc) up to 30 m route length.
2. Individual and collective screened cables shall be used:
 - a. For circuits as in (1) but exceeding 30 m route length and for inputs to data loggers, telemetry systems, microprocessors, computer, also cable to transducers.

2.11 DATA TRANSMISSION CABLES

- A. Defined as extra low voltage, digital signaling cables between computers, programmable logic controllers (PLCS) and remote telemetry units (RTUS) and other data transmission equipment.
- B. The minimum cross sectional area of cable conductors shall be 0.5 mm².
- C. The following types of cable may be used unless otherwise indicated:
 1. Those complying with BS 5308: Parts 1 & 2;
 2. UTP Category 5; and
 3. Those specified by the equipment manufacturer.
- D. PE or PVC/IS (individually screened)/SWA/PVC and PE or PVC/CS (Collectively Screened)/SWA/PVC (Multi-pair).
 1. PE insulated cables shall comply with BS 5308: Part 2 (type 2), with each core identified according to table 12, Appendix A.
 2. PVC insulated cables shall comply with BS 5308: Part 1 (type 2), with each core identified according to table 11, Appendix A.
 3. Cables shall have stranded, copper conductors.
- E. PE or PVC/IS/PVC and PE or PVC/CS/PVC (multi-pair)
 1. PE insulated cables shall comply with BS 5308: Part 1 (type 1), with each core identified according to table 12, Appendix A.
 2. PVC insulated cables shall comply with BS 5308: Part 2 (type 1), with each core identified according to table 11, Appendix A.
 3. Cables shall have stranded, copper conductors.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install work in accordance with approved standards, as per manufacturer's recommendations, and to the satisfaction of the Engineer.
- B. Conduit wiring system shall be used for final branch circuit wiring.
- C. Wiring termination and joints shall be made only at switches, isolators and appliance fittings.
- D. Installation of each conductor is to be color-coded. Contractor has to maintain coding throughout the installation.

- E. Before any cables are installed, the conduit installation and erection of distribution boards shall be complete, dry, clean and free of burns.
- F. Cables required to be run on walls, ceilings, or other structures should be carried on cable trays or cable ladders.
- G. All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Allowance shall be made for expansion and contraction of the cable.
- H. The Contractor shall take all precautions to ensure that cables are not subjected to excess heating from adjacent service pipes.
- I. Where cables are routed externally and are subject to exposure to direct sunlight, they shall be protected with a suitably ventilated cover to shade the cables and to allow adequate ventilation. Where changes in direction occur in cable runs, bends having a radius of curvature not less than the minimum-bending radius recommended by the manufacturer shall be used.
- J. All cables run between defined terminal points shall be installed without intermediate joints.
- K. Every cable shall be permanently identified using purpose made indelible markers.
- L. Single cables are to be fixed directly to walls or ceilings. Where three or more cables are run in parallel, they are to be fixed on cable trays.
- M. Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Each cable entry into a terminal box shall be made through a suitable gland.
- N. At terminations the cores of the cables shall be left of sufficient length beyond the termination to form cable tails for connecting to the equipment. Tools shall be adequately insulated and end cable core shall have its phase identification clearly marked.
- O. A sufficient number of terminals shall be provided to terminate all control cable cores.
- P. Terminal blocks for different voltage or circuits type should be segregated into groups and distinctively labeled.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Work is deemed to include:
1. Supply and installation of electrical fittings including switches, automatic and manual lighting control equipment, sockets, disconnecting switches, etc., as shown on the drawings.
 2. Wiring devices are deemed to include outlets, wires with protective earthing conductors, conduits, trunking, and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches, etc.), or to final branch circuit panelboard.
 3. Fixing and supporting material.
 4. Cables, conduits and fittings from telephone or data outlet to telephone/data distribution frame/ telephone box.
- B. All devices are to be standard manufactured items, uniform and modular.

1.3 SUBMITTALS

- A. The following data (but not limited to) shall be submitted for approval:
1. Manufacturer's catalogue cut with complete detailed specifications, catalogue number, rating, overall dimensions, etc.
 2. Shop and construction drawings showing exact location of each outlet box, installation details, wiring diagrams, etc.
 3. Samples along with material approval requests.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

- A. LEGRAND (FRANCE)
- B. TICINO (ITALY)
- C. GIRA (GERMANY)
- D. GEWISS (ITALY)
- E. Or other equal approved.

2.2 OUTLET BOXES

- A. Boxes and covers are to be made of heavy gauge pressure moulded plastic and to be manufactured for required application. Boxes to have brass threads for cover screws fixing. Provision for securely terminating conduits are to be provided.
- B. Cover plates to be heavy gauge, break resistant, made from pressure moulded plastic.
- C. Surface or recessed boxes are to be suitable for the type of related conduit system. Sizes of boxes are to be suitable for application with switches, sockets, etc.

2.3 SWITCHES

- A. Switches are to be of the quick-make, quick-break type with silver alloy contacts in arc resisting moulded base. Types are as shown and described on the drawings.
- B. Single pole switches are to switch the phase wire. Switches are to be mounted with long dimensions vertical and operating handle up when in the "OFF" position.

2.4 SOCKET OUTLETS

- A. Socket outlets are to have injection moulded plastic base with self-adjusting, non-expanding contacts to prevent permanent distortion, arranged for side or back connection with screws accepting all required branch circuit wires. Types are as shown and described on the drawings.
 - 1. 16 A sockets shall be compliant with German standards.
 - 2. 20 A sockets shall be compliant with French standards.

2.5 ISOLATING SWITCHES

- A. Used to interrupt loads, rated as shown on drawings, 250 V AC with tumbler operating handle to give positive indication of "ON/OFF" position of contacts.
- B. Housing: Weatherproof, IP55, made of:
 - 1. Die cast aluminum with anti-corrosion paint for outdoor use.
 - 2. Rigid polycarbonate for indoor use.

2.6 CONNECTORS FOR JUNCTION BOXES

- A. Connectors for junction boxes shall have the following features:
 - 1. Body made of self extinguishing material, from the polyamide.
 - 2. Screw less connector.
 - 3. Cage clamp technology.
 - 4. Vibration free.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install work in accordance with approved standards, as per manufacturer's recommendations, and to the satisfaction of the Engineer.

- B. Locations shown on drawings are approximate. Exact locations are to be shown on shop drawings. Switches are to be located at strike sides of doors. Unless otherwise shown or instructed, lighting switches are to be mounted at 120cm from finish floor level, socket outlets are to be mounted at 30cm from finish floor level.
- C. All fittings are to be visually inspected for fixing, workmanship and operation to the satisfaction of the Engineer.

END OF SECTION

SECTION 16262

PHOTOVOLTAIC CELLS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes a photovoltaic system comprising PV arrays on roof, batteries, DC/AC inverter, controller, cables, conduits and raceways, fixing supports, all necessary devices and accessories.
- B. Related Sections:
 - 1. Division 16 - Electrical: Requirements for electrical wiring connections.

1.2 REFERENCES

- A. The photovoltaic system shall be in accordance with approved codes and standards.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate manufactured assembly's system and PV arrays installation, layout, support details, wiring connections and all necessary accessories.
- C. Product Data: Submit data on specialties, including manufacturers catalog information. Indicate materials and equipment. Submit details for PV cells.
- D. Manufacturer's Installation Instructions: Submit framing and fixing requirements.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- F. Manufacturer's Field-Reports: Indicate start-up of system and include electrical analysis of photovoltaic system.

1.4 QUALITY ASSURANCE

- A. Perform Work as specified, in accordance with the drawings, to the manufacturer's recommendations and to the satisfaction of the Engineer.
- B. Maintain one copy of each approved standard document on site.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum five years documented experience.

1.6 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.7 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for product storage and handling.
- B. Accept and store PV arrays and accessories in shipping containers and maintain in place until installation.

1.8 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.9 WARRANTY

- A. The manufacturer should warrant the solar modules to be free from defects and/or failures due to manufacturing or quality of materials, for a period not less than 10 years from the date of sale to the customer.

1.10 MAINTENANCE SERVICE

- A. General Requirements: Execution requirements for maintenance service.
- B. Furnish monthly technical service visits for one year starting with date of substantial completion to perform field inspections and make electrical analysis on site. Detail findings in writing. Submit two copies of report after each visit.

PART 2 PRODUCTS

2.1 Solar PV Modules:

The contractor will be responsible for supplying and installing photovoltaic modules with the certifications listed below (when applicable), issued by an internationally recognized laboratory, and should be listed as Tier 1. Including but not limited to:

- A. PV modules must be crystalline silicon PV modules that comply with the norm IEC 61215 edition 2 and shall be qualified to and be classified as Class A or B according to IEC 61730. PV modules shall also comply with the requirements of IEC 61701 (Salt Mist Corrosion test) and IEC 62716 (Ammonia Corrosion test).
- B. PV panels should be procured from tier-1 manufacturers (as per the latest Bloomberg Tier 1 manufacturer listing).
- C. Minimum Capacity: 600 Wp per module at STC

- D. The rated output power of any supplied module shall have a positive tolerance: of up to 3%.
- E. Efficiency: >21%
- F. Orientation: South
- G. Inclination: Between 5° and 20° to prevent row to row shading
- H. Standards: Compliance with the following standards: NL EN 61730-1:2016 / NL EN 61730-2:2016 / NL EN 61215:2016
- I. Earthing of the components
- J. All fixing accessories on module framing
- K. Device preventing any risk of electrolytic couple
- L. Area of all wiring loops kept as small as possible
- M. Reports of flash testing of the modules to be provided to the owner before installation
- N. Modules shall be guaranteed by the manufacturer for 25 years with no more than 10% de-rating for the first 10 years, and 15% de-rating within 30 years.
- O. The contractor is required to submit a list of references, including project certificates and an authorization letter from the manufacturer. The manufacturer must have a local distributor capable of supplying spare parts and providing local support as necessary.

2.2 STRUCTURES:

The structure carries the PV modules and DC electrical components of the plant (cabling, junction boxes, protections, sensors, etc.). It should only be accessed by authorized persons.

The main specifications for the design of this structure are:

- Reduce the weight of the structure
- Reduce the cost of the structure
- Use hot dip galvanized steel only. Cold galvanization or anti-rust paintings are not accepted. The cutting edges and openings are cold galvanized. The evaluation of the proposed structure will be made on a case-by-case basis.
- Allow workers to access any part of the system and any electrical or mechanical component for maintenance
- Provide a maximum security for workers (railings, lifelines, etc.)
- Reduce the risks of intrusion and object-throwing on PV modules
- Minimize the costs and difficulties of maintenance

- Visual appeal
- Wind load to be considered as per standard NL 137
- The design and weight of the metallic structure along with the wind load analysis must be supported by calculation notes.

2.3 HYBRID INVERTERS

- Hybrid inverters accept batteries to store excess produced solar power.
- Hybrid inverter to be connected as shown on the drawings and schedules and in the bills of quantities with at least four MPPT per inverter, preferably with a plug & play modularized lithium battery storage rack as specified in the below section.
- Hybrid inverters include a solar MPPT charger and an AC power charger to charge battery banks and a DC to AC converter to supply AC current from the battery storage rack.
- 380-400 V, three-phase, 50 HZ output.
- Maximum DC Voltage 1000 V
- MPPT operating voltage range 150V-850V
- Dynamic compensation of reactive power, inverter automatic reconnection conditions, linear output power control from a third device (read and write capabilities), utility-interactive photovoltaic inverter system.
- IP 65 minimum
- MODBUS or CAN (with communication bridge if required), allowing reading and controlling the inverter.
- Compliance to IEC/EN 61000-6-1/2/3/4, IEC/EN 62109-1, IEC/EN 62109-2
- Minimum of 4 MPPT
- The minimum 'European Efficiency' of the inverter shall be a minimum of 96%
- Minimum Warranty of 5 years
- **The Hybrid inverter shall be approved by EDL, and able to inject excess power to grid.**
- The contractor is required to submit a list of references, including project certificates and an authorization letter from the manufacturer. The manufacturer must have a local distributor capable of supplying spare parts and providing local support as necessary.
- Protection:
 - Anti-islanding Protection, PV String Input Reverse Polarity Protection.
 - Insulation Resistor Detection, Residual Current Monitoring Unit, Output Over Current Protection,
 - DC disconnect switch to isolate the inverter from the DC bus.
 - An AC disconnect to isolate the inverters from the AC network.
 - Suitably rated MCCBs on both the AC and DC buses.
 - DC and AC surge protection type I+II

2.4 HIGH VOLTAGE BATTERIES

- High Voltage Lithium iron phosphate battery banks to be provided to work with hybrid high voltage inverters. Cells provide high safety and efficiency.
- Nominal DC voltage shall be from 200V to 850V but preferably 650V, as the cable sizing between the lithium batteries and the inverters is completed with a 650V nominal DC voltage.
- Batteries should be supplied with their respective battery management system (BMS). Batteries should be installed in an enclosed rack system in NEMA I case rating or higher in a dedicated location according to the manufacturer's recommendations. BMS protects the cell in all angles such as abnormal temperature, current, voltage, State of Charge SOC, and State of Health SOH. The system can automatically manage the charge and discharge state and balance the current and voltage of each cell.
- All battery cables must be labeled and installed decently with the necessary routing protection to inverters or chargers.
- Batteries to have more than 5000 cycles with 80% DoD
- The contractor to choose the batteries and the inverter to be compatible, namely in the communication protocol, Modbus, or CAN
- Working Temperature: 0-50° C
- Authentication Levels: CE/IEC62619 / VDE2510-50 / UL1973 / UL9540A / UN38.3
- Modular design with the ability to add/reduce the storage capacity easily
- The contractor is required to submit a list of references, including project certificates and an authorization letter from the manufacturer. The manufacturer must have a local distributor capable of supplying spare parts and providing local support as necessary.
- Minimum Warranty: 10 Years

2.5 DC- SIDE INTERCONNECTION:

A. DC Cabling:

The DC cabling is made of:

- The string cables connecting the modules themselves to the SJB (string junction boxes), where the string cables are connected in parallel
- The group cables if any, connecting the SJB (string junction boxes) to the GJB (group junction boxes), where the group cables are connected in parallel
- The main cables connecting the GJB (group junction boxes), if any, or the SJB, to the DC Protection box, located in the technical building, close to the inverter(s). The main cables connect also the DC protection box to the inverter(s)

The cables must have the following features:

- -Specific PV cables:
 - Flexible
 - Unipolar
 - Double insulated (class II)
 - Fireproof

- Halogen-free
 - Cables equipped with plug-in connectors
 - Cables stretched and fixed at regular intervals (max. 2 m) on the underside of the modules
 - Labeling "Warning: DC energized cables" every 5m on the cables

DC cables between the modules and the inverters section has to be sized to limit the total voltage drop in the DC circuit to a value less than 4% of its value at rated power (operation at "MPP").

B. DC Circuit Cable Routing:

The contractor will be responsible for the supply and installation of necessary accessories for routing the electrical connections of the DC circuit.

- Contact plating of active conductors against the ground conductor (without any loop induced by the active conductors and ground conductor)
- Tracking in covered UV resistant cable trays, hot-dip galvanized, or trenches to the junction boxes, DC protection boxes and inverters
- Includes all the elements for installation and fixing
- Conduits and cables glands

C. DC Protection boxes:

The contractor will be responsible for the supply and installation of a box for general DC load break of a PV array connected to a single inverter input (DCPB). If necessary, this box can also be used as a junction box for parallel connection of cables connected to a single inverter input.

- Class II boxes
- Includes a disconnecting device upstream box
- Includes suitable DC fuses on each polarities (+) and (-) if appropriate
- Protective device against transients suitable for photovoltaic systems (according to French guide UTE C 61-740-51 or equivalent) where appropriate. Using Type 2 SPD with fault signal and thermal disconnection (short-circuit at the end of life)
- Includes general DC disconnect switch easily recognizable and readily accessible for disconnection under load
- Includes labels marking "Emergency stop input inverter – DCPBk, m, n" (where: k is the number of GJB (if any, or SJB); m is the number of the input of the inverter, n is the number of the inverter)
- Includes the signal "Warning: DC energized cables " and "Do not operate in charge" where applicable
- Wiring inside the DCPB with unipolar double insulated cables

NOTE: The number of DC protection boxes must exactly match the number of the input and inverter to which it is connected.

Location: The DC boxes should be placed near the inverter(s).

D. Earthing & equipotential Bonding:

The contractor will be responsible for:

- The interconnection of all the metallic parts of the PV plant including but not limited to metal module support structures, metal cable trays, hot-dip galvanized, every single module, etc. on both the DC side and the AC side.
- The use of material to avoid any risk of electrolyte torque when fitting metallic masses for equipotential bonding (e.g. bimetal lugs or rings).

NOTE: The earthing and bonding cables have to be yellow-green colored if they are insulated.

PART 3 EXECUTION

3.1 PREPARATION

- A. Remove scale and dirt on inside and outside before assembly.
- B. Prepare wiring connections.

3.2 INSTALLATION

- A. Install Work as directed, in accordance with the drawings, to the manufacturer's recommendations and to the satisfaction of the Engineer.
- B. Route conduits and wires in orderly manner.
- C. Conserve space; do not interfere with use of space and other work.
- D. Where any support member is welded to structural building framing, scrape, brush clean and apply one coat of zinc rich primer to welding.

3.3 SCHEDULES

- A. As indicated on drawings and were directed by the Engineer.

3.4 OPERATION & MAINTENANCE

The contractor is responsible for a 2-year Operation and Maintenance of the system.

The O&M obligations during the performance guarantee period should cover the various types of maintenance strategies for a PV plant including yet not limited to the following:

- **Preventive Maintenance** activities are the core element of the maintenance services to a PV plant. It comprises regular visual and physical inspections, as well as verification activities conducted with specific frequencies. It is under the responsibility of the contractor to prepare the task plan until the end of the contract

- **Corrective Maintenance** covers the activities performed by the Maintenance team in order to restore a PV plant system, equipment or component to a status where it can perform the required function. Corrective Maintenance include:
 - Fault Diagnosis: also called troubleshooting to identify fault cause and localization
 - Temporary Repair: to restore the required function of a faulty item for a limited time, until a Repair is carried out
 - Repair: to restore the required function permanently

- **Predictive maintenance** is a Condition-based maintenance carried out by evaluating typical patterns of significant parameters of plant components degradation. Predictive techniques help to determine the condition of in-service equipment to predict when and whether maintenance should be performed.

The intervention of the contractor should be within two weeks of the due date for preventive maintenance and a report with tasks' checklist should be sent to the beneficiary within three weeks of the due date.

END OF SECTION

SECTION 16290

LIGHTNING PROTECTION SYSTEM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. The contractor shall supply and install a complete lightning protection system in conformity with NF C17-102 and including:
1. The lightning rod and its mast.
 2. The down conductor.
 3. Earth termination network.
 4. All fixing and connecting accessories.
 5. Bonds and clamps.
 6. Surge Arresters.

1.3 SUBMITTALS

- A. The following data and drawings (but not limited to) are to be provided:
1. Manufacturer's catalogue cuts for all components.
 2. Shop drawing coordinated with all other trades showing exact location and routing of the installation.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. Lightning and Earthing System:
1. HELITA (FRANCE)
 2. FRANKLIN (FRANCE)
 3. INDELEC (FRANCE)
 4. Or other equal and approved.
- B. Lightning & Surge Protection:
1. SOULE (FRANCE)
 2. DEHN (GERMANY)
 3. KRONE (GERMANY)
 4. Or other equal and approved.

2.2 SYSTEM DESCRIPTION

- A. The rod type conductor shall consist of an early streamer emission lightning rod profiled and inalterable. It shall be of the double polarity type.

- B. The rod type conductor shall be installed on a five-meter stainless steel mast for corrosive atmosphere with all fixing accessories.
- C. Lightning earth consists of one or more earth pits at ground floor level providing an earth connection point with less than five (5) Ohms resistance to the general mass of the earth.
- D. Concrete earth pit is to contain one directly driven 2.5m with cable conductor on top.
- E. All metal works including water pipes, handrails, air conditioning units, window frames, cladding, metal roof, chimneys, ducts, tanks, etc., in the vicinity of the lightning protective system must be bonded to it, to avoid the danger of side flashing.

2.3 COMPONENTS

- A. Vertical and horizontal conductors shall be of hard drawn high conductivity copper tape of 25 mm x 3 mm section. The lowest accessible part of the down conductor should be protected using a heavy gauge rigid PVC pipe attached to the wall
- B. Earth rods shall not be less than 16 mm diameter pure electrolytic copper molecularly bonded onto a high tensile steel core to a minimum thickness of 0.25 mm.
- C. Earth link conductors shall be of high conductivity, soft drawn stranded conductor, 70mm².
- D. All bonds, saddles, clamps, clips, earth bonding points and flexible bonds are to be copper or copper alloy.
- E. Permanent earthing connections are to be made by exothermic welding process.
- F. Materials used for earthing are to be copper or approved copper alloys specially manufactured for the purpose. Electrical continuity is to be of durable construction providing an independent fault current return path of low resistance to the site earth.

2.4 SURGE ARRESTERS

- A. Four Pole Combined Lightning Current and Surge Arrester:
 - 1. Nominal discharge current 25/100 KA per phase.
 - 2. Residual voltage less than 1500 V.
 - 3. Response time 25 ns.
 - 4. Self protected via built-in thermal protection.
 - 5. Supplied with associated disconnecter.
 - 6. To be installed for the MDB
- B. Four Pole Surge Arrester:
 - 1. Nominal discharge current 20 kA, wave 8/20 μ s.
 - 2. Residual voltage less than 1000 V.
 - 3. To be installed for the DBs.
- C. Two Pole Modular Protective Devices:
 - 1. Nominal discharge current L-N 2.5 kA.
 - 2. Residual voltage less than 500 V.

3. Response time 5 ns
4. Self protected via built-in thermal protection.
5. Supplied with associated disconnecter.
6. Two pole devices are to be installed for each low current system supply.

D. Telephone Line Surge Arrestor:

1. Discharge current 10 KA (Wave 8/20 μ s)
2. Residual voltage less than 300 V.
3. Service voltage 230V.
4. 10 two-pole telephone line surge arrestors installed in "MDF" shall be used to protect external telephone lines

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install work as specified, as shown on the drawings, in accordance with approved standards, as per manufacturer's instructions and to the satisfaction of the Engineer.

END OF SECTION

SECTION 16413

TRANSFER SWITCHES (*CHANGE-OVER SWITCHES*)

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches with by-pass isolating switches.
- B. Related Sections:
 - 1. Section 16010 - General Electrical Requirements.
 - 2. Section 16950 - Electrical Testing.

1.3 SUBMITTALS

- A. Product Data: Include ratings and dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
- B. Wiring Diagrams: Detail wiring for transfer switches and differentiate between manufacturer-installed and field-installed wiring. Show both power and control wiring.
- C. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources and load.
- D. Product Certificates: Signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for load ratings and short-circuit closing and withstand ratings applicable to units for Project.
- E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- F. Field Test Reports: Indicate and interpret test and inspection results for compliance with performance requirements.
- G. Maintenance Data: For each type of product to include in maintenance manuals specified in Division 16. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing emergency maintenance and repairs at Project site with an eight-hour maximum response time.
- B. Testing Agency Qualifications: Testing agency or a member company of the international Electrical Testing Association and that is acceptable to authorities having jurisdiction.
- C. Source Limitations: Obtain automatic transfer switch through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in BSS Code and IEE regulations, for emergency service, by a testing agency acceptable to authorities having jurisdiction.
- E. Comply with BSS Code and IEE regulations.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products to be from the following or approved equal:
 - 1. TELEMECANIQUE (France)
 - 2. MOELLER (Germany)
 - 3. MITSUBISHI (Japan)
 - 4. GHISALBA (Spain)

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in BSS Code and IEE regulations for continuous loading and total system transfer, as shown on the drawings.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to BSS Code and IEE regulations.
- C. Solid-State Controls: Repetitive accuracy of all settings is $\pm 2\%$ or better over an operating temperature range of -20°C to $+70^{\circ}\text{C}$.
- D. Resistance to Damage by Voltage Transients: Components meet or exceed voltage-surge withstand capability requirements when tested according to BSS Code and IEE regulations.
- E. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- F. Transfer Switches Based on Molded-Case-Switch Components.

2.3 AUTOMATIC TRANSFER-SWITCH FEATURES

- A. Undervoltage Sensing for Each Phase of Normal Source: Senses low phase-to-ground voltage on each phase. Pickup voltage is adjustable from 85% to 100% of nominal, and dropout voltage is adjustable from 75% to 98% of pickup value. Factory set for pickup at 90% and dropout at 85%.
- B. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
- C. Voltage/Frequency Lockout Relay: Prevents premature transfer to generator set. Pickup voltage is adjustable from 85% to 100% of nominal. Factory set for pickup at 90%.
- D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes; factory set for 10 minutes. Provides automatic defeat of delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
- E. Test Switch: Simulates normal-source failure.
- F. Switch-Position Pilot Lights: Indicate source to which load is connected.
- G. Source-Available Indicating Lights: Supervise sources via transfer-switch, normal- and emergency-source sensing circuits.
 - 1. *Normal Power Supervision*: Green light with nameplate engraved "Normal Source Available."
 - 2. *Emergency Power Supervision*: Red light with nameplate engraved "Emergency Source Available."
- H. Engine Starting Contacts: One isolated, normally closed and one isolated, normally open, rated 10 A at 32 VDC minimum.
- I. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes; factory set for five minutes. Initiates shutdown at remote engine-generator controls after retransfer of load to normal source.

2.4 BYPASS/ISOLATION SWITCHES

- A. Comply with requirements for Level 1 equipment per BSS Code and IEE regulations.
- B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
 - 1. Means to lock bypass/isolation in the position that isolates transfer switch, with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
 - 2. Draw out Arrangement for Transfer Switch: Provides physical separation from live parts and accessibility for testing and maintenance operations.

3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with the same phase arrangement and number of poles.
 4. Contact temperatures of bypass/isolation switches do not exceed those of automatic transfer-switch contacts when they are carrying rated load.
 5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less.
 6. Legend: Manufacturer's standard legend for control labels and instruction signs give detailed operating instructions.
 7. Maintainability: Fabricate to allow convenient removal of major components from the front without removing other parts or main power conductors.
- C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars, plated at connection points and braced for the indicated available short-circuit current.

2.5 FINISHES

- A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.6 SOURCE QUALITY CONTROL

- A. Factory Test Components, Assembled Switches, and Associated Equipment: Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with BSS Code and IEE regulations.

PART 3 EXECUTION

3.1 APPLICATION

- A. Four-Pole Switches: Where four-pole switches are indicated, install neutral switching.

3.2 INSTALLATION

- A. Floor-Mounted Switch: Level and anchor unit to floor.
- B. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- C. Identify components according to Division 16 Section "Basic Electrical Materials and Methods."
- D. Identify components according to Division 16 Section "Electrical Identification".

3.3 WIRING TO REMOTE COMPONENTS

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

3.4 CONNECTIONS

- A. Ground equipment as indicated and as required by BSS Code and IEE regulations.

3.5 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing under the supervision of the manufacturer's factory-authorized service representative in addition to tests recommended by the manufacturer:
 - 1. Before energizing equipment, after transfer-switch products have been installed:
 - a. Measure insulation resistance phase-to phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Meet manufacturer's specified minimum resistance.
 - b. Check for electrical continuity of circuits and for short circuits.
 - c. Inspect for physical damage; proper installation and connection; and integrity of barriers, covers, and safety features.
 - d. Verify that manual transfer warnings are properly placed.
 - e. Perform manual transfer operation.
 - 2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50% from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown sequence.
- B. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - 1. Assist in verifying grounding connections and locations and ratings of sensors.
 - 2. Assist in observing reaction of circuit-interrupting devices when simulated fault current is applied at sensors.
- C. Coordinate tests with tests of generator plant and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean equipment internally, on completion of installation, according to manufacturer's written instructions.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain transfer switches and related equipment as specified below:
 - 1. Coordinate this training with that for generator equipment.
 - 2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 - 3. Review data in maintenance manuals. Refer to Division 16 Section "Contract Closeout."
 - 4. Review data in maintenance manuals. Refer to Division 16 Section "Operation and Maintenance Data".
 - 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 - 6. Provide a minimum of four hours of instruction.

END OF SECTION

SECTION 16442

PANELBOARDS AND SWITCHBOARDS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.02 SUMMARY

- A. Provide labor, materials, equipment and services, and perform operations required for installation of low voltage switchboards 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. Switchboard components shall be coordinated and include, but not be limited to, the following:
 - a. Switchboard section.
 - b. Accessories.
- C. Related Work Specified Elsewhere
1. Basic Electrical Requirements - Section 16010.
 2. Basic Electrical Materials and Methods - Section 16050.
 3. Electrical Testing - Section 16950.

1.03 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. *Codes and Standards*
 - a. Code Compliance: Comply with requirements of the applicable electrical code (IEC 439-1 and IEC 57-1/1A).
- B. Factory Testing and Inspection: The manufacturer shall thoroughly test the assembled switchboard for proper functioning and compliance with the specifications. Submit certification to the Engineer that this testing has been completed and that the function and compliance conform to the specifications.

1.04 SUBMITTALS

- A. Submit the following in accordance with submittal requirements specified in Section 16010.
1. Shop Drawings: Submit layout drawings including, but not limited to, the following:
 - a. Outline and arrangement drawings showing overall dimensions of the switchboard assembly, front views, floor plan, side views, shipping sections, weights of each shipping section, recommended clearances to the front, rear, sides and top.
 - b. Certified dimensional drawings of the switchboard showing mounting or anchor bolts required, space available at top and bottom of the switchboard for feeder conduit and cable.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Handle switchboard equipment carefully to prevent damage, breaking, and scoring. Do not install damaged sections or components; replace with new.
- B. Store switchboard equipment in a clean, dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage. Assume responsibility and security for materials and equipment.
- C. Comply with manufacturer's rigging and moving instructions for unloading switchboard components and transporting them to final location for installation.
- D. Coordinate and schedule delivery of equipment which permits, ready building ingress for large equipment components to their designated installation spaces.
- E. Each packing crate and carton shall be visibly marked to identify contents.

2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products to be from the following or approved equal:
- a. SCHNEIDER (France)
 - b. LEGRAND (France)
 - c. EATON (USA)
 - d. SCHIAVI (Italy)
 - e. RITTAL (Germany)

2.02 MATERIALS AND EQUIPMENT

A. Distribution System

2 LV meters will be provided as shown on the drawings. One meter for each building (the existing and the new). Each meter will display line-to-line voltage, line-to-neutral voltage, and current per phase.

The Main Distribution Switchboard shall feed the Sub-Main and General Switchboards which, by turn, shall feed the Secondary Switchboards.

The distribution circuits supplying the light points, the socket outlets and the other utilities fed from the secondary distribution switchboards shall be drawn inside heavy gauge rigid PVC conduits for recessed installation or metal conduits for surface mounted installation as described in section 16110.

Every circuit shall have an earth continuity conductor.

2.03 SWITCHGEAR

A. General

All the switchgear shall be of the totally enclosed metal clad type.

All the switchboards shall be supplied complete with all the necessary wiring, bus bars, equipment, fittings, cable boxes and fixing material.

All the switchboards shall be free from distortion and welding strains. They shall be sufficiently rigid to support the equipment without distortion under normal and short circuit conditions. They shall be suitably braced for short circuit duty.

All parts of the switchboards carrying current including the equipment connections, joints and instruments shall be capable of carrying their specified rated currents continuously, without a temperature rise exceeding the acceptable values of the relevant specifications at any part of the switchboards.

The derating of the different items resulting from the prevailing conditions shall be allowed for in the design of the switchboards.

The switchgear shall be designed to facilitate inspection, maintenance and repair.

All units of the same rating and specifications shall be fully interchangeable.

All live terminals and component parts under voltage shall be properly isolated from the switchboard structure. The switchboard structure shall be securely connected to the earthing system.

The standard name plates in both Arabic and English languages shall be supplied to indicate clearly the function of all major and control equipment in the switchboards.

An earth bar extending over the entire length of the switchboard assembly shall be provided. It shall be sized in accordance with the regulations.

All metal parts shall be connected to the earth bar in an approved manner.
All metal instrument cases shall also be properly connected to the earth bar.

All metallic parts of the switchboards shall be chemically treated to provide protection against corrosion. They shall be painted on the outside and inside surface with one prime coat and two light gray finish coats.

The switchboards shall be of the single bus bar system with a neutral bar. The bus bars shall be of ample cross section so as to carry their rated currents without the development of excessive heat.

These rated currents shall correspond to the frame size of the main circuit breaker of the switchboard.

The bus bars shall be of high conductivity hard drawn electrolytic copper according to BS 1433. Alternatives using different material for the bus bars may be offered. Full details concerning the accessories and connection fittings shall be submitted to the Engineer for approval.

All the switchboards shall be of manufacturer's standardized construction. They shall be completely wired, factory tested and ready for installation when received at the site.

B. Construction

The construction of the switchgear to be supplied may be divided into four (4) main types as follows:

Type A: Main, Sub-Main and General Switchboards

These switchboards shall be of the totally enclosed metal clad type for indoor service **(form 2b)**.

They shall be designed for floor mounting and shall be completely self-supporting.
These switchboard shall be of rigid construction.

They shall be composed either of enclosure sheet steel cabinets or assemblies of sectional elements equipped with air or molded case circuit breakers. In both cases, the assembly for the switchboards shall form a continuous integral structure having a rectangular shape and shall be accessible via the front plates of the assemblies (BS 4727 and BS 5486).

All fastenings between structural members shall be bolted to provide flexibility during installation.

Each assembly shall be provided with a continuous copper earth bar running the whole length sized in accordance with BS 7430 for the prospective short-circuit.

This ensures a good standard of protection against accidental contact or damage to live conductive parts of the switchboard during maintenance.

Cables to and from the switchboard therefore run at high level on tray and then drop down into the top of the switchboard. Access would then be from both front or back.
All switchrooms will have suitably wide access doors and corridors.

Type B: Secondary Switchboards

These switchboards shall be installed, for the lighting circuits, the socket outlets and the small power requirements (minimum size of conductors 2.5mm² for lighting and 4mm² socket) PVC insulated according to BS 6231 and IEC 947.

These switchboards shall be of sheet steel general purpose cabinet type equipped with miniature circuit breakers according to BS 5486: Part1.

These switchboards shall be designed for surface or flush wall mounting.

The cabinet of these switchboards shall consist of a sheet steel box properly jointed, welded and reinforced, and of a sheet steel front having a door with concealed hinged and a flush type combination lock and catch or a multiple point contact.

The interior of these switchboards shall be assembled as a complete unit to fit the cabinet. This interior shall be composed of bus bars and the branches mounted on them.

Every switchboards shall be provided with:

- One neutral bar fully insulated from the cabinet.
- One earth connector welded to the cabinet.
- Circuit breakers as specified hereunder and as shown on the drawings.

C. Instruments and Metering

All electrical indicating instruments shall comply with BS 89 and shall have an Accuracy Class Index as follows:

Instrument Function	Accuracy Class Index
Switchboard indicating instruments:	1.0
Ammeters and voltmeters on motor control panels:	2.5

All electrical indicating digital instruments shall be the product of a single manufacturer. All instruments shall be logically grouped, relative to the equipment with which they are associated.

The scale ranges of ammeters, voltmeters, wattmeters and varimeters shall be chosen so that, under normal operating conditions, each instrument will read between 60-75% of the effective scale range.

Instrument dials shall bear only those items of information classified as essential in BS 89, all other required information shall be marked on the exterior of the case.

Notwithstanding the requirements of BS 89, dials of power factor meters shall be marked 'LEAD' and 'LAG' in the appropriate quadrants.

All instruments shall be provided with external means for adjusting the zero indication.

D. Private Metering Equipment

Single-phase and 3-phase integrating meters for watt-hour (and kilo watt-hour and maximum demand).

Polyphase meters for registering maximum demand in kilowatts (or MW) shall comply with BS 5685: Part 3, as applicable. They shall operate on the basis 1000 impulses per Kwh.

Provision for transmission of data to an external device shall be made as follows:

- i- kilowatt-hour consumption
- ii- kilowatt-maximum demand
- iii- time-reset pulse for maximum demand.

All meters covered by the preceding clauses shall have a minimum Accuracy Class "B" Designation according to EN 50470-3.

All 3-phase meters shall be suitable for operation on a 4-wire system with unbalanced load.

All meters shall be dual tariff.

All these measuring instruments shall be digital, LED display, 7-Character display, 2-Tariff measurements and DIN-Rail mounted.

E. Current Transformers

All CTs shall comply with all relevant requirements of BS 3938 and shall have an Accuracy Class Designation according to the following table:

Current Transformer Function	Accuracy Class Designation
Tariff metering:	0.5
Non-tariff metering:	1.0
Switchboard indicating instruments:	1.0
Motor starter ammeters:	3.0

Unless otherwise specified in the schedules or drawings, the CTs are required for use under service conditions not more onerous than those set out in BS 3938.

CTs shall be designed either for measurement or for protection and shall not be used in a dual-purpose role serving both instruments and protective gear.

Unless otherwise specified, all CTs shall have 5A secondary windings.

One side of the secondary of each CT shall be connected to earth at one point via a bolted removable link.

For metering circuits, either, a proprietary front of panel CT test block or special 'shorting' terminals within the panel shall be provided for test purposes.

All CTs of the ring type for use at voltages exceeding 1000V shall be epoxy resin encapsulated.

All CTs shall be provided with a rating plate bearing the information set out in BS 3938.

CTs shall be installed in accessible places. The secondary connections shall be brought out by means of insulated leads, and made off on a suitable terminal block-mounted in a readily accessible position.

Magnetization curves and/or type Test Certificates shall be provided for all CTs associated with protection devices.

Every CT shall have a rated burden at least 50% greater than the total burden of the instruments, relays, and/or other apparatus which it is to serve.

2.04 LOW VOLTAGE CIRCUIT BREAKERS

A. Circuit Breakers

1- *General features:*

All the circuit breakers shall comply with IEC 947-2 and IEC 157.1 and shall have the following features:

- They shall be suitable for operation on the system which is:
 - 380 volts, 3-phase, 4-wire, 50Hz.
 - 220 volts, 1-phase, 2-wire, 50Hz.
- The Two-pole, Three-pole and Four-pole circuit breakers shall be designed to break all the poles simultaneously and they shall have a single mechanism.
- Each pole of the circuit breaker shall be equipped with an inverse time delay thermal overcurrent trip device. The trip device shall be direct acting.
- Disconnecting devices (on-load switches) of approved types shall be provided to facilitate the removal of circuit breakers from the housings for test and maintenance purposes.
- They shall be trip free from all positions.

- They shall be ambient compensated. All overload trips of the thermal type shall be compensated for the ambient temperature of the site.
- They shall have an arc-quenching device on each pole.
- They shall have auxiliary contacts whenever required for signaling, interlocking, etc...
- All circuit breaker poles shall be protected, except as shown on the drawings.
- All the circuit breakers shall be manually operated.

2- Air Circuit breakers (ACB)

Air circuit breakers (ACB) shall be either normal, with drawable or motorized rated 1200-2500A as shown on the drawings. They shall be suitable for applications in their intended enclosures for 100% of their continuous ampere ratings and complying with IEC 947 Parts 1 & 2 and shall be rated for uninterrupted duty.

Breakers shall be manually operated (MO) unless electrically operated (EO) is indicated on the drawings. The breaker control faceplate shall include color coded visual indicators to indicate contact "OPEN" and "CLOSED" positions as well as mechanism "CHARGED" and "DISCHARGED" positions. Manual control pushbuttons shall be provided for "OPENING" and "CLOSING" the breaker.

Electrically operated circuit breakers shall be complete with OPEN/CLOSE color coded "PUSHBUTTONS" and open/close color coded indicating "FLAGS" integral to the breaker to indicate the position of the breaker contacts.

Air circuit breakers shall have symmetrical interrupting capacity of 50000 or 70000 Amperes RMS at rated voltage.

A selective override circuit shall be provided on breakers having short time adjustments but without instantaneous adjustments that will allow selectivity up to its RMS symmetrical short-time rating.

This selective override circuit shall allow the breaker to ride through a fully offset (asymmetrical) fault equal to its RMS symmetrical short-time rating in a system having an X/R ratio of 6.6 with a maximum single-phase peak current of 2.3 times the RMS symmetrical short-time rating. No deviations from these specifications shall be allowed.

All breakers shall be provided with a true, two-step stored energy mechanism providing a maximum of five-cycle closing. All the energy required for closing the breaker shall be completely stored and held in readiness pending a release to close action. Manual operated breakers shall be convertible to motor operation by insertion of an internally mounted motor operator.

Both manually and electrically operated breakers shall have multiple charge/close provisions providing the following possible sequence: Charge-close-recharge-open-close-open. As a safety feature, provisions shall be available to manually discharge the

stored energy without closing the breaker. Anti-pump provisions shall be provided as standard for motor operated breakers and optional for manual breakers with spring release solenoids.

Each circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall provide the basic adjustable time-current protection functions.

True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensor and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker.

The trip shall be provided with a discriminator or making-current release circuit to prevent closing the circuit breaker on a faulted system. The circuit shall be armed for approximately 8 cycles and shall operate for all fault levels above 11 times the ampere value of the rating plug.

The trip unit shall contain an integral panel with a test selector switch and a test pushbutton.

A potentiometer shall be provided to enable the user to select the values of test currents within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker may be tested in the "trip" or "no trip" test mode.

The trip unit shall contain a keyed receptacle for use with an auxiliary power module.

The auxiliary power module when connected to 220V, 50Hz power source shall provide power for testing the trip unit while the breaker is out of the cell or in the "disconnect" or "withdrawn" position. Provide one auxiliary power module unit per assembly.

Trip unit shall have thermal memory for enhanced circuit protection.

Key interlocks shall be provided as indicated on the drawings.

3- Molded case circuit breakers (MCCB)

All breakers shall be of the same manufacturer and standard ratings and frame sizes shall be used where appropriate and possible.

Molded case circuit breakers shall be air break de-ion type, quick make and quick break, having free toggle mechanism ensuring full contact pressure until time of opening, whether actuated automatically or manually.

The mechanism shall be completely enclosed in a compact molded Bakelite case, sealed to prevent tampering.

Circuit breakers shall have inverse time tripping characteristics with automatic release secured through action of a combination thermal magnetic or hydraulic magnetic trip element which shall trip free of the handle and operate in response to an overload or short circuit.

Breaker contacts shall be non-welding and non-corrodible silver tungsten composition. Circuit breaker handle shall have three positions, 'OFF', 'ON' and 'TRIP', thus indicating clearly abnormal conditions of the circuit. Single pole circuit breakers with handle tie or bar equivalent construction are not acceptable for a multi-pole breaker.

Molded case circuit breakers shall be of the bolted type. Plug-in type breaker connections are not acceptable. Breakers shall have ratings and breaking capacity as indicated on the Drawings.

All circuit breakers shall have a rupturing capacity of not less than 25KA at 400V, 3-Phase 50 Hz, with thermal hydraulic and magnetic trips incorporated, the former being initially set at the load/supply rated circuit current and the latter at the supply side fault current for the particular breaker characteristics.

Where indicated on the Schematic Drawing, selected circuit breakers shall also include residual current detection causing either the circuit breaker to be tripped, or a local audio/visual alarm to operate, depending on the category of supply load. Operation and ratings of these devices shall be as indicated on the Drawings.

Circuit breakers designated for residual current tripping shall be provided with shunt trip arrangement.

4- *Miniature circuit breakers (MCB)*

Miniature Circuit Breakers shall comply with IEC 947-2 or BS 3871: Part 1 or demonstrated equivalent standard and shall have a minimum breaking capacity of 6KA.

The Frame size of all MCB shall be the same so that they could be easily interchanged.

The MCB shall be either of the plug-in or bolt-on type. Screw type breakers are unacceptable. Circuit breaker devices shall be of the trip free pattern to prevent closing the breaker on a fault and shall be engraved to indicate "ON" and "OFF" positions.

Lighting circuit shall be protected with 2x10A MCB.
Socket outlet circuit shall be protected with 2x16 MCB.

The boards shall be surface type unless indicated otherwise on the Drawings. Cable glands shall be provided where required.

All MCB shall ensure protection against sub-circuit overloads by means of ambient temperature compensated thermal overload trips for temperatures up to 50°C and against short circuits by instantaneous magnetic overload trips.

Service and ultimate short-circuit capacities shall be as specified in the schedules.

All MCB shall be clearly engraved to indicate the particular current rating.

All fire pumps circuit breakers shall be of the magnetic type only.

5- *Earth Leakage Circuit Breaker (ELCB)*

Current operated ground fault relays shall be used either in conjunction with MCB where indicated on the Drawings, for tripping the breakers or for giving alarm signal only by an indicator lamp and alarm sounder in cases of ground fault at the prescribed setting level.

The ground fault relays shall consist of a core balance current transformer and a trip coil.

All components shall be enclosed in a casing of molded plastic. A reset button shall be provided for resetting the relay. The relays shall have 30mA sensitivity as indicated on the Drawings and the tripping time shall be less than 100 millisecond.

ELCB shall provide accident protection by causing the associated MCB to trip, thereby interrupting dangerous contact voltages which may be present in faulty electrical appliances, devices or equipment fixtures as a result of frame faults, insulation faults or misuse.

ELCB shall comply with the recommendation IEC 227 of the International Commission on Rules for the Approval of Electrical Equipment and/or BS 4293 and BS 3871-1.

ELCB shall be all insulated type and consist of a current transformer, tripping coil and contact, "ON/OFF" trip free front operated handle and a test push button. The tripping mechanism shall cause interruption of the supply on a ground fault current of 30mA and as indicated on the Drawings.

The tripping arrangement shall not be affected by ambient temperature changes. The current carrying contacts shall be of robust construction, made of suitable copper alloy and they shall be non-welding and self-wiping and designed for a minimum 20,000 operations.

B. General Features

Breaking Capacity

- All the circuit breakers used shall have guaranteed breaking capacities sufficient for the maximum short circuit duties that could possibly be imposed on the different breakers.
- In any case the following figures indicate the minimum breaking capacities of the circuit breakers. Lower capacities shall not be offered even if the short circuit currents expected are lower.
- For MCCB circuit breakers having a frame size of (800A→1000A): fifty thousand (50,000) Amp. at the system voltage.
- For MCCB having a frame size of (400A & 630A): forty five thousand (45,000) Amp. at the system voltage.

- For MCCB having a frame size of (160A & 250A): thirty six thousand (36,000) Amp. at the system voltage.
- For MCCB having a frame size of (100A): twenty five thousand (25,000) Amp. at the system voltage.
- For MCB having a frame size of (125A): ten thousand (10,000) Amp. at the system voltage.
- For MCB having a frame size of (63A): ten thousand (10,000) Amp., and five thousand (5,000) Amp. at the system voltage.

3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

3.02 PREPARATION

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades, so as not to delay job progress.
- C. Provide templates as required to related trade for location of items.

3.03 INSTALLATION

Install switchboard as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices.

Install switchboard on vibration isolators in accordance with manufacturer's requirements.

Mounting heights of the distribution switchboards shall have the centerline at (1.50) meter over finished floor level, unless otherwise specified by the Engineer.

They shall be installed flush mounted with finished walls and surface mounted inside the vertical shafts reserved for them.

Distribution switchboards shall be securely fastened and properly aligned and leveled. Adjoining power and lighting boards shall be mounted at the same heights, one near the other.

Concealed surfaces of the cabinets shall be given a thick coat of asphalt before the installation.

Circuit breakers shall not be installed inside the cabinets before completion of civil works.

Switchboards and all circuits breakers and circuits shall be properly numbered for identification. Name-plates shall be provided for all circuits protection.

A table indicating the circuits, numbers, references area served, etc... shall be supplied for each switchboard.

All switchboards shall be securely connected to the earthing system of the metallic frames.

3.04 FIELD QUALITY CONTROL

- A. Prior to energization of switchboards and circuitry, perform tests as specified in Section 16950 "Electrical Tests." If the testing should indicate failure to meet the requirements of the specifications, the manufacturer shall provide additions, modifications or replacements necessary to provide the Employer with a unit which fully conforms to the specifications. Repair work shall be scheduled at a time convenient to the facility being served.

3.05 ADJUSTING AND CLEANING

- A. Adjust operating mechanisms for free mechanical movement. Touchup scratched or marred surfaces to match original finishes.

END OF SECTION

SECTION 16443

MOTOR CONTROL CENTERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall 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 capacities.
 - 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.
 - 3. All documents required by EDL in the format required by these parties.
- 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 60439 & 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.

1.7 SPARE PARTS: provide manufacturer's recommended spare parts for emergency replacement and one year's maintenance including, but not limited to, the followings:

- A. One set of fixed and moving contact for every type of replaceable (consumable) contact set.
- B. One operating motor and/ or coil for each type of electrically operated circuit breaker or contactor.
- C. Miniature circuit breakers: Quantity equal to 5 percent of amount of each type installed, but not less than one unit of each type.
- D. Motor circuit breakers (non-MCCB): Quantity equal to 5 percent of amount of each type installed, but not less than one unit of each type.
- E. Contactors: Quantity equal to 5 percent of amount of each type installed, but not less than one unit of each type.
- F. Two sets of each type of indicating lights, fuses, LEDs etc.

1.8 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 system / panelboard assemblies that do not meet requirements or that fail within the specified warranty period.
- C. Warranty Period: 2 years from date of Substantial Completion for any component of the system.

PART 2 - PRODUCTS

2.1 PRODUCTS

- A. Enclosures: Free standing cabinets as indicated. Unless otherwise indicated to meet environmental conditions at installed location. Motor control centers are to comply as a minimum with EN 60439-1 factory-built type tested (TTA).
 - 1. Ingress Protection: IP55 (provide anti-condensation heaters and submit thermal study to justify the panel's cooling method). Enclosure to have suitable temperature control apparatus (heat sinks, fans, air conditioning ...etc) as required to keep internal temperature below 40 °C when ambient temperature outside the panel is 50 °C. Special attention shall be given to soft-starters and variable frequency drives in that effect.
 - 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: Plated copper.
- B. Capacity 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, over-current 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. Over-current 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, non-reversing, 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 over-current protection.
 - 1. Moulded case non-fusible Disconnect: heavy-duty, non-fusible 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 SOFT STARTER MOTOR SET

- A. Description: Soft starter drive controller, providing a soft starting and stopping of asynchronous squirrel cage motors.
The soft starter microprocessor shall control the torque during starting and stopping without any need for a tachogenerator.
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. Rating: to be at least as mentioned on the drawings.
- C. Isolation transformer: Match transformer voltage ratings and capacity to system and motor voltages and controller, motor, drive, and load characteristics.
- D. Standards:
 1. Vibration resistance: conforming to IEC 68-2-6.
 2. Maximum ambient pollution: conforming to IEC 664.
 3. Maximum relative humidity: conforming to IEC 68-2-3.
 4. Category of use: conforming to IEC 947-4-1 coordination type 2.
- E. Electrical characteristics
 1. Current adjustment: motor nominal current adjustable from 0.5 to 1.3 times the product rating.

2. Maximum starting current adjustable from 2 to 7 times the motor nominal current, and limited to 5 times the starter current limit.
 3. Stopping: adjustable by programming from 0.5 to 60s.
 4. Output relays: for end of start signaling.
 5. Safety output relay: including 2 separate contacts 1 "N/O" + 1 "N/C". Those contacts could be reassigned (for isolation on stopping,.)
 6. Analog output, 2 logic outputs and 3 logic inputs.
 7. 1 isolated output (+24V) available from the soft starters for control purposes.
 8. Thermal protection: microprocessor based, which monitors continuously the temperature rise of the motor and of the starter unit.
The protection device shall be adapted for different starting closes (10A, 20, 30) and it shall be fitted with a thermal memory.
The protection devices shall prevent the motor from restarting after a thermal fault, if the motor temperature is still too high.
 - a. Phase failure and imbalance, indicated by output relay.
 - b. Protection against short circuits less than 13IcL.
- F. Display parameters: all messages shall be displayed on a digital LCD screen. The soft starter shall be fitted with soft-touch membrane keypad switches, LED pilot lights and multi-fault memory.
- G. Communication port for J bus communication protocol.

2.6 VARIABLE-SPEED DRIVES

- 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.
- B. 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.
- C. Design and Rating: Match type pumps or fans; and type of connection used between motor and load such as direct or through a power-transmission connection.
- D. Isolation Transformer: Match transformer voltage ratings and capacity to system and motor voltages; and controller, motor, drive, and load characteristics.
- E. Output Rating: 3-phase, 0.5 to 320 Hz, with torque constant as speed changes.
- F. Starting Torque: 100 percent of rated torque or as indicated.
- G. Speed Regulation: Plus or minus one percent.
- H. Ambient Temperature: 0 to 40 deg C.
- I. Efficiency: 95 percent minimum at full load and 320 Hz.
- J. 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.
- K. 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.
- L. 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 over-current trip.
 6. Loss of phase protection.
 7. Reverse phase protection.
 8. Under- and overvoltage trips.
 9. Over-temperature trip.
 10. Short-circuit protection.
- M. 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.
- N. Power-Interruption Protection: Prevents motor from reenergizing after a power interruption until motor has stopped.
- O. Status Lights: Door-mounted LED indicators to indicate the following conditions:
1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Over-current.
 6. External fault.
- P. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- Q. 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.
- R. Automatic Bypass: Magnetic contactor arranged to safely transfer motor between controller outputs and bypass controller circuit when motor is at zero speed. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contactors and a motor overload relay. An Additional manual Controller-off-bypass selector switch indicator lights set and indicate mode selection.

- S. Integral disconnect.
- T. 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.
- U. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

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

- A. MCCB below 800 Amperes and Air Circuit Breaker above 800 Amperes, both with utilization category “B” and electronic trip unit.

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 (electrical parameters measurement): Power meter as indicated in Section 16442.
- 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.
- 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 Section 16120.
- 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 type tested (TTA) to IEC EN 60439-1.

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 the corresponding IEC standards. Certify compliance with test parameters.
 - 2. Remove and replace malfunctioning units with new units, and retest.
 - 3. THERMOGRAPHIC SURVEY: all current carrying components should be subject to a thermographic survey prior to certification and handling over. Values obtained by the thermographic survey should be compliant to the applicable standards and manufacturer recommendations.

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.

END OF SECTION

SECTION 16500

LIGHTING INSTALLATIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Work is deemed to include supply and installation of:
1. Lighting fixtures.
 2. Wires/cables including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or to final branch circuit panelboard.
 3. Lamps.
 4. Fixing and supporting materials.
- B. All fixtures are to have two cable entry holes.
- C. LED Lamps Fixtures:
1. All LED lamps shall have a minimum lifetime of 50,000 hours.
 2. LED strip lighting shall be white (4000°K) with a maximum of 24W per meter, with electronic driver.
- D. Low Voltage Lamp Fixtures:
1. Fixtures are to be supplied with transformers and accessories.
- E. Lighting Levels:
1. The required lighting levels and color temperatures are the following:
 - a. Office: 500 lux
 - b. Entrance: 200 lux
 - c. Reception: 300 lux
 - d. Corridor: 100 lux
 - e. Toilet: 150 lux
 - f. Guard: 200 lux
 - g. Janitor: 300 lux
 - h. Technical Room: 300 lux
 2. The uniformity ratio and lux level should be in accordance with CIE, CIBSE standards.

1.3 SUBMITTALS

- A. The following data (but not limited to) shall be submitted for approval:
1. Details on each fixture, lamp and control gear including manufacturer's catalogue cuts, catalogue number, rating, material specification, overall dimensions, operating characteristics, photometric data, etc.
 2. Installation details.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

- A. THORN/ZUMTOBEL (UK)
- B. BEGA (GERMANY)
- C. PHILIPS (NETHERLANDS)
- D. MAZDA (FRANCE)
- E. SIMES (ITALY)
- F. IGUZZINI (ITALY)
- G. Or other equal approved.

2.2 LIGHTING FIXTURES

- A. Unless otherwise specified, fixtures are to be manufacturer's standard series.
 - 1. Fixtures are to be fabricated, assembled and wired entirely at the factory. Site work is to be restricted to reassembling parts dismantled at the factory for packing and transportation.
- B. Housing is made of not less than 0.6 mm thick sheet steel.
 - 1. Sheet steel for reflectors should not be less than 0.8 mm thick.
 - 2. Aluminum sheet for reflectors should not be less than 1.0 mm thick.
- C. Light reflecting surfaces are to be finished with white baked enamel paint having a reflection factor not less than 80%. Finish is to withstand 72 hours exposure to an ultra-violet RS lamp placed 100 mm from surface.
- D. Wiring to be not less than 1mm², insulated for 220 V supply. Wiring is to be terminated on screw type insulated, terminal blocks.

2.3 TUBULAR FLUORESCENT LAMPS (26mm DIAMETER)

- A. Normal start, bi-pin, rated as described on the drawings. Guaranteed rated life is to be above 10000 hours if with conventional control gear and above 13000 hours if with electronic control gear. The luminous output shall be above:
 - 1. 650 lumens for 10 W lamps.
 - 2. 680 lumens for 15 W lamps (for daylight), 850 (for universal white), and 950 (for other colors).
 - 3. 850 lumens for 16 W lamps (for warm white), 1050 (for universal white), and 1250 (for other colors).
 - 4. 1200 lumens for 18 W lamps.
 - 5. 2000 lumens for 30 W lamps (for universal white), and 2350 (for other colors).
 - 6. 2700 lumens for 36 W lamps (for universal white), and 3250 (for other colors).

7. 2500 lumens for 38 W lamps (for universal white), and 3300 (for other colors).
8. 4150 lumens for 58 W lamps (for universal white), 5000 (for daylight), and 5200 (for other colors).

2.4 TUBULAR FLUORESCENT LAMPS (26mm DIAMETER)

- A. Normal start, bi-pin, rated as described on the drawings. Guaranteed rated life is to be above 16000 hours. The luminous output shall be above:
1. 300 lumens for 8 W lamps (for daylight) and 450 lm (for other colors).
 2. 600 lumens for 13 W lamps (for warm white) and 950 lm (for other colors).
 3. 1100 lumens for 14 W lamps (for daylight) and 1200 lm (for other colors).
 4. 1750 lumens for 21 W lamps (for daylight) and 1900 lm (for other colors).
 5. 1600 lumens for 24 W lamps (for daylight) and 1750 lm (for other colors).
 6. 2400 lumens for 28 W lamps (for daylight) and 2600 lm (for other colors).
 7. 3050 lumens for 35 W lamps (for daylight) and 3300 lm (for other colors).
 8. 4300 lumens for 49 W lamps.
 9. 4050 lumens for 54 W lamps (for daylight) and 4450 lm (for other colors).
 10. 5700 lumens for 80 W lamps (for daylight) and 6150 lm (for other colors).

2.5 PL FLUORESCENT LAMPS

- A. Compact, with special bi-pin socket, rated as described on the drawings. Guaranteed rated life is to be above 13000 hours and luminous output above the following:
1. 250 lumens for 5W lamps.
 2. 400 lumens for 7W lamps.
 3. 600 lumens for 9W lamps.
 4. 850 lumens for 11W lamps.
 5. 900 lumens for 15W lamps.
 6. 1200 lumens for 18W lamps.
 7. 1800 lumens for 26 W lamps.
 8. 2400 lumens for 32 W lamps.
 9. 2800 lumens for 36 W lamps.
 10. 3500 lumens for 40 W lamps.

2.6 HALOGEN LAMPS

- A. Lamps shall be rated as described on the drawings. Glass is to be made of UV-absorbent quartz guaranteed rated life is to be above 2000 hours for mains voltage and 4000 hours for 12 V halogen lamps. The luminous output shall be above:
1. 320 lumens for 20 W, 12 V lamps.
 2. 600 lumens for 35 W, 12 V lamps.
 3. 900 lumens for 50 W, 12 V lamps.
 4. 2500 lumens for 150 W lamps.
 5. 4350 lumens for 250 W lamps.
 6. 5000 lumens for 300 W lamps.
 7. 9500 lumens for 500 W lamps.

2.7 METAL HALIDE LAMPS

- A. Lamps shall be rated as described on the drawings. Color of light is to be warm white with excellent color rendering properties. Luminous output to be above 12000 lumens for 150 W lamps.

2.8 LED LAMPS

- A. Within the Luminaires:
1. The light source shall be high white Light Emitting Diodes (LEDS) with individual minimum efficacy of at least 100 lm/W arranged modularity to provide the required lighting output. All lumen figures shall be delivered {Hot} Lumens.
 2. The LEDs shall be from a reputed manufacturer of LEDs with proven past performance in accordance with ANSI/NEMA/ANSLG C78.377-2008 – (American National Standard for Chromaticity of Solid State Lighting Products) or similar approved International Standard.
 3. They shall only be from MacAdam Ellipse Step-3 or Step-4 Bins. Step-7 Binning is not acceptable.
 4. The CRI ≥ 70 .
 5. The LEDs shall be removable/replaceable on site by modular means without any possible risk to maintaining luminaire photometry and without the need to demount the fixtures for sake of future upgrading/maintenance requirements.
- B. Whole Luminaire Efficacy:
1. The optimum efficiency of the luminaire shall be confirmed as follows:
 2. Minimum luminaire efficacy shall be ≥ 75 lm/cctW (@ min 50°C, min 95%RH).
 3. Which is given as Total Luminaire Design (Deliver) Lumen Output (lm) over Total Luminaire Circuit Watts (cctW) at minimum 50°C Operating outside Ambient Temperature and minimum 95% Relative Humidity.
 4. The efficacy being stated at minimum 50°C (Greater than or equal to 75 lm/cctW) should be supported by a thermal test report for the luminaire. This report should provide percentage depreciation of light output at 50°C from testing value of 25°C or 35°C. This can be compared with LM-79 efficacy at lab temperature from photometric report and de-rated. The effect on the driver case temperature at minimum 50°C should also be shown.
- C. Optical Control:
1. Luminaire shall be fitted with optical refractors, diffusers and/or reflectors.
 2. Different optics shall be proposed to exactly suit the specific applications.
 3. Independent laboratory photometric test reports shall be submitted for the luminaire photometric files used in the lighting calculations. The testing should conform to IESNA LM-79-08 standards.
- D. Thermal Management:
1. The LED modules shall be mounted on heavy duty heat sinks to ensure excellent head dissipation. The design of the heat sinks shall be such that there is a direct thermal path from the LED junctions to the atmosphere, thus providing a thermal transfer effect throughout the life of the luminaire. The

heat sinks shall be proprietary and designed by the lighting manufacturer to enable the luminaires to work efficiently in local climatic conditions. The luminaire shall be provided with a demonstrated ventilation arrangement allowing heat to be dissipated to the atmosphere. The luminaire shall be designed to prevent collection of debris on the heat sinks by proven and stated means.

- E. The Manufacturer shall provide test certification in accordance with "IEC 60068 – 2 68 Part 2 Test L: Dust and Sand" and should be submitted by the manufacturer from an independent / independently certified test laboratory. The test certificate should provide evidence that the heat increase inside the housing enclosure with dust and sand, should not be more than 10% of the heat inside without accumulation and with no adverse effect on the lifetime of the luminaire and components.
- F. The design shall be such that the luminaire shall be self cleaning in normal operation. The luminaire shall be provided with heavy-duty rugged cast aluminum adjustable slip fitter mountable to suit the proposed pole. The Contractor shall coordinate with the LED fitting manufacturer and pole manufacturer to make sure complete compatibility of the products.
- G. Ingress Protection:
1. The LED Fixture Driver and LED Engine/optical unit components shall be externally fully rated at a minimum of IP-65 (with the driver or driver housing to have a minimum rating of IP-66) and have proven means of negating internal condensation build-up.
 2. They shall have a minimum mechanical strength rating of IK-07 (minimum IK-08 required for all glass components). All synthetic materials shall be 100% UV stable and scratch resistant.
- H. Copper Content:
1. All Aluminum Die-cast components shall have a very low copper content of less than 0.1% for corrosion resistance or similar proven methodology of protection.
- I. LED Sources Technical Requirements:
1. Within the fixture, the LED sources shall meet the following requirements:
 - a. Operating temperature rating shall be between [-40°C] and minimum [+50°C] at a minimum 95% Relative Humidity (RH).
 - b. Storage (i.e. non-operating/daytime) temperature: all LED components to be designed to tolerate between [-40°C] and minimum [+80°C] at a minimum 95% Relative Humidity (RH).
 - c. Correlated Color Temperature (CCT): 4000-6000K
 - d. Color Rendering Index (CRI): ≥ 70 .
 2. Luminaire manufacturer shall submit reliability reports indicating that the manufacturer of the LED (chip, diode, or package) has performed Joint Electron Devices Engineering Council (JEDEC), or similar International approved equivalent; reliability tests on the LEDs as follows. Factory prerelease test reports shall be provided from the LED manufacturer duly complying with JEDEC JESD22-A108C, or equivalent, for operating life tests at 85°C ambient temperature and also for humidity and salt atmosphere corrosion tests. Standards and tests used must be stated.

- J. LED Drivers Technical requirements:
1. Drivers shall be 1-10V dimmable and have a minimum efficiency of 85%.
 2. Case (Tc °C) Temperature rating [-40°C] to minimum [+80°C] and at a minimum 95% Relative Humidity (RH). Driver/Fixture to have some means of built-in overheat thermal protection in the form of automatic dimming or stepping/holding down of the driver where temperature exceeds operational limits. Thermal cut-out devices which turn the fixture LEDs completely off are not acceptable.
 3. The driver and driver output current must be shown to be fully tested and compatible with the exact LED chips/engine of the luminaire. All information provided and the cost analysis/payback calculations should be calculated with the exact drive current including the calculation for the cycle, life and resultant increase or decrease of the energy consumption if applicable.
 4. Input Voltage: Capable of 120-277 Volt, single phase, or as required by the site.
 5. Power supplies can be UL Class 1 or II output, or similar European CE or International equivalent.
 6. Surge Protection: Must be tested in accordance to the requirements of IEEE/ASNI C62.41.2-2002, Scenario I, Location Category C, or International equivalent.
 7. Drivers shall have a Power Factor (PF) of $L: \geq 0.90$.
 8. Drivers shall comply with non-consumer RFI.EMI standards or equivalent.
 9. Drivers shall be RoHS Compliant.
 10. Drivers shall have a total individual luminaire Harmonic Distortion (THD) of: $\leq 20\%$ in accordance with ANSI C82.77 (2002). However the Contractor shall measure the harmonic at the supply point (LV side of the distribution substation) after the installation of all the LED street lights and adopt harmonic compensation methods to limit the total harmonics distortion in the supply voltage to maximum 5% as per IEEE 519 Regulations.
- K. Useful Life requirements: The useful life of the luminaire in terms of lumen output must be as specified by one of the following two methods.
1. As per LM-79-08 or approved International equivalent: Simplified B20-L70 threshold. A minimum of 50,000 operating hours before reaching the B20-L70 lumen output degradation point with no catastrophic failures. The B20-L70 lumen output must be capable of providing the luminance level and uniformity.
 2. Site Performance Method: A life time of number of hours specified by the site based on expected site lighting useful life must be capable of providing the luminance levels of uniformity.
- L. Useful Life Testing and Verification Procedure:
1. Simplified B20-L70 Threshold: Perform LM-79-08 (or approved International equivalent) testing on the luminaire at both time intervals of 0 hours and 6,000 hours. The luminaire shall be operated continuously in the appropriate UL 1598/153 environment or equivalent except when it is removed to perform the LM-79 light output tests. If the light output determined at 6,000 hours is $\geq 96\%$ of the light output determined at 0 hours, the luminaire meets the simplified B20-L70 threshold for useful life.

M. Site Performance Method:

1. Perform lumen depreciation testing per LM-80-08 (or approved International equivalent) on the light sources (s) (module/array) for a minimum of 6,000 hours (longer testing period is encouraged). Identify the installed (in luminaire) operating temperature of the LED using the Ts point under operating ambient temperature of 50°C. From this interpolated curve, determine the lamp lumen depreciation (LLD) value and useful life that meets the needs of the site defined hours of operation to end of useful life as well as the luminance level and uniformity required.

2.9 COLD CATHODE TUBES

- A. Cold-cathode lamps shall include cold-cathode fluorescent lamps (CCFLs) and neon lamps. Neon lamps primarily rely on excitation of gas molecules to emit light. CCFLs use a discharge in mercury vapor to develop ultraviolet light, which in turn causes a fluorescent coating on the inside of the lamp to emit visible light.
- B. Extrusion: The extrusion will be 2 parts (top and bottom) and shall be made of aluminum. The bottom extrusion shall have four .125 diameter holes for end plates to screw into, or for steel pins to be pressed into so that the adjacent fixture can be attached. The base extrusion can be used as a wire way. The top extrusion will be notched at the ends to allow the electrodes to pass thru, then the lamp and transformer will be mounted to the extrusion.
- C. Lamp: As manufactured by Neotek, shall be 25mm diameter, lead glass halophosphor or triphosphor coated as per specified color and fabricated to proper size, shape, and made with flat ends. The electrodes shall be rated for 200mA, and welded onto tube in a "bend back" configuration. The tube will then be heated and annealed to relieve stress and strengthen tube. Tubes will be processed with turbomolecor pump system and bombarded as per the electrode manufacturer. Color of lamps shall be selected by the Designer.
- D. Transformer: The transformer is a dimmable solid state type and is mounted inside the top extrusion. The transformer is UL2161 with the secondary fault detectors. The voltage will be 990 volts on the output and rated at 120mA. The secondary wire shall be listed GTO5 or greater and rated for 105°C. Transformers have three wires that are Hot (120V), Dimmed Hot (0-120V), and Neutral (-). The transformer is High Power Factor for efficiency. Primary is 120volts/ 0.80 Amps each. A maximum of 14 fixtures per 20 Amp circuit is recommended.
- E. Lens: (optional) The fixture will have a protective lens made of UV protected acrylic and will snap onto the sides of the extrusion. These lens are recognized by UL and have a flame class of 94HB.
- F. Testing: The fixture shall be tested by Underwriters Laboratories, Inc. (UL) as a complete unit and shall be listed for indoors and/or outdoors wet location. Each fixture shall have a UL Listing Mark under UL File E216527. The fixture shall be tested under UL-48, UL-1598, and UL-5 Standards.

- G. Components Accessories:
1. Clip: To hold the Cathode tube in the assigned position; polycarbonate, or plastic material, or stainless steel.
 2. Support: To increase the distance of the clip from the installation surface.
 3. End Cap: To protect the cable connection on the electrodes.
 4. Electrode: The core of the cold cathode tube.
 5. Cable: To connect the secondary circuit of the transformer to the cold cathode tube.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install work in accordance with approved standards, as per manufacturer's recommendations, and to the satisfaction of the Engineer.
- B. Fixtures are to be installed aligned, leveled and at uniform heights within one room or area. Fixtures are to be supported with hangers to support weight of fixture.
- C. Exact position of fixtures must be coordinated with the reflected ceiling plan.
- D. Recessed fixtures in suspended ceilings are to be coordinated with exact dimensions of ceiling tiles.

END OF SECTION

SECTION 16525

OUTDOOR AND ROAD LIGHTING INSTALLATIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Works to include outdoor area and road lighting including luminaires, bracket/arm, poles, related power distribution and control, protective earthing and related builder's work (pole foundations, cable earth pits, cable trenches, ductwork, etc.).
- B. Manufacturer is to verify compliance with standards and the applicable local regulations and design standards.
- C. Luminaires generally are to comply with IEC 598 and the applicable C.I.S.P.R. recommendations. Manufacturer is to verify compliance with these standards and the applicable local regulations and design standards.
- D. Minor deviations from Drawings may be considered for improvement in construction details, but no changes are to be made without the written approval of the Engineer.
- E. Unless otherwise specified, equipment is to be designed and derated for continuous and trouble-free service at 40°C ambient temperature and 85% relative humidity, with temperature reaching 50°C in direct sunlight and with high content of ultra-violet rays. Equipment is to withstand full load operation whilst exposed to sun.
- F. Submit complete data for approval including, but not limited to, the following:
 - 1. Detailed literature, in English, for each type of luminaire or fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principals, and any modification to a standard product if applicable.
 - 2. Detailed specification and drawings for each pole type including shape, base/mounting flanges, bolts, nuts etc, cross-sections, design criteria and calculations, brackets, finishes, provisions for cabling, service cut-out or circuit breaker etc.
 - 3. Photometric data for lighting calculations including polar curves, coefficients of utilization, efficiency and depreciation factors.
- G. Submit drawings for approval including, but not limited to, the following:
 - 1. Layout of equipment in exact positions with mounting and construction details, foundation dimensions and reinforcement, routing and sections of duct-banks and trenches, backfill and packing material, earthing rods, etc.
 - 2. Cabling and wiring diagrams, single line drawings, loads, phase distribution, protection and control, earthing and the like.
 - 3. Calculations of illumination levels and glare, based on CIE methods.

- H. Submit fully equipped sample of luminaire or other materials or components if required by the Engineer.
- I. Provide items necessary for maintenance, and up to 5% (or nearest whole unit) of installed quantities of each type of lamp, control gear, fuses, luminaire covers, breaker, special bolts or nuts, lamp-holders and the like which are subject to burning, breakage or failure.

1.3 DESIGN CRITERIA

- A. Lighting design criteria to be applicable to all roads as detailed on the Drawings. The road surface on which the lighting levels are to be measured is defined as the width of all the traffic lanes of all road ways, ramps, interchanges, etc.
- B. Luminance and illuminance levels of the roadways as specified below are the maintained average level, which are to be calculated and substantiated by the Contractor. Initial values after 100 hours of operation are to be submitted and substantiated by computer printouts (established by an approved computer program) for the results. Contractor is to specify the lumen and luminaire dirt depreciation factors after two years of operation recommended by the manufacturers, to assist the Engineer in assessing the maintained lighting levels of the installation.
- C. Luminance and illuminance levels and uniformities are to be calculated by the Contractor for the travel lanes. The Contractor shall take account of the different elevations of roadways and ramps in his lighting calculations. The Contractor is to include for the luminaires manufacturer to carry out the final setting of all rights after site erection to ensure maximum utilization of light output.
- D. Maintained lighting levels for all traffic roads are to be:
 - 1. Minimum Maintained Average Luminance Levels (L_{avg} cd/sq.m): 1.0.
 - 2. Overall Uniformity: $U_O = L_{min}/L_{avg}$: 0.4.
 - 3. Longitudinal Uniformity: $U_L = L_{min}/L_{max}$: 0.7.
 - 4. Relative Threshold Increment: $T_i < 10\%$.
- E. Contractor is to check location of all poles, to ensure that the installation does not cause any conflict with other installations.
- F. Clearances required by International Regulations are to be applied. In case of a conflict, the issue is to be raised to the Engineer accompanied with the proposed solution for approval before proceeding with any works. It is the Contractor's responsibility to ensure that above Regulations and Clearances required are met.

PART 2 PRODUCTS

2.1 LIGHTING POLES

- A. Poles are to be of section suitable for the fixture, tapered, formed sheet steel, electrically welded, and of the height specified and as shown on the Drawings. Poles are to be one piece section. Poles are to have minimum wall thickness of 3 mm at base. Sheet steel is to have minimum rupturing resistance of 37 kg/mm² and minimum yield strength of 24 kg/mm².

- B. Top of pole is to be designed to receive single or multiple arm brackets or other arrangement required, so as to support the number of luminaires shown on the Drawings. Bracket arrangement is to be designed to ensure that failure, due to wind induced oscillations, does not occur and that rotation from desired alignment is not possible.
- C. Pole cross-section, thickness of steel, joints, welds, bolts etc. are to be designed to withstand gust wind velocity of 160km/hr blowing in the most unfavorable direction at a height 10m above ground level, with pole fully equipped. Fatigue of steel is in no case to exceed half elasticity limit, taking into account dynamic stresses due to vibrations. Steel flange plate, of adequate thickness, is to be solidly welded onto lower edge of pole as shown on the Drawings, and is to have specified number of holes for holding down bolts together with central cable access hole not less than 150mm diameter.
- D. Access door of weatherproof construction is to be positioned at pole base and is to be suitably sized to insert and service the supply cable terminations and protective device. Door is to be flush fitting with retaining mechanism and positive locking arrangement with removable hexagonal key. Pole is to be reinforced at door opening. Opposite each door, a non-hygroscopic baseboard of suitable size to accept appropriate equipment is to be fixed to inside of pole by purpose-made brackets. Stainless steel earthing stud with washers and nuts is to be welded inside the pole near the access door.
- E. Welds are to be smooth with spatter removed. Inside and outside surfaces of pole are to be cleaned by pickling or blasting and are to be free of grease. Steel components of poles are to be painted with approved three-coat protective paint system after grit blasting and shop priming, or hot-dip galvanized and painted with approved three-coat protective paint system after application of approved mordant coat. Minimum thickness of zinc coating is to be 500g/m² on both inside and outside surfaces of pole. Galvanizing is to be to NFA 91 121 (June 1958) or BS 729. Any damage to galvanizing is to be rectified during erection by wire brushing affected area and treating with approved rust converter to the satisfaction of the Engineer. Flange plate and inside and outside of pole base 2.5m high above ground level are to be coated with heavy bitumen paint prior to erection. Washers and nuts used for pole fixation on the foundation are to be protected by approved covers, to the Engineer's satisfaction.
- F. Poles are to be connected over 3-phase cables and neutral, unless otherwise shown on the Drawings. Suitable bolted terminals and cable lugs are to be provided, for incoming and outgoing 3 phase 4 wire cable, and of the sizes shown on Drawings. One single phase circuit breaker, rated according to lamp wattage and to short circuit level calculated at pole location is to be provided for each luminaire. Circuit breakers are to be compensated and rated for 50°C ambient with interrupting capacity as specified under other sections of the specifications, and are to be mounted in weatherproof enclosure at baseboard. Wiring is to be XLPE insulated 3 or 4 core 90°C conductor temperature. Cable is to be at least 4 mm² copper conductor.

2.2 ROAD AND OUTDOOR LIGHTING LUMINAIRES

- A. Luminaires are to be totally enclosed, dust protected and splash proof, with lamp compartment protection conforming to at least IP 65 of IEC 529, unless otherwise shown on drawings, and control gear protection to at least IP 44. Luminaire is to be shock resistant and specially designed to house required lamps, electrical gear and accessories. Body is to be corrosion resistant, extruded, pressure die-cast or fabricated aluminum alloy.
- B. Exposed metal parts of luminaires are to be factory finished, stove enameled, with suitable corrosion resisting paint capable of resisting heat emitted by lamp during continuous operation, and under full sunlight conditions. Color is to be agreed with the Engineer.
- C. Mirror reflectors are to be single piece, with 99.5% purity, glazed and anodized aluminum or die-cast, super-purity aluminum vapor-deposited, and coated with transparent layer of silicon protection against wiping.
- D. Luminaire protectors are to be heat and shock resistant cured and smooth glass, mounted into suitable frame assembly fixed to body by captive screws, and secured by extra safety clamps to allow replacement of protector and reflector. Ozone resistant ethylene propylene or approved equivalent rubber is to ensure sealing of the front glass.
- E. Lamp sockets are to be high grade porcelain, mounted in support brackets with provision to adjust lamps vertically and axially. Lamp support and locking system are to grip and prevent lamp movement in operation.
- F. Ballast and control gear are to be mounted in luminaire in separate compartment isolated from lamp, and with enclosed terminal blocks fitted with quick-disconnect electrical leads. Where required, control gear is to be contained in the prewired box, having an enclosure of IP 65, and mounted on luminaire ring separately from luminaires. Control gear is to be plug in type for operation at 220V, ac single phase, 50 Hz, ballast is to be specially selected for particular type of lamps used, and lamps are to be able to start with at least +/-10% variation of nominal voltage and continue in normal operation with dips attaining 20% for four seconds. Control gear losses are not to exceed 10% of normal lamp wattage. RFI suppression device is to be provided. Power factor is to be compensated to at least 0.9 lagging.
- G. HRC fuse cartridges, suitably rated and conforming to IEC 269 or BS 88, are to be provided, complete with base, for protection of the luminaire. Fuse is to be rated to withstand starting current and is to be preferably located in control gear enclosure.
- H. Terminal blocks are to be of the suitable screw-underpass type, clearly marked with arrangement to facilitate maintenance, quick replacement and easy disconnection of individual components.
- I. Types of lamps are to be as shown on the Drawings.

- J. Fixtures:
1. The fixtures 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 as indicated on drawings and in accordance to the specification and to the Engineer approval.
 2. Fixtures 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.
 3. Ballasts and ignitors 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.

2.3 GUIDE TO SPORTS LIGHTING LEVELS

- A. In general, fast action, a small playing object (cricket ball) and long viewing distance will require high lighting levels. A slower speed, larger playing object (football) and closer viewing distance will require lower lighting levels. Exterior sports lighting is provided to achieve either supervised training, club, national, international or CTV coverage.
- B. Various lighting guides and lighting specifications are available, recommending appropriate illuminance levels for individual sports. Within Europe, a European Standard exists covering minimum sports lighting levels: EN 12193:2007. In addition, many sports governing bodies also provide separate specific lighting requirements.
- C. Most recommendations of individual sports lighting levels are divided into classes of play:
1. Class I - Top Level Competition.
 2. Class II - Intermediate Level Competition.
 3. Class III - Lower Level Competition & Supervised Training.
- D. Lighting for CTV broadcasting has specific requirements and recommendations (CIE No.83:1989).

- E. The table below provides a selection of recommended lighting levels for principle sports in accordance with EN 12193:2007 (**Class II to be used in the Project**).

Recommendations of Minimum Lighting Levels (Table 1)										
Sport	Illuminance Level (Em. Horizontal) Lux * (Non CTV)							Glare Rating (GR)		
	Class I		Class II		Class III			I	II	III
	Em Lux	Uo Min/ave	Em Lux	Uo Min/ave	Em Lux	Uo Min/ave				
Athletics	500	0.7	200	0.5	50 to 100		0.5	50	55	55
Baseball	In Fld	750	0.7	500	0.7	300	0.5	50	50	55
	Out Fld	500	0.5	300	0.5	200	0.3	50	50	55
Basketball	500	0.7	200	0.6	75	0.5	50	50	55	
Bowls (Flat Green)	300	0.7	200	0.7	100	0.5	50	50	50	
Cricket Grounds	Sq	750	0.7	500	0.7	300	0.5	50	50	55
	Field	500	0.5	300	0.5	200	0.3	50	50	55
Equestrian	500	0.7	200	0.7	100	0.5	50	50	55	
Football (soccer)	500	0.7	200	0.6	75	0.5	50	50	55	
Hockey	500	0.7	200	0.7	200	0.7	50	50	55	
Horse racing	200	0.6	100	0.4	50	0.2	50	50	55	
Netball	500	0.7	200	0.6	75	0.5	50	50	55	
Rugby	500	0.7	200	0.6	75	0.5	50	50	55	
Tennis	500	0.7	300	0.7	200	0.6	50	50	55	
Volleyball	500	0.7	200	0.6	75	0.5	50	50	55	

* Em is the Maintained Illuminance Level (specification level) and is the design illuminance level, below which the lighting should not be allowed to fall during the period to planned maintenance.

2.4 LOW VOLTAGE CABLE IN LIGHTING POLES

- A. Electrical cables inside poles, between electrical cut-outs and lanterns shall be as specified in the Technical Specifications. The temperature rate of PVC insulation and sheaths shall be 105°C and test certificates from independent laboratory shall be submitted. Street lighting property, temperature rating and size data shall be printed on the outer sheath of cable.
- B. Electrical Cut Out for Street Poles:
- All lighting poles shall be provided with an electrical cut-out at the pole base near the hand-hole for terminating and interconnecting underground cables. Lantern wiring cable dimensions and steel thickness shall meet requirements as specified in the Technical Specifications. There shall be suitable provisions inside the pole shaft to properly fix the electrical cut-out. All electrical cut-outs enclosures shall

-
- be IP 43 designed, manufactured, tested and sized in accordance with requirements of specifications.
2. The electrical cut-outs shall be provided with adequate MCBs matching requirement of various lantern sizes and types as described in the applicable clauses of the specifications. Supply and installation of electrical cut-outs for the light poles is to be considered as a part of installation of the lighting poles as indicated in the Bills of Quantities.
 3. The cut-outs shall be dust and damp protected, totally enclosed and made of zinc coated steel 1.6 mm thickness. The cut-out shall be provided with an earthing terminal and shall accept cables up to 25 mm². The cut-outs shall be suitable for looping-in 4-cores incoming and outgoing underground power cables.
 4. 10 A or 16 A (according to lantern power) MCBs shall be provided to protect the outgoing 2.5 mm² cable and connected control gear. The cut-out cover shall be made in such a way that the MCBs shall be operated without removal of the cover.
 5. All terminals shall be securely fixed within the cut-out enclosure. The cut-out shall be fitted with Brass Compression Cable Glands Type BW according to BS 6121 and with Earth Tag and PVC Shroud suitable for the proposed cable sizes. The cut-out shall have the number of MCBs corresponding to the lanterns on each pole.
 6. MCB's shall be thermal magnetic operated with the following features:
 - Short circuit current interrupting capacity shall be 10 kA at 240/415V.
 - Reference ambient temperature of MCB shall be 50°C.
 - Mechanical service life of the device shall be 100,000 switching cycles.
 - Service life of the device at rated voltage shall be 50,000 switching cycles.

PART 3 EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

- A. Install equipment to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made to accomplish this but no changes are to be made without the approval of the Engineer.
- B. Install poles on concrete bases as detailed on the Drawings. Before commencement of construction, ensure that bases are suitable for pole installation. Holding down and plumb adjusting nuts, washers, locknuts or nyloc nuts are to be stainless steel or cadmium plated.

- C. Erect poles so that luminaires are located on a line parallel to theoretical profile of road. Alignment of poles, both horizontally and vertically, is to be secured to the satisfaction of the Engineer. Brackets are to be set at 90° to longitudinal axis of road.
- D. After demonstrating to the Engineer that specified lighting requirements have been met, carry out final setting and locking in position of the floodlights.
- E. Carry out in accordance with the Specifications. Cabling, conduits, ductwork, and cable ducts are to be directly buried except at crossings with other service work or roads.
- F. Carry out earthing in accordance with the Specifications.
- G. Visual inspection is to include inspection of condition of each piece of equipment, quality of workmanship, alignment, perpendicularity, labeling and the like, all in conformance with the Specification.
- H. Insulation resistance and continuity tests are to be carried out on each circuit and piece of equipment before energization, with circuit breakers in the open position and lamps not installed.
- I. Operational tests are to be carried out on all circuit breakers and control gear, with lamps installed, including recording voltage at terminals of ballasts on final poles of each circuit and at distribution panel or the like.
- J. Performance tests to be carried out after 100 hrs normal operation, and are to include measurement of lighting levels and uniformities on required illuminated surfaces.
- K. Other tests are to be carried out as required by the Engineer to verify conformity with the Specification.
- L. Earthing resistance tests are to include measurement of earth electrode resistance at final points of circuits and continuity of protective conductors.
- M. Results of tests are to be recorded on site and signed by witnessing parties.
- N. Provide equipment and labor including instruments and complete provisions for carrying out tests.

3.2 INSTALLATION

- A. Install work in accordance with approved standards, as per manufacturer's recommendations, and to the satisfaction of the Engineer.

END OF SECTION

SECTION 16530
EMERGENCY LIGHTING

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes emergency lighting units and exit signs.
- B. Related Sections:
 - 1. Section 16060 - Earthing.
 - 2. Section 16500 - Lighting Installations.

1.2 REFERENCES

- A. National Electrical Manufacturers Association:
 - 1. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

1.3 SYSTEM DESCRIPTION

- A. Emergency lighting to comply with relevant local authorities' requirements, and EN 50171.
- B. Exit light to comply with EN 60598-2-22.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit dimensions, ratings, and performance data.
- C. Samples: Submit two color chips 3 x 3 inch (75 x 75 mm) in size illustrating unit finish, color and texture.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.

1.6 MAINTENANCE MATERIALS

- A. General Requirements: Execution requirements for spare parts and maintenance products.
- B. Furnish one replacement lamps for each lamp installed.
- C. Furnish one replacement battery for each battery type and size.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Emergency Lighting Units:
 - 1. Cooper Industries.
 - 2. General Signal Corp.
 - 3. Mule Emergency Lighting.
 - 4. Or other equal approved.

- B. Exit Signs:
 - 1. Cooper Industries.
 - 2. General Signal Corp.
 - 3. Mule Emergency Lighting.
 - 4. CEAG-EATON
 - 5. Or other equal approved.

2.2 EMERGENCY LIGHTING UNITS

- A. Product Description: Emergency lighting system will have lighting with 3 hours autonomy battery pack; as shown on drawings.
- B. Lamps: As shown on drawings:
 - 1. LED lights.
- C. Input Voltage: 220 Volts.

2.3 EXIT SIGNS

- A. Product Description: Exit sign fixture suitable for use as emergency lighting unit; as shown on drawings.
- B. Face: Unless otherwise shown on drawings:
 - 1. Translucent glass or plastic face with red or green letters on white background; OR
 - 2. Aluminum or steel stencil face with red or green letters.
- C. Directional Arrows: As indicated on Drawings.
- D. Mounting: Wall, ceiling or pendant, as indicated on Drawings.
- E. Lamps: LED or compact fluorescent, as indicated on Drawings.
- F. Input Voltage: 220 Volts.

PART 3 EXECUTION

3.1 EXISTING WORK

- A. Disconnect and remove abandoned emergency lighting units, exit signs, lamps, and accessories.
- B. Extend existing emergency lighting and exit sign installations using materials and methods compatible with existing installations, and/or as specified.
- C. Clean and repair existing emergency lighting units and exit signs remaining, or are to be reinstalled.

3.2 INSTALLATION

- A. Install suspended exit signs using pendants supported from swivel hangers. Install pendant length required to suspend sign at indicated height.
- B. Install surface-mounted emergency lighting units and exit signs plumb, and adjust to align with building lines and with each other. Secure to prevent movement.
- C. Install wall-mounted emergency lighting units and exit signs at height as indicated on Drawings or directed by the Engineer.
- D. Install accessories furnished with each emergency lighting unit and exit sign.
- E. Connect emergency lighting units and exit signs to branch circuit outlets as indicated on Drawings.
- F. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within unit.
- G. Install specified lamps in each emergency lighting unit and exit sign.
- H. Ground and bond emergency lighting units and exit signs in accordance with Section 16060.

3.3 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting, and balancing.
- B. Operate each unit after installation and connection. Inspect for proper connection and operation.

3.4 ADJUSTING

- A. General Requirements: Execution requirements for testing, adjusting, and balancing.
- B. Aim and adjust lamp fixtures as indicated on Drawings.
- C. Position exit sign directional arrows where applicable as indicated on Drawings.

3.5 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished work.
- B. Relamp emergency lighting units and exit signs having failed lamps at Substantial Completion.

END OF SECTION

SECTION 16721

STANDALONE FIRE ALARM SYSTEM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Work is deemed to include supply and installation of a standalone fire alarm detection system including one combined detector with built in sounder in pump room, one heat detector with built in sounder in kitchen and one smoke detector with built in sounder in bedroom's corridor as shown on the drawings and specified herein.
The fire alarm system shall comply with requirements of NFPA Standard No.72, or requirements of BS EN54 and the civil defense local requirements.

1.3 GENERAL DESCRIPTION

Standalone Smoke Detectors with sounder base will be installed in all prefab units.

Built with high-quality components and advanced technology, the alarm shall have an excellently stable performance and low power consumption. A 9V battery will operate up to one year. An internal buzzer shall be provided with a loud local alarm.

An output terminal shall be available in case the alarm has to be linked to other alarms in a common alarm network or must be interfaced to other systems.

1.4 TECHNICAL SPECIFICATIONS

Power Supply: PP3 (H6F22) DC9V battery

Indicator: Red flashes in every 50 seconds in normal condition.

Output Interface: Available for optional use

Network Output: Maximum 30 alarm in one system, available for optional use.

Photoelectric Output: 5mA /30VDC, Optional

Local Alarm > 80dB

Detection Area: 40m²

Operating Environment: Temperature: -10°C ~ +50°C Relative Humidity: 95%

1.5 DETECTOR FUNCTIONS

Correct functioning: Indicated by a flash of its LED approximately every 45 seconds.

Fire alarm: Penetration of smoke into the detector after a certain period of time is indicated by its LED blinking rapidly. If smoke persists, the built-in alarm siren sounds (intermittent tone).

End of fire alarm: An alarm lasts until the smoke disappears and cannot be interrupted.

1.6 TESTING:

Connect the battery and press the test button, the buzzer will generate alarm and the LED flashes quickly. Release the button, the alarm resumes to normal operation. The test button can simulate the alarm condition.

1.7 SUBMITTALS

- A. General: Two copies of all submittals shall be submitted to the Engineer for review.
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s) including technical data sheets.
 - 2. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnections between the items of equipment.
 - 3. Provide a clear and concise description of operation which gives, in detail, the information required to properly operate the equipment and system.
 - 4. Approvals will be based on complete submissions of manuals together with shop drawings.
- D. Certifications: Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of Contract maintenance is an authorized representative of the major equipment manufacturer. Include names and addresses in the certification.
- E. Guarantee: All work performed and all material and equipment furnished under this Contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of substantial completion. The full cost of maintenance, labor and materials required to correct any defect during this one year period shall be included in the submittal bid.
- F. Applicable Publications:
 - 1. The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only.
 - 2. National Fire Protection Association (NFPA) - USA:
 - a. No. 70 National Electric Code (NEC).
 - b. No. 72 National Fire Alarm Code.
 - c. No. 101 Life Safety Code.

3. BS EN54

- B. Approvals: Fire alarm control panel shall meet the modular listing requirements of Underwriters Laboratories, Inc. Each subassembly, including all printed circuits, shall include the appropriate UL modular label, with all printed circuit board assemblies, power supplies, and enclosure parts. Systems which do not include modular labels may require return to the factory for system upgrades, and are not acceptable.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. SIMPLEX GRINNEL
- B. GENT
- C. SIEMENS FIRE TECHNOLOGY
- D. EDWARDS SYSTEMS
- E. OR OTHER EQUAL APPROVED.

2.2 EQUIPMENT AND MATERIAL

- A. Equipment and components shall be new, and the manufacturer's current model. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.
- B. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc. before beginning system installation. Refer to the riser/connection diagram for all specific system installation / termination / wiring data.
- C. All Equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place. (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

2.3 CONDUIT

- A. Conduit shall be in accordance with the specifications, minimum diameter 25mm.
- B. Where possible, all wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.

- C. Conduit shall not enter the fire alarm control panel, or any other remotely mounted control panel equipment or back boxes, except where conduit entry is specified by the FAP manufacturer.

2.4 WIRE

- A. All fire alarm system wiring must be new.
- B. Wiring shall be in accordance with specifications / drawings and as recommended by the manufacturer of the fire alarm system.
- C. Wire and cable not installed in conduit shall be fire resistant.
- D. Cables installed for the speaker circuit shall be fire resistant.
- E. All field wiring shall be completely supervised. In the event of a primary power failure, disconnected standby battery, removal of any internal modules, or any open circuits in the field wiring; a trouble signal will be activated until the system and its associated field wiring are restored to normal condition.

PART 1 EXECUTION

1.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, NFPA 72, local codes, as shown on the drawings, as recommended by the major equipment manufacturer, and to the satisfaction of the Engineer.
- B. All conduits, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas.

END OF SECTION

SECTION 16740

VOICE AND DATA DISTRIBUTION SYSTEM INSTALLATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

- A. Work comprises supply and installation of:
 - 1. RJ45 CAT6a outlets.
 - 2. 4 pairs, UTP, category 6a cables, conduits, raceways and accessories.
 - 3. Indoor telephone cable.
 - 4. Cable termination with all necessary cable termination accessories.
 - 5. Cable trays.
 - 6. Telephone and data distribution frame with cross-connect jumper wiring to connect EPABX extension lines to telephone riser cables, public external lines to the exchange.
 - 7. Electronic private automatic branch exchange (EPABX).
 - 8. Termination of conduits with all necessary conduit fittings, etc....
- B. The design and materials used shall conform to the following norms and standards (or updated versions of same, where applicable):
 - 1. ISO 11801 "ISO Wiring System Norm";
 - 2. EIA/TIA 568A "Commercial Building Telecommunications Wiring Standard";
 - 3. Technical Systems Bulletin "Transmission Performance Specification for Field Testing of Shielded Twisted Pair Wiring Systems";
 - 4. EIA/TIA-607 "Commercial Building Grounding/Bonding Requirements";
 - 5. EIA/TIA-569 "Commercial Building Standard for Telecommunications Pathways and Spaces";
 - 6. EIA/TIA-606 "Administration Standard for Telecommunications Infrastructure of Commercial Buildings".
- C. The useful life of the installation is to exceed 10 years.
- D. A warranty of 5 years is required on the whole installation (including all components, end-to end, no exceptions allowed).
- E. A full installation must conform to CAT6a standards (end-to end CAT6a, no exceptions allowed).
- F. Cables used for connectivity must be unshielded twisted pair category 6a (UTP CAT6a). UTP cables
- G. Cables of the same type must originate from the same manufacturer.

- H. All cables must be properly labeled with a standard, unique number on both ends.
- I. Outlets shall be RJ45 CAT6a, ISO 8877 compliant. They must be properly labeled and securely mounted at their locations.
- J. All equipment must be ISO 9002 certified (for parts and assembly)

1.3 SUBMITTALS

- A. The following data (but not limited to) are to be provided:
 - 1. Drawings: Riser diagrams, Layout of equipment, Typical wiring diagrams.
 - 2. Samples: Provide one sample of all field devices
 - 3. Installation details: Provide one copy of installation instruction sheet for all system components
 - 4. Specifications: Provide one copy of specification sheet for all system component

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

- A. Telephone and Data Distribution System:
 - 1. KRONE (GERMANY)
 - 2. POUYET (FRANCE)
 - 3. INFRA+ (FRANCE)
 - 4. 3M (FRANCE)
 - 5. Or other equal approved.
- B. EPABX System:
 - 1. ERICSSON (SWEDEN)
 - 2. AVAYA (USA)
 - 3. SIEMENS (GERMANY)
 - 4. Or other equal and approved.

2.2 TELEPHONE AND DATA SYSTEM COMPONENTS.

- A. Telephone and data system shall be complete with RJ45 CAT6a outlets, RJ45 CAT6a UTP cables, multi-mode fiber optic cables, cable trays and conduits.
- B. Cable trays and conduits shall be in accordance with section 16110.
- C. Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance.
- D. 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 wire ways to accommodate 30 percent future increase in active workstations and terminal points.
- E. Utilize cables that are LSOH plenum rated when passing unconcealed in air plenums.

- F. It must host 19" racks and provide facilities (space, power, grounding, etc.) for the passive and active devices. Cabinet shall be of the two sections type with two rotating axes (for the 19 U wall mounted cabinet).
- G. The passive and/or active components shall be separated by spacer panels.
- H. Cabinet shall be grounded to the main ground bar, as per EIA/TIA-607 standard. It shall be equipped with 1U switched power supply panel (with a minimum of 6 sockets 16A, 2P+E), wire guide modules, spacer panel, in addition to a number of RJ45 or RJ11 panels, fiber optic panels and 10 pairs connection modules as shown on the drawings and/or as directed by the Engineer.
- I. All racks shall be labeled.
 - 1. 19" rack available in 42 U (or 19 U) useful heights.
 - 2. Glass front door.
 - 3. Leveling feet and wheels (for the floor mounted 42 U cabinet).
 - 4. Fully forced ventilated (with 6 fans for the 42 U cabinet).
 - 5. Sheet steel rear panel.
 - 6. Lifting eyebolts.
 - 7. Cable entry plates, cables glands and cable clamps.
 - 8. Locks on the front door.
 - 9. Minimum Depth: 600mm.
 - 10. Minimum Width: 600mm.
 - 11. Earth strap.
 - 12. Earth bonding bar.

2.3 EPABX SYSTEM

- A. EPABX is to be manufactured using the latest "Solid State" integrated circuits technology and VLSI technology.
- B. The electronic private automatic branch exchange (EPABX) shall be of digital stored program controlled (SPC) communication system and time division multiplexing (TDM).
- C. The EPABX must have at least the following features:
 - 1. Dial access to operator.
 - 2. Internal calls communication.
 - 3. Direct outward dialing.
 - 4. Call transfer.
 - 5. Call park.
 - 6. Call pick up.
 - 7. Music on hold.
 - 8. Abbreviated dialing.
 - 9. Call waiting indication.
 - 10. Day/Night Service.
 - 11. Backup feature.
- D. The system shall be modular design with free position allocation of boards to give greatest flexibility, and expandability.

- E. The system shall have the programming facility to be configured as operator controlled system with an operator console.
- F. The EPABX shall allow the connection of any combination of TDDF and rotary dial telephones.
- G. The system shall have the flexibility to interchange analogue and digital sets without changing the wiring.
- H. Local programming of the system shall be done from operator console or standard PC. Manuals to be supplied.
- I. The EPABX shall be wall mounted embedded in fibre or metal cabinet containing:
 - 1. The extensions equipment.
 - 2. The central unit controlled by microprocessor.
 - 3. 220 VAC, single phase 50 Hz main power supply.
 - 4. Back-up power system including rectifier-charger and batteries of sealed maintenance free type to provide a minimum of six hours operation without loss of functions or reduction in system capacity after normal power supply failure, the whole system is to be housed in a steel cabinet with protection devices (breakers, etc.).
- J. Cooling shall be self convection. Fans are not accepted by any means.
- K. Noise generated by the system plus the power supply shall not exceed 40dB at 1m distance.

2.4 BALANCED TWISTED-PAIR PRODUCT SPECIFICATIONS

- A. All 500 MHz shielded category 6A information outlets designed for termination of 4-pair balanced twisted-pair category 6A copper cable must possess the following characteristics at the minimum:
 - 1. Exceed category 6A component compliance through the frequency range of 1 to 500MHz.
 - 2. Be available in multiple colors
 - 3. Have available a gravity feed (45 degree angled) design to help control patch cord bend radius as well as flush mount design
 - 4. Have insulation displacement connectors with quadrant pair isolation that separates paired conductors when lacing cables to simplify and reduce installation time.
 - 5. Allow termination with a single conductor 110 style impact tool
 - 6. Have available termination aid for stabilization of module to facilitate lacing and impact during termination
 - 7. Be backwards compatible to allow lower performing categories of cables or connecting hardware to operate to their full capacity
 - 8. Have rear protective strain relief caps with side or rear entry, which can be installed onto cable before or after termination
 - 9. Support industry standards for T568A or T568B wiring options on each individual outlet
 - 10. Allow installation from the front or rear of the faceplate, and allow for the jack to pass through the faceplate without re-termination

11. Have an available spring door allowing one handed operation
12. Provide color-coded, slide-in icons available for circuit identification
13. Allow for a minimum of 20 terminations without signal degradation below standards compliance limits
14. Be constructed of high impact, flame-retardant thermoplastic
15. Have, as an option, an outlet, which can be mounted into an IEC 60603-7 compliant opening (keystone)
15. Must be certified by Underwriters Laboratories to United States Standards and C22.2 Canadian Telecommunications Standards

2.5 PATCH CORDS

- A. All 10G CAT6A modular equipment cords shall conform to the following minimum performance standards:
 1. Be augmented category 6 component compliant out to 500MHz
 2. Be factory assembled and 100% transmission tested with laboratory grade network analyzers for proper performance up to 500MHz
 3. Utilize Category 6A F/UTP stranded screened cable for optimal transmission
 4. Be backwards compatible with lower performing categories
 5. Be equipped with identical modular 8-position plugs on both ends, wired straight through with standards compliant wiring
 6. Incorporate internal stranded cordage isolator within a round, dual flame-retardant jacket to provide extended alien crosstalk performance, flex life and maintain ideal pair geometry
 7. Use bend relief compliant boots (with optional color-coded icons) to ensure proper augmented category 6 performance
 8. Use modular plugs, which exceed FCC CFR 47 part 68 subpart F and IEC 60603-7 specifications, and have 50 micro-inches minimum of gold plating over nickel contacts
 9. Have an optional color-coded boot with a latch guard to protect against snagging
 10. Be available in standard lengths of 3, 5, 7, 10, 15 and 20 ft. with custom lengths available upon request
 11. Offer multiple cable colors (with color matching boots) in standard colors of black, white, red, gray, yellow, blue and green for proper circuit identification
 12. Be certified by Underwriters Laboratories to United States Standards and C22.2 Canadian Telecommunications Standards

2.6 PATCH PANELS

- A. All 10G CAT6A termination panels shall facilitate cross-connection and inter-connection using modular patch cords and shall conform to EIA standard, 19-inch relay rack mounting requirements.
 1. Allow the use of the same modular outlets used in the work area
 2. Be made of lightweight, high strength brushed aluminum in 24, and 48-port configurations
 3. Allow the use of other multimedia outlets including optical fiber and coaxial
 4. Have openings, which allow terminated jacks to pass through panel for easy rearrangement
 5. Provide port spacing optimized to ensure alien crosstalk compliance
 6. Have port identification numbers on both the front and rear of the panel

7. Accommodate at least 24 ports for (1) one rack mount spaces and 48 ports for (2) two rack mount spaces (1RMS = 44.5 mm [1.75 in.]
8. Be with an integrated rear wire management bar for proper bend radius control and ease of cable routing
9. Be provided with self-adhesive, clear label holders and white designation labels

2.7 CAT6A CONNECTING BLOCKS

- A. The connecting block shall facilitate cross-connection and/or inter-connection using patch cords. The CAT6A blocks shall possess the following characteristics:
1. Be made of flame-retardant thermoplastic, with the base consisting of horizontal index strips for terminating up to 16-pairs of conductors.
 2. Be available in 64, 128, and 192 pair sized field termination kits.
 3. Have detachable stand-off legs on the 64-pair base, while non-detachable stand-off legs are available for the 128 and 192 pair bases.
 4. Contain access openings between each row of connecting blocks allowing cables to be routed directly to the point of termination.
 5. The wire entry system on bases and connecting blocks shall be such to facilitate lacing of pairs and minimize geometric disturbance of pairs to the point of termination.
 6. Have termination strips on the base marked at 4-pair increments.
 7. Have clear label holders with the appropriate colored inserts available for the wiring blocks. The insert labels provided with the product shall contain vertical lines spaced on 4-pair circuit size and shall not interfere with running, tracing or removing patch cords. Label holders must be capable of mounting between each row of connecting blocks.
 8. Have bases available in 19-inch panels and high-density frame configurations for rack or wall mounting with cable management hardware.
 9. Have connecting blocks used for either the termination of cross-connect (jumper) wire or patch cords. The connecting blocks shall only be available in 4-pair size with internal cross-talk barriers to provide 360 of pair isolation and staggered pair spacing. All connecting blocks shall have color-coded pair identification on face of blocks with tip and ring designation markers and be of single piece construction. Have connecting blocks with a minimum of 200 re-terminations without signal degradation below standards compliance limit.
- B. Support Wire Sizes: Solid 22-26 AWG (0.64 mm - 0.40 mm), and 7-strand wires.
1. Must be certified by Underwriters Laboratories to United States Standards and C22.2 Canadian Telecommunications Standards.
 2. Meet the following performance specifications:

Margin over category 6 @ 250MHz		
Parameters	Worst	Typical
Case		
Insertion Loss (dB)	0.12	0.15
NEXT* (dB)	12.7	13.9
FEXT* (dB)	22.1	22.6
Return Loss (dB)	5.3	5.9

* Tested in both Differential and Common modes

2.8 CABLE

- A. All 10G CAT6A UTP cables shall conform to the following minimum performance standards:

1. Have a round cable jacket available in LSOH, PVC and plenum options with a nominal cable O.D. of less than or equal to 7.4mm
2. Have a construction comprised of 4-pairs of 0.57mm (0.02 in) (24AWG) solid bare copper conductors utilizing a center isolation member to maintain pair geometry for optimal NEXT performance
3. Have a Foil tape surrounding the cable pairs with a drain wire with an aluminum foil tape surrounding the drain wire
4. Have a rip cord installed under the jacket for jacket removal
5. Be available in different jacket colors for PVC, LSOH and plenum versions
6. Meet the following electrical specifications:

Max DC Resistance (@ 20°C)	<17.0Ω /100m
Characteristic Impedance (no impedance averaging allowed)	1-100 MHz: 100 ohms ± 15% 100 - 750MHz: 100 ohms ± 2%
Nominal Velocity of Propagation (NVP)	LSOH & PVC – 72% Plenum – 68%

2.9 OPTICAL FIBER PRODUCT SPECIFICATIONS

- A. In addition to meeting the specifications outlined in ANSI/TIA/EIA-568-B.3 and ISO/IEC 11801:2000 Ed2.0, the requirements in this section must also be met for all applicable optical fiber products as listed below.

2.10 OUTLETS & ADAPTERS

- A. All optical fiber outlets/adapters shall meet the following characteristics:
1. Be flush mounted, gravity feed (45 degree angled) design.
 2. Accommodate SC, ST, MT-RJ or LC adapters.
 3. Universally accept both multimode and singlemode connectors.
 4. Be equipped with dust covers for all ports.
 5. Have color-coded, snap-in icons available for circuit identification.
 6. Be made of high impact flame-retardant thermoplastic.

2.11 CONNECTORS

- A. All optical fiber connectors shall meet the following characteristics.
- B. Multimode LC Connectors:
1. Meet the Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-10.
 2. Be available in simplex and duplex versions.
 3. Terminate both 50/125µm optical fiber.
 4. Have a quick field termination process, which does not require power.
 5. Have a termination process, which incorporates use of a reliable anaerobic adhesive, which has a high resistance to environmental extremes.
 6. Utilize a precision Zirconia ceramic ferrule.
 7. Have jacketed and buffered versions.
 8. Meet the following electrical specifications:

Parameter	Performance (dB)
Insertion Loss (typ)	0.1
Insertion Loss (max)	< 0.2
Durability (500 cycles)	< 0.1
Return Loss (min)	20

C. Singlemode LC Connectors

1. The Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-10A.
2. Be available in simplex and duplex versions.
3. Have a quick field termination process, which does not require power.
4. Have a termination process, which incorporates use of a reliable anaerobic adhesive, which has a high resistance to environmental extremes.
5. Utilize a precision Zirconia ceramic ferrule.
6. Have jacketed and buffered versions.
7. An outer housing color-coded (blue) in accordance with TIA and ISO cabling standards.
8. Meet the following performance specifications:

Parameter (dB)	Performance
Insertion Loss (typ)	0.1
Insertion Loss (max)	< 0.2
Durability (500 cycles)	< 0.1

2.12 PATCH CORDS & PIGTAILS

A. LC to LC multimode Fiber equipment cords shall possess the following characteristics:

1. Be available in standard lengths of 1, 2, 3 and 5 meters with custom lengths available upon request
2. Utilize 50/125µm duplex multimode fiber cable that is OFNR riser grade and meets the requirements of NEC/NFPA 70 Section 770-51(B)
3. Feature premium fiber that meets IEEE 802.3ae 10 Gigabit Ethernet requirements as well as IEC 60793-2-10 and TIA 492AAAC specifications for laser bandwidth Differential Modal Delay (DMD) specifications
4. Have one sensor pin for each duplex connector to connect to an intelligent patching system.
5. Sensor pins to feature 30 micro-inches of gold over nickel for long term reliability
6. Have access to the sensor pin at the rear of the sensor clip for test and mapping purposes.
7. Offer a superior connector polish that meets Telcordia and ISO/IEC specifications for end-face geometry (including radius of curvature, apex offset, and spherical undercut)
8. Use cable and connectors that are complaint with color coding specifications as listed in ANSI/TIA/EIA-568-B.3 and ANSI/TIA/EIA-598-B
9. Utilize precision zirconia ceramic ferrules on connectors
10. Have LC-SC hybrid versions available
11. Include dust caps on all assemblies

12. Be 100% optically tested to meet the following performance specifications:

Parameter	50/125µm		
	850mm	1300nm	850nm*
Min. Cable Bandwidth (MHz•km)	1500	500	2000
Max. Insertion Loss (dB)		0.50	(0.10 Typical)
Min. Return Loss (dB)		30	(35 Typical)

*Laser bandwidth

B. LC to LC singlemode Fiber equipment cords shall possess the following characteristics:

1. Be available in standard lengths of 1, 2, 3 and 5 meters with custom lengths available upon request
2. Utilize duplex singlemode fiber cable that is OFNR riser grade and meets the requirements of NEC/NFPA 70 Section 770-51(B)
3. Offer a superior connector polish that meets Telcordia and ISO/IEC specifications for end-face geometry (including radius of curvature, apex offset, and spherical undercut)
4. Have one sensor pin for each duplex connector to connect to an intelligent patching system.
5. Sensor pins to feature 30 micro-inches of gold over nickel for long term reliability
6. Have access to the sensor pin at the rear of the sensor clip for test and mapping purposes.
7. Use cable and connectors that are complaint with color coding specifications as listed in ANSI/TIA/EIA-568-B.3 and ANSI/TIA/EIA-598-B
8. Utilize precision zirconia ceramic ferrules on connectors
9. Have SC-LC hybrid versions available
10. Include dust caps on all assemblies
11. Be 100% optically tested to meet the following performance specifications:

Parameter	Singlemode
Max. Insertion Loss (dB)	0.40 (0.1 Typical)
Min. Return Loss (dB)	55 (60 Typical)

2.13 FIBER TRUNK CABLES

A. Multimode Fiber Trunk assemblies shall meet the following minimum requirements:

1. Be available in custom lengths measured in both meters and feet.
2. Utilize 50/125µm multimode fiber cable that is available in OFNR, OFNP, LSOH and armored jackets
3. Use cable and connectors that are complaint with color coding specifications as listed in ANSI/TIA/EIA-568-B.3 and ANSI/TIA/EIA-598-B
4. Be available with a variety of connector styles including, MTRJ, LC, SC and ST. Unless otherwise noted, LC connectors shall be provided.
5. Include dust caps on all assemblies
6. Each leg to be to be designated for proper connector orientation.
7. Each cable to be coded with a unique identification number for administrative purposes.
8. Have trunk assembled with option “pulling-eye” for ease of installation and to protect terminated ends.
9. Be available in strand counts of 6, 12, 24, 36, 48, 72, 96 and 144.

10. Be 100% optically tested to meet the following performance specifications in the tables below.
11. Singlemode Fiber Trunk assemblies shall meet the following minimum requirements:
 - a. Be available in custom lengths measured in both meters and feet.
 - b. Utilize Singlemode fiber cable that is available in OFNR, OFNP, LSOH and Plenum Interlocking Armored jackets
12. Use cable and connectors that are complaint with color coding specifications as listed in ANSI/TIA/EIA-568-B.3 and ANSI/TIA/EIA-598-B
13. Be available with a variety of connector styles including LC and SC. Unless Otherwise noted, LC connectors shall be provided.
14. Include dust caps on all assemblies
15. Each leg to be to be designated for proper connector orientation.
16. Each cable to be coded with a unique identification number for administrative purposes.
17. Have trunk assembled with option “pulling-eye” for ease of installation and to protect terminated ends.
18. Be available in strand counts of 6, 12, 24, 36, 48, 72, 96 and 144.
19. Be 100% optically tested to meet the following performance specifications in the tables below:

Cable Type	Multimode 50/125µm (850/1300 nm)	Singlemode 9/125µm (1310/1550 nm)
Fiber Cable Attenuation, Max (dB/km)	3.5/1.0	0.5/0.5
OFL Bandwidth, min (MHz x km)	1500/500	N/A
Effective Modal Bandwidth, min (MHz x km)	2000/NA	N/A
Break-Out Colors: Single Fiber Strands	Blue, Orange, Green, Brown, Slate, White, Red, Black, Yellow, Violet, Rose, Aqua (Per TIA-598-C)	Blue, Orange, Green, Brown, Slate, White, Red, Black, Yellow, Violet, Rose, Aqua (Per TIA-598- C)
Sub-Unit Colors and/or Markings	Blue, Orange, Green, Brown, Slate, White, Red, Black, Yellow, Violet, Rose, Aqua (Per TIA-598-C)	Blue, Orange, Green, Brown, Slate, White, Red, Black, Yellow, Violet, Rose, Aqua (Per TIA-598- C)

CONNECTORS — Optical Specifications

Fiber Type	Max Insertion Loss (dB)	Min Return Loss (dB)
50/125µm Multimode	0.50 (0.10 Typical)	30 (35 Typical)
Singlemode	0.40 (0.25 Typical)	55 (57 Typical)

CONNECTORS — Physical Specifications

Connector Type	IEC Intermateabilty Compliance	TIA Intermateabilty Compliance
SC (only where specifically indicated, otherwise LC connector)	IEC 60874-14	TIA/EIA-604-3
LC	IEC 61754-20	TIA/EIA-604-10

2.14 MAIN DISTRIBUTION FRAME (PATCH PANEL)

- A. Cabinet must have proper ventilation, be lockable, with a transparent front door. It must be able to host all switches, all connection modules, as well as all patch panels needed for all wired outlets.
- B. It must host 19" racks and provide facilities (space, power, grounding, etc...) for the passive and active devices.
- C. The passive and/or active components shall be separated by spacer panels.
- D. Cabinet shall be grounded to the main ground bar, as per EIA/TIA-607 standard. It shall be equipped with 1U switched power supply panel (with a minimum of 6 sockets 16A, 2P+E), wire guide modules, spacer panel, in addition to a number of RJ45 panels as shown in the BOQ.

PART 3 EXECUTION

3.1 DESIGN GUIDE

- A. All structure cabling design should be based on latest relevant local authorities' requirements and latest applicable codes and standards.
- B. All structure cable works should be carried out by a Sub-Contractor approved by the relevant local authorities.

- C. It is the responsibility of the Contractor to coordinate with the relevant local authorities before commencement of construction works to get final clearance.
- D. It is the responsibility of the Contractor to supply and built entry box of reinforced concrete structure, with a heavy duty ductile iron frame and cover of rating guide "A". The cover shall have marking "telephones".
- E. The Contractor should coordinate with the relevant local authorities to locate the entry box and entry pipe.
- F. An earth rod must be provided at the entry box. The required earth resistance should not exceed 5 ohms.
- G. For entry box details coordinate with the relevant local authorities.
- H. Supply and install UPVC ducts as per the relevant local authorities' requirements.

3.2 MAIN TELECOM/CONTROL ROOM

- A. Number of power socket outlets to be added as shown on the drawings.
- B. The room must be air conditioned.
- C. Adequate supply light.
- D. A raised floor of minimum 30Cm should be provided if required.
- E. The room must be provided with a good earth as indicated on the earthing drawings.
- F. Telephone rooms should be free of water drainage pipes and air conditioning ducts.
- G. The room should be provided with an emergency light and smoke detector.

3.3 RISER

- A. Refer to drawings.
- B. The telecom cable tray should have adequate separation from electrical cable trays.

3.4 MISCELLANEOUS

- A. A single conduit of 25mm internal diameter UPVC should be provided from each floor distribution box to the indoor equipment cabinet of each office, residence, flats, etc.
- B. A minimum of 12U indoor equipment should be fixed in each flat/office to accommodate the Optical Network Unit (ONU).
- C. All conduits shall meet in this cabinet.
- D. Structure cabling system to be installed in star topography.

3.5 TESTING

- A. Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of equipment to technically supervise and participate during all of the tests for the system.
- B. During the acceptance testing the following characteristics of the copper cabling shall be, at least, tested:
 - 1. Return loss
 - 2. Insertion loss
 - 3. NEXT
 - 4. ACR
 - 5. ELFEXT
 - 6. Propagation delay
 - 7. Skew
 - 8. Length
 - 9. Wiremap
 - 10. Other tests as directed by the engineer.
- C. In addition, the following characteristics shall be calculated:
 - 1. PS NEXT
 - 2. PS ELFEXT

3.6 INSTALLATION

- A. Riser cables should be installed in accordance with manufacturer's specifications ensuring that cable maximum pull-force and minimum bend radius are respected.
- B. Cables are to run through heavy gauge rigid surface mounted PVC conduits maintaining a minimum of 30cm separation from any disturbance source as lighting fixtures, power cables, HVAC equipment, etc.
- C. All cables are to be pulled in a continuous run. No cable splices will be permitted.
- D. Conduit ends shall be sealed against dirt, rats and insects.
- E. All cables shields shall be grounded at each termination.
- F. All jumper wires shall be routed neatly through the appropriate rings and hooks.
- G. Label cables at every termination, bent and twice at each floor.
- H. Label connection modules and their supports, cabinets.

3.7 EDGE SWITCHES

- A. The edge switches shall include as a minimum, the following features/functions specifications:
 - 1. GE switch with support for advanced Layer 2, static routing, and IPv6 manageability.

2. EnergyWise for operational cost optimization by measuring actual power consumption of the PoE devices, reporting, and reducing energy consumption over the network.
3. Standards based 802.1x and identity based solution.
4. Smart operations to simplify LAN deployment, configuration, and troubleshooting.
5. Cisco FlexStack stacking for ease of operation with Cisco Catalyst Smart Operations.
6. LAN Base Software.
7. USB storage for file backup, distribution, and simplified operations.
8. The system shall provide edge connectivity into core networks.
9. The system shall provide 24/48 Ethernet 10/100/1000 PoE ports. (Refer to Riser diagram drawing).
10. The system shall provide two 1 Gigabit Ethernet SFP uplink ports.
11. The system shall provide 370W PoE capacity.
12. The system shall be available in a 1 RU configuration.
13. The system shall have an external redundant power supply.
14. The system shall have an operating temperature of -5°C to 45°C and an operating humidity of 0% to 95% non-condensing.

3.8 CORE SWITCH

- A. The core switches shall include as a minimum, the following features/functions specifications:
 1. GE copper and fiber stackable switches with support for advanced Layer 3 and IPv6 capabilities higher availability and resiliency using StackWise Plus and Cisco StackPower technology.
 2. Configuration flexibility and future-proofing with four hot-swappable network modules and the choice of LAN Base, IP Base and IP services software.
 3. Ensure data confidentiality and integrity with Media Access Control Security (MACsec) hardware-based line-rate encryption
 4. EnergyWise for operational cost optimization by measuring actual power consumption of the PoE devices, reporting, and reducing energy consumption over the network.
 5. Smart operations to simplify LAN deployment, configuration, and troubleshooting.
 6. USB Type-A and Type-B ports for storage and console respectively and an out-of-band Ethernet management port
 7. The system shall provide 24 10/100/1000 Ethernet ports
 8. The system shall provide 12 Gigabit Ethernet SFP ports
 9. Dual power supplies and fans
 10. The system shall have an operating temperature of -5°C to 45°C and an operating humidity of 5% to 95% non-condensing

3.9 REDUNDANT CORE SWITCH

- A. The core switches shall include as a minimum, the following features/functions specifications:

1. GE copper and fiber stackable switches with support for advanced Layer 3 and IPv6 capabilities higher availability and resiliency using StackWise Plus and Cisco StackPower technology.
 2. Configuration flexibility and future-proofing with four hot-swappable network modules and the choice of LAN Base, IP Base and IP services software.
 3. Ensure data confidentiality and integrity with Media Access Control Security (MACsec) hardware-based line-rate encryption
 4. EnergyWise for operational cost optimization by measuring actual power consumption of the PoE devices, reporting, and reducing energy consumption over the network.
 5. Smart operations to simplify LAN deployment, configuration, and troubleshooting.
 6. USB Type-A and Type-B ports for storage and console respectively and an out-of-band Ethernet management port
 7. The system shall provide 24 10/100/1000 Ethernet ports
 8. The system shall provide 12 Gigabit Ethernet SFP ports
 9. Dual power supplies and fans
 10. The system shall have an operating temperature of -5°C to 45°C and an operating humidity of 5% to 95% non-condensing.
- B. Voice Gateway, IP router and firewall security to be provided to complete the system and connect it to the WAN using all the necessary security equipment to the satisfaction of the Client.

END OF SECTION

SECTION 16785

VIDEO SURVEILLANCE SYSTEM (CCTV)

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including "Conditions of Contract" and "General Requirements" specification sections, shall apply to this section.

1.2 SCOPE

Work comprises supply and installation of a complete closed circuit television (CCTV) system.

Work is deemed to include at least:

1. The software.
2. Network Video Recorders.
3. 5MP IP cameras.
4. 5MP IP cameras.
5. 5MP IP PTZ cameras.
6. 55" LED screens.
7. 24" LED screens.
8. Hands free emergency phones.
9. UTP CAT6A cables.
10. Network Time Protocol Server (NTP Server)
11. System integration with interfaced systems listed in page 51.
12. Complete testing of the system including integration test.
13. Training of personnel.
14. Supply of spare parts for one year.
15. System maintenance tools delivery.
16. Documentation.
17. Wiring, conduits and accessories required to provide a complete operating system.
18. Surge protection.

1.3 SUBMITTALS

A- General

1. The contractor is responsible to submit Construction Documents consisting of Product Data, Shop Drawings, Samples, Decommissioning list including plan, and a detailed completion schedule.
2. Work will not proceed without the Owner's/Engineers's approval of the submitted items.
1. The Contractor will receive approval from the Owners/Engineers on all substitutions of material. No substituted materials will be installed except by written approval from the Owner.

B- Shop drawing

Shop Drawings will be based on the TENDER drawings and Specifications included in this Project. Shop drawings shall include the following:

- Three (3) hard copies of all information.
- Three (3) electronic copies of all information. The electronic copies shall be acceptable on CD/DVD only. Acceptable format for drawings is AUTOCAD.
- A drawing legend sheet.
- Floor Plan Drawings indicating device locations, wire runs, wire pathways, conduit and wire designations.
- System riser diagram with all devices, wire runs and wire designations.
- Schematic block diagrams for each system showing all equipment (typical), interconnects, data flow, etc.
- Functional block diagrams for each subsystem.
- Wiring diagrams for each subsystem defining the interconnection of all inputs and outputs for all equipment. Diagrams shall indicate exact equipment counts.
- Wiring diagram for fail-safe release of electric locking mechanisms.
- Mounting details for all equipment and hardware.
- Fabrication shop drawings for all custom equipment (if applicable).
- Wiring details showing rack elevations, equipment wiring and terminations, and inter-rack wiring.
- Elevations of security closet layouts showing panel locations, power supply locations, conduit, wire ways, wire molds, and all other equipment to be mounted at each location.
- Point to point charts listing all conductors, cables and equipment required for the project and their termination points.

C- Product Data

1. Submit copies of Manufacturer's specifications, recommendations, installation instructions, and maintenance data for each type of material required. Include letter indicating that each material complies with the requirements and is recommended for the applications shown.
2. Submit appropriate cut sheets and samples where necessary.

D- As-built

1. The contractor shall also submit Record ('as-built') Documents, including electronic and hard-copy (three copies) formats, using the latest version of AutoCAD.

E- Manuals

In addition, the contractor shall submit the Operation and Maintenance Manuals, and shall include:

1. Operational description of each subsystem.
2. Detailed programming descriptions for each subsystem, including step-by-step procedures with illustrations identifying how computer screens will appear after each entry.
3. Explanations of subsystem interrelationships.
4. Electrical schematics for each piece of equipment specified.
5. Power-up and power-down procedures for each subsystem.
6. Description of all diagnostic procedures.

7. A menu tree for each subsystem.
8. Setup procedures for each component of the subsystems.
9. A list of manufacturers, their local representatives and subcontractors that have performed Work on the Project.
10. Installation and service manuals for each piece of equipment.
11. Maintenance schedules for all installed components.
12. Definitions of all software related terms and functions.
13. Description of required sequences.
14. Directory of all disk files.
15. Description of all communications protocols, including data formats, command characters, and a sample of each type of data transfer.
16. Instructions for manufacturer supplied report generation with illustrations showing what reports should look like and screen by screen illustrations for each entry made.
17. Instructions for custom report generation.
18. Database format and data entry requirements.

1.4 QUALITY ASSURANCE

A- Manufacturer qualifications

Manufacturer: Company specializing in manufacturing products specified in this section with minimum 10 (ten) years documented experience.

B- Contractor qualifications

Contractor: Company specializing in performing work of this section with minimum 5 (five) years documented experience.

C- Testing Agency

Agency: Company member of International Electrical Testing Association and specializing in testing products specified in this section with minimum 10 (ten) years documented experience.

1.5 WARRANTY

- A. Furnish a 3-year manufacturer warranty for the system and 1-year warranty for the software. (after the issuance of the taking over certificate)

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURERS

The software approved manufacturer can be:

1. TYCO
2. GENETEC
3. MILESTONE
4. BOSCH
5. TDSI

The hardware manufacturer can be:

1. AMERICAN DYNAMICS USA

2. PELCO (USA)
3. BOSCH (GERMANY)
4. ARECONT VISION (CANADA)
5. AVIGILON (CANADA)
6. AXIS (SWEEDEN)
7. SONY (JAPAN)

2.2 SYSTEM DESCRIPTION

- A. The CCTV system shall be installed in order to:
1. Monitor buildings entrances and exits, outdoor areas and surroundings at ground floor level by installing 5MP IP fixed cameras with built-in infrared illuminator and PTZ IP cameras.
 2. Monitor the indoor areas as well, by installing 5MP IP fixed cameras with built-in infrared illuminator inside lobbies and stairs at ground floor and basement level.
 3. General surveillance is ensured at basement level. The surveillance is done by installing 5MP IP fixed cameras with built-in infrared illuminator.
 4. Main technical rooms and monitoring rooms are monitored by installing 5MP IP fixed cameras with built-in infrared illuminator.
Monitor the car lift by installed cameras inside the cabin (by lift supplier).
- B. The recording parameters should be set as follows:
1. The cameras should be set at minimum 8 frames per second.
 2. Recording period should be 30 days.
 3. The compression type to be adopted shall be H.264.
 4. However these parameters are subject to change in case of alarm:
At an alarm state in an area, the cameras monitoring that specified area shall start recording at a higher frame per second and POP UP screen showing the breakthrough area or alarm location should be shown on the operator screen.
- C. All cameras are fed through PoE in addition to their built-in infrared illuminator.
- D. Two NVRs will be installed inside the main data cabinet in the control room. One effectively connected to the system and a second one will be used as a backup/spare in case of any failure.
- E. Cameras installed in critical areas (specified on the drawings) are connected to a hands free emergency phone allowing a two-way communication with the operators at monitoring rooms in case of panic or abuse. Once the call button is pushed, pop up window will appear at operator's screen showing the related camera and the 2 way communication could then be applied.

2.3 SYSTEM TECHNOLOGY

A- 5MP IP CAMERA

1. The camera shall be a high resolution 5 megapixels dual mode color and black and white IP based camera.
2. The camera shall utilize a 1/3-inch CMOS sensor.
3. The camera shall produce a resolution of 1920 x 1080 pixels at 30 ips with a 16:9 aspect ratio.

4. It shall be possible to program the camera to output a variety of lower resolution images.
5. The camera shall support H.264 format as compression type.
6. The camera shall have dual standard compression support with simultaneous streaming of both H.264 and MJPEG formats.
7. It shall be housed in a weatherproof, minimum of IP66 rated housing, where indicated on drawings.
8. The camera's primary power source shall be Power over Ethernet (PoE) complying with the IEEE 802.3af standard.
9. The camera shall have a built-in infrared illuminator with 15m viewing distance. The IR illuminator shall not require any additional power.
10. The network camera shall provide a removable, local storage medium (Micro SD) for scheduled and event-based recording of images.
11. Operation temperature shall be from 0°Cc to 50°Cc and operation humidity shall be 10-90% none condensing.
12. The camera shall have the following additional features:
 - Fully embedded architecture
 - Native support for multiple compression algorithms
 - White balance: auto tracking, manual and presets
 - Backlight compensation control
 - Wide Dynamic Range: 100 dB
 - Minimum Illumination: 0.2 lux in color mode
0.04 lux in black and white mode
 - Supported protocols: TCP/IP, UDP/IP (Unicast, Multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4,SNMP, QoS, HTTP, HTTPS, LDAP (client), SSH, SSL, STMP, FTP, MDNS
13. The camera lens shall be a high performance lens specially designed for mega- pixel cameras and have the following features:
 - Advanced optical design to provide high-resolution image throughout the focal range.
 - High resolution with minimum distortion in both center and corner of image.
 - Varifocal lenses shall be used

The Contractor has to make sure that the correct type and size of lens is installed on each camera location.
14. The network camera shall provide line-in and line-out audio and built-in microphone, if indicated on drawings.
15. The camera should be equipped with minimum 1 alarm input and 1 alarm output.

16. The camera system shall be conformant to ONVIF.

B- 5 MP IP CAMERA

1. The camera shall be a high resolution 5 megapixels dual mode color and black and white IP based camera.
2. The camera shall utilize a 1/3-inch CMOS sensor.
3. The camera shall produce a resolution of 1280 x 720 pixels at 30 ips with a 16:9 aspect ratio.
4. It shall be possible to program the camera to output a variety of lower resolution images.
5. The camera shall support H.264 format as compression type.
6. The camera shall have dual standard compression support with simultaneous streaming of both H.264 and MJPEG formats.
7. It shall be housed in a weatherproof, minimum of IP66 rated housing, where indicated on drawings.
8. The camera's primary power source shall be Power over Ethernet (PoE) complying with the IEEE 802.3af standard.
9. The camera shall have a built-in infrared illuminator with 15cm viewing distance. The IR illuminator shall not require any additional power.
10. The network camera shall provide a removable, local storage medium (Micro SD) for scheduled and event-based recording of images.
11. Operation temperature shall be from 0°C to 50°C and operation humidity shall be 10-90% none condensing.
12. The camera shall have the following essential additional features:
 - Fully embedded architecture
 - Native support for multiple compression algorithms
 - White balance: auto tracking, manual and presets
 - Backlight compensation control
 - Wide Dynamic Range: 100 dB
 - Minimum Illumination: 0.2 lux in color mode
0.04 lux in black and white mode
 - Supported protocols: TCP/IP, UDP/IP (Unicast, Multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4,SNMP, QoS, HTTP, HTTPS, LDAP (client), SSH, SSL, STMP, FTP, MDNS
13. The camera lens shall be a high performance lens specially designed for mega- pixel cameras and have the following features:

Advanced optical design to provide high-resolution image throughout the focal range.

High resolution with minimum distortion in both center and corner of image.

Varifocal lenses shall be used

The Contractor has to make sure that the correct type and size of lens is installed on each camera location.

14. The network camera shall provide line-in and line-out audio and built-in microphone, if indicated on drawings.
15. The camera should be equipped with minimum 1 alarm input and 1 alarm output.
16. The camera system shall be conformant to ONVIF.
17. The camera shall have a dome enclosure, where indicated on drawings.

C- 5MP IP PTZ CAMERA

1. The camera shall be a high performance 1/2.8-in progressive scan day/night CMOS sensor with 1920 x 1080 resolution.
2. The camera shall provide two simultaneous video streams.
3. The camera shall offer multiple simultaneous video streams with 5 megapixel (MPx) 1920 x 1080 resolution, auto iris with 30X optical, and 12X digital zoom.
4. The camera shall be supplied from a 12 VDC power supply.
5. The PTZ camera shall provide a wide dynamic range of 130 dB.
6. The camera shall support proportional pan/tilt functions dependant on the depth of view of the zoom lens.
7. The camera shall support 256 user-programmable presets.
8. The camera shall support 16 user-programmable tours.
9. The network camera shall provide a removable, local storage medium (Micro SD) for scheduled and event-based recording of images.
10. The network camera shall provide line-in and line-out audio and built-in microphone, if indicated on drawings.
11. The camera should be equipped with minimum 1 alarm input and 1 alarm output.
12. The camera system shall be conformant to ONVIF.
13. Camera Specifications
 - a. Sensor Type 1/2.8-inch CMOS sensor
 - b. Optical Zoom 30X
 - c. Digital Zoom 12X
 - d. Maximum Resolution 1920 x 1080
 - e. Frame Rate 60 frames per second (fps) maximum
 - f. Lens
30X: f/1.6 ~ f/4.7, (4.7 mm (wide) ~ 129.0 mm tele)
 - g. Horizontal Angle of View 30X: 59.5° (wide) ~ 2.1° (tele)
 - h. Aspect Ratio 16:9
 - i. Light Sensitivity
Color (33 ms) 0.20 lux
Color (250 ms) 0.025 lux

Mono (33 ms) 0.06 lux

- Mono (250 ms) 0.008 lux
- j. Day/Night Capabilities Yes
 - k. IR Cut Filter Yes
 - l. Wide Dynamic Range 130 dB
 - m. Iris Control Auto iris with manual override
 - n. Backlight Compensation Yes
 - o. Automatic Gain Control Yes
 - p. Active Noise Filtering Yes
 - q. Electronic Image Stabilization (EIS) Yes
 - r. 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, and 802.1x (EAP)
 - s. Pan Movement 360° continuous pan rotation
 - t. Pan Speed Variable between 280° per second continuous pan to 0.1° per second
 - u. Maximum Pan Speed 430° per second
 - v. Vertical Tilt Unobstructed tilt of +1° to -90°
 - w. Manual Control Speed Pan speed of 0.1° to 80° per second; tilt operation shall range from 0.1° to 45° per second
 - x. Automatic Preset Speed Pan speed of 280° and a tilt speed of 160° per second
 - y. Presets 256 positions
 - z. Tours 16 tours
 - aa. Preset Accuracy $\pm 0.1^\circ$

ENCLOSURE FOR THE OUTDOOR CAMERAS

1. For outdoor cameras, surge protection device shall be installed in a weatherproof, painted steel enclosure, which meets standard IP 66. The enclosure is to be installed from the inside and not on the façade with a maximum distance of 50cm for the earth cable.
2. The enclosure shall include a hinged cover, stainless steel hardware and a tamper device. The enclosure shall be connected to earth ground.
3. The enclosure shall be equipped with indicating lamps at the front cover showing the status of each installed surge protection device.

D- NETWORK VIDEO RECORDER (NVR)

1. Description

The Network Video Recorder shall operate in server-client architecture as a network appliance and simultaneously supports live viewing, recording, and playback of video while managing all alarms, alerts, analytics generation and system management.

The Network Video Recorder shall provide required functionality in the following areas:

- System Performance
- Initial Installation / Configuration Wizard
- Video Recording, Live Viewing & Playback
- Dynamic Bandwidth Management
- Video Analytics

- Video Search & Export
- Event or Alarm Management
- Archiving Alert Video
- Recording Scheduler
- Archiving
- Security
- Backup & Restore
- Local Client
- Web Client

2. **NVR Functionality**

2.1 **System Performance**

While operators are actively using the system and accessing the live and recorded video/audio, a single NVR bundled server shall support any combination of supported IP cameras or encoders that meet both of the following criteria:

- Maximum aggregate throughput of 400Mbit/s on recorded video streams.
- Supports 64 cameras at H.264 resolution, H.264 encoding, 30 FPS, with medium scene activity and motion detection on all streams.
- Maximum of 128 streams can be supported simultaneously on a single NVR server.

Maximum aggregate throughput of 400Mbit/s shall be supported both when writing to internal server hard disks and to external storage over iSCSi or Fiber connections. Manufacturer shall provide, on request, documented test results demonstrating this performance.

While recording up to 400Mbit/s the Network Video Recorder shall simultaneously support delivery of up to 64 concurrent video streams to connected clients with no impact to recording or alerts.

The Network Video Recorder shall allow the completion of motion searches on any camera without reducing the aggregate recorded throughput or impacting recording or event management.

The Network Video Recorder shall support the completion of a motion search over 1 week of recorded video of a scene containing an average level of motion throughout, regardless of codec or resolution of the recorded video, within 2 minutes.

The Network Video Recorder shall synchronize audio and video streams and maintain synchronization to within ½ a second.

The Network Video Recorder shall support RAID 5 storage configurations.

2.2 **Initial Installation / Configuration**

The Network Video Recorder supports the following initial installation and configuration options using an intuitive wizard:

- The software shall offer an installer that requires minimal steps to install the NVR.

- A setup wizard mode for first time installations to guide the user to configure the NVR with minimum number steps.
- The NVR supports a web admin interface that allows local or remote users to easily administer the NVR server using a standard web browser interface (e.g. Internet Explorer 9 & 10 from remote Windows clients).
- Auto-discovery of all supported IP cameras or encoders on the network and allow ability to select the devices for import into the NVR. For IP cameras and encoders that support standard network discovery protocols, these devices are quickly discovered and easily configured on the NVR. While the scan devices functionality is executed for the other devices.
- The NVR supports the ability to add data storage with no need to reconfigure the recording system.
- Adding or reconfiguring storage does not require data backup.
- The NVR supports assigning cameras or encoders to any storage set.
- The NVR user interface enables batch editing functionality for a group of cameras to quickly adjust configuration settings.
- The NVR supports ability to control the maximum retention period on a per- camera basis and receive alerts from the NVR if the specified duration is unable to be satisfied.
- The NVR supports various storage configurations (defaults are RAID-0 or RAID-5, and other configurations are available based on the RAID controller).
- The NVR's operating system and application are required to be installed on a dedicated hard drive, separate from the hard drives used for video recording, to reduce the risk of system failure.
- The NVR's operating system and application can be deployed on a qualified virtual machine environment (VMware).
- The NVR shall allow the System Use Banner to be configured to display an approved system use notification message or banner prior to users logging onto the system locally or remotely. This configuration option can be utilized to provide privacy and security notices consistent with applicable federal laws, executive orders, directives, policies, regulations, standards and guidances.

2.3 Video recording / live viewing / playback

The Network Video Recorder shall support the following video recording, live viewing and playback functions:

- The Network Video Recorder shall be able to stream live video to connected clients.
- The Network Video Recorder shall be able to stream recorded video (instant playback) to connected clients.
- The NVR is based on streaming technology and does not require clip download or video buffering for live or playback video viewing

- The Network Video Recorder shall be able to support streaming recorded video content at the following rates:

Fast Forward x1

Fast Forward x2

Fast Forward x4

Fast Forward x8

Fast Forward x16

Fast Rewind x2

Fast Rewind x4

Fast Rewind x8

Fast Rewind x16

- The NVR at a minimum provides the following playback options:
 - Frame by Frame Forwards
 - Frame by Frame Backwards
- NVR software supports recording video in the following formats:
 - MJPEG (Motion JPEG)
 - MPEG-4
 - H.264
- The NVR software allows the user to create and edit video recording schedules for each connected camera
- Recording schedules are configurable by day-of-week or hour-of-day
- The NVR software allows camera-by-camera configuration of the following recording modes:
 - Not Recording
 - Continuous Recording
 - Alert-Based Recording only
 - Continuous recording with Alert-based tagging
- The NVR provides the ability to set the maximum recording period per camera
- The NVR provides the ability to record during the duration of a dry contact alarm while it is active.
- The NVR provides an alert through the user interface and email alerts when the recorder statistics are identifying insufficient storage to maintain the recording days required
- The NVR provides dual streaming per each of the supported hardware capable cameras connected to the NVR

- The NVR software supports the configuration of the following video parameters for each available stream on connected cameras or encoders:

Video Compression Frame Rate Resolution Quality

- The NVR can be accessed by an Administrative connected client using Microsoft Internet Explorer web browser to view live video in a 1x1 and 2x2 video display grid. Any camera on the NVR shall be selectable in any of the grid panes.

2.4 Dynamic Bandwidth Management

The NVR supports the following features that enable optimization of video streamlining to local and remote clients:

- The NVR supports dynamic bandwidth management with no need to add additional hardware or software that provides video format (CODEC), and resolution transcoding for up to four streams.
 - The NVR makes the transcoded streams available to Windows based clients and mobile applications running on mobile devices (e.g. smart-phone, tablets, etc...).
 - The NVR makes the transcoded stream available through the product API and SDK to provide 3rd party applications the ability to view transcoded streams through the Dynamic Bandwidth Management interface.
 - The NVRs can be clustered into a NVR group to work together and share transcoding resources to allow remote transcoding to optimize streaming bandwidth to improve user experience for the clients.
 - The NVR includes dynamic bandwidth management that provides frame dropping built in to the NVR without the need to add additional hardware or software
- The NVR supports the following four bandwidth throttle settings: Bandwidth priority
Traffic smoothing WAN bit rate cap LAN bit rate cap
- The NVR software auto-detects whether a connected client is on a Local-Area or Wide Area Network and automatically, seamlessly switches streaming protocols.
 - The NVR software minimizes bandwidth and eliminates video interruptions due to network packet collisions by supporting multiple networks.
 - The client network is used for outbound video transmission to client applications and two-way communication via the web client for administration and configuration purposes.
 - The camera network is used for transmission of video and events from supported IP cameras and encoders to the Network Video Recorder and for communication of configuration and other settings from the NVR to each individual IP camera and encoder.
 - The NVR software supports network time protocol (NTP) servers for date and time synchronization.

- The NVR's operating system supports multi-path I/O (MPIO) for fault- tolerance but must be configured via the command line interface.

2.5 Video Analytics

The NVR supports all of the following video analytics that can be enabled with a valid license.

- The NVR supports motion detection with up to a maximum of 10 configurable motion alarm rules. Up to a maximum of 64 simultaneous channels set to low sensitivity is supported to generate the motion detection meta-data.
- The NVR supports Video Content Analysis (VCA).
- The VCA is licensed to the recorder and can be used by any camera on the recorder with no need to update, change or download a new license.
- Video intelligence supports at a minimum the following eleven (11) types of configurable alarm rules:

Object Detection

Object Abandoned/ Removed

Direction

Linger

Enter an area

Exit from an area

Dwell

Crowd Formation Queue Analysis Color Analytics

- One type of video intelligence can be enabled on a camera at any one time.
- The NVR analytic Object Abandoned/Removed shall support the ability to detect Shelf Sweeping.
- The NVR analytic Crowd Formation shall support the detection and raising an alarm when a crowd forms in a specified region of interest.
- The NVR analytic Queue Analysis shall support the monitoring length of queues.
- The NVR analytic Color Analytic shall enable limiting the search results to specified color(s) only but is not applicable for Crowd Formation and Queue Analysis.
- VCA licenses can be moved between cameras on the NVR up to the maximum number of licensed cameras.
- Video intelligence region tools includes polygon, free draw, brush sizes, erase, etc
- The NVR shall allow a selectable percentage to ensure that the appropriate minimum values can be utilized based on the required field-of-view to trigger the desired video analytics results.

2.6 Video Search & Export

The NVR supports the following video search and export functions:

- Configuration of both Date / Time and Motion searches via connected Security Management Client applications.
- To enable fast post recording motion-based video searches over days, weeks or months of video, the NVR supports generation and storage of motion metadata information from one of the camera's MJPEG or MPEG4 video streams connected to the NVR.
- The integrated motion-detection video analytics supports the configuration of the following rules:
 - Motion-detection anywhere in scene
 - Motion-detection within user-defined region-of-interest
 - Motion-detection outside of user-defined region-of-interest
- Integrated motion-detection video analytics have the ability to capture and store motion activity events on every frame of video from every camera in an industry standard database.
- Rules can be applied on the analytics database as follows:
 - Object Detection
 - Object Abandoned/ Removed
 - Direction
 - Linger
 - Enter an area
 - Exit from an area
- The NVR analytic Object Detection should be capable of being used for detecting objects not present, such as when a customer is not present at a POS terminal.
- Integrated motion-detection video analytics have the ability to be enabled / disabled on each connected camera.
- Thumbnail support for search results can allow users to quickly search through a period of time by easily identifying when the scene has changed on the Field of View for the forensic video.
- The NVR allows the user to export clips of video from one or multiple connected cameras.
- The NVR provides the user the ability to export video clips in their native format which can be played using the client player application.
- The VMS supports exporting "tamper-protected" video clips from the NVR using check-sum authentication.

2.7 Event or alarm management

The NVR supports the following event / alarm management functions:

- The Network Video Recorder shall allow for the following alarm recording settings:

Codec

Maximum Video Frame Rate (FPS) Resolution

Quality

Pre-Alarm Duration – (Selectable from 30 to 300 seconds) Post-Alarm Duration –
(Selectable from 30 to 300 seconds)

- The Network Video Recorder software shall support the generation of the following alarm events:

Motion Detection

Video Contact Analysis (VCA) Dry Contact via the IP device Camera Video Lost

Camera Video Restored Video Stream Lost Video Stream Restored

Video Restored Unit Status Changed (Normal or Reboot) Video Dark Frame

Video Pipeline Failure Video Recording Failed Video Recording Restored Audio

Recording Failed Audio Recording Restored

Unit Protection Status Changed (None, Monitor or Failover)

Unit Storage Status Changed (Normal, Degraded, Backup or Missing) Camera Status

Notification (Add, Remove, Video Loss or Normal) Storage Status Degraded

Storage Status Missing

- The Network Video Recorder shall support the configuration of Motion Detection alarms with multiple independent regions-of-interest on each camera.

2.8 Archiving Alert Video

The NVR supports the following archiving alert video functions:

- The NVR software supports Vaulted Media to implement archiving and protecting of media
- The vaulted media interface is flexible enabling selection of any number of cameras for any period of time.
- The NVR software shall natively support archiving of recorded video to a variety of configured archive locations configured as CIFS shares. The archived data shall be seamlessly searchable via date and time by the video management software system.
- Media that is tagged as Vaulted Media is protected from being deleted during data culling.
- The NVR software allows authorized operators with “Protect” permission to assign the Vault Media status to any partition used by the NVR.

2.9 Recording Scheduler

The NVR supports the following recording scheduler functions:

- The Network Video Recorder software supports defining custom recording schedule groups

- Each group supports a different schedule that supports a specified recording mode for each hour of each day
- Each group has a unique user-defined name
- Each group can be assigned one or more cameras
- The NVR software supports a “default” schedule group
- Default group is setup for 24x7 continuous recording and cannot be deleted
- Newly added cameras or encoders are automatically assigned to the default group
- Any custom group that is removed will have its cameras automatically reassigned to the default group

2.10 Internal storage

The 2U NVR supports 20 TB of available video storage in RAID5 configuration.

2.11 Redundancy and Failover

The NVR supports the following redundancy and failover functions:

- The NVR software is designed to provide both redundancy and high availability as standard built-in features.
- The NVR software includes server-based fail-over so when an NVR is setup to be a redundant standby fail-over server, it is setup to monitor one or more active Network Video Recorders (1-to-1 or N-to-1 configurations).
- When a failure is detected, the standby fail-over server automatically takes control over all cameras for access and recording.
- The standby fail-over server has its own storage resources, on the same network segments, and licensed to support the Network Video Recorder with the largest number of camera slots.
- When the fail-over server takes over for a failed NVR, the transition to view the live video and search the recorded video shall be relatively seamless to the victor VMS clients. In addition, when the failed recorder is brought back online with the cameras and the fail-over recorder returns back to its monitoring mode, the video recorded on the fail-over unit shall be seamlessly searchable and retrievable by the victor VMS clients.

2.12 Archiving

The NVR supports the following archiving functions:

- The NVR software shall natively support archiving of recorded video to a variety of configured archive locations configured as CIFS shares.
- The NVR software shall support archive video settings that can be different from the current live and record video streams.
- The NVR software shall allow the archived data to be seamlessly searchable via date and time by the VMS system.

2.13 Security

The NVR supports the following security functions:

- The NVR is designed to provide a very secure environment that is less prone to malicious attack than Windows-based NVR products.
- The NVR software supports hardening for FISMA readiness.
Additional Remote Access restriction options (SNMP, SSH) Remote Web Access restrictions
Enhanced Password Validation
New User Credentials
- The NVR software supports only pre-defined roles of permissions and restrict the ability to add any new roles:
Admin (Read/Wire privileges) Operator (Read Only privileges)
Support (Read/Write privileges with access to additional supported functionalities)
Viewer1 (Applicable for Local Client and rich thin client) Viewer2 (Applicable for Local Client and rich thin client) Viewer3 (Applicable for Local Client and rich thin client)
- The NVR software restricts and limits the functionality of the NVR Admin Interface:
Access to any recorded video is not allowed. Access to the recording for instant playback is only available from the connected victor client with applicable credentials.
Majority of the user operations are available through the video client software
Configuration of presets, sequences, and/or execution of any PTZ operations (exception is “Return to home”) are not allowed. These functions are available from the connected victor client with applicable credentials.
- The NVR software supports a read-only audit trail log of system changes that have been made by a privileged user that include:
Software Upgrades
Modification to System Time
Modification to FTP Log Management Settings Modification to User Login Passwords Modification to Network Settings
- The NVR software shall support custom password groups for IP cameras and encoders.
- As most camera devices have a default administrator or root username and password. For added security, the password for the highest level user account can be modified on the camera device. Therefore, a custom password group for each unique password can be easily generated on the NVR and utilized for the applicable devices.

2.14 Backup and Restore

The NVR supports the following backup and restore functions:

- The NVR software supports the administrator’s ability to save a backup of the system configuration from any local and remote server. This file contains all

of the current settings and configuration information for the server:

Camera Settings System Settings User Information DHCP Settings NTP Settings

2.15 Local Client

The NVR software supports the following local client features:

- Local client feature set shall be based on simple ease-of-use design criteria for improved user experience.
- Local client shall be launched from a desktop icon and can be configured to automatically start during user login.
- Local client shall allow video streams to be displayed in any of the following views, saving the layouts, supporting tours within the video layouts, and on the Hybrid recorders, drag-n-drop the view onto any connected spot monitor:

1x1 (1 Camera)

1x2 (2 Cameras)

2+3 (5 Cameras)

1+1 (2 Cameras)

2x2 (4 Cameras)

3x2 (6 Cameras)

3x3 (9 Cameras)

4x4 (16 Cameras)

1+5 (6 Cameras)

- Local client shall be able to switch between layouts and retain the previous selected cameras in the views.
- Local client shall be able to double-click on a video pane to display the camera in a 1x1 view.
- Local client shall be able to view both live and playback video simultaneously within the same layout. Panes highlighted in yellow shall indicate video playback.
- Local client shall be able to right-click on a video pane to revert a single pane to LIVE.
- Local client shall be able to configure Instant Playback time ranging from 5 seconds and up to 5 minutes.
- Local client shall support ability to turn on/off the camera name and the date- time overlay display, customize the text display using up to 16 colors, and selecting between 12 or 24 hour time and regional date format.
- Local client shall support instant playback speeds: Fast Forward x1
Fast Forward x2
Fast Forward x4
Fast Forward x8
Fast Rewind x1

Fast Rewind x2

Fast Rewind x4

Fast Rewind x8

- Local client shall enable digital PTZ controls to support:
Pan (Also supported for virtual PTZ)
Tilt (Also supported for virtual PTZ) Zoom (Also supported for virtual PTZ) Iris
Focus Presets Sequences Patterns
- Local client shall automatically open the control bar when the operator selects video for playback.
- Local client shall support standard date-time and advanced search mechanisms for motion and intelligent video analytics that can be quickly reviewed. Advanced searches shall include ability to save search specifications as new alarms and triggers.
- Local client shall provide user-customizable 'Site View' for administrators. It will allow organization of cameras, audio and/or dry contact devices with support up to 3-levels of folders. Sites are accessible from the sidebar device icon and can be dragged into a layout to auto-populate the cameras.
- Local client shall be able to select one or more snapshot views for export.
- Local client shall be able to retrieve a snapshot in LIVE mode.
- Local client shall be able to export MP4/AVI video clips to external USB/DVD devices. Text stream data and audio stream can also be included with the exported video clips.
- Local client shall support configuration of events for motion, video analytics, dry contacts, video loss and storage alarms that triggers an action such as audible, PTZ to pre-defined preset, display a view on the local and/or spot monitor.
- Local client shall support real-time indicator and acknowledgement of events.
- Local client shall be able to configure text stream alarms for simple string match and advanced matching criteria. Marker or receipt definitions can be defined for each text stream for easier viewing entire transactions with video associated to the alarms.
- Local client shall be able to configure text stream events for configured text streams to trigger an event if a specific alarm or all alarms fire for a configured text stream device. Text stream events can be dragged into a video layout to synchronized video playback and display the associated data in a text stream window. Triggered lines will be identified as red highlighted text and marker definitions as yellow highlighted text.
- Local client shall utilize visual indicators for all triggered events on the timeline. Events will be identified by priority and can view the events by clicking on the desired priority icon. Events can also be dragged into a video layout to synchronized video playback.
- Local client shall support CCTV PTZ keyboards for basic input such as selecting active panes for optical, digital and virtual PTZ camera controls.

- Local client can be configured for auto-login upon login to the desktop after specifying the required username and password credentials. User preferences such as date/time format, font colors, and instant playback settings can be configured on a per-role basis.
- Local client shall be able to clear all events link.

2.16 Web Admin Client

The NVR supports the following web client functions:

- The NVR software supports remote and local administration and configuration via a standard web browser:

Internet Explorer version 9 and 10 (remote Windows clients) Firefox (local Linux desktop)

- The NVR software supports a standard interface that allows authorized users to easily change system settings that are most common to the server:

Current Date, Time and Time Zone

Modifying Role Passwords (default “admin” and “operator” accounts) Update the License

SSA Expiration Notification

Save and Load System Templates to setup other NVRs with same settings

Backup and Restore System Settings

Update the Software and Camera Pack Drivers

- The NVR Recorder software supports a standard interface that allows authorized users to easily change network settings that are most common to the server:

Modify the Domain Name and Server Settings

Modify NTP Server Settings

Modify the Settings for all Network Interface Cards

- The NVR provides a web interface for the configuration of connected cameras.

The NVR software supports simple live camera view using the web client (browser) with appropriate drivers.

- The NVR software supports access to advanced camera settings from within the web client. The software provides a standard interface that allows authorized users to easily change settings that are most common to all devices:

Camera Name Password Group Storage Set Camera Streaming Recording Mode
Meta-Data

Motion Sensitivity

Maximum Recording Retention Period

Audio

Video Codec (Stream 1 and/or 2)

Video Frames-Per-Second (Stream 1 and/or 2) Resolution (Stream 1 and/or 2)

Maximum Bit Rate Setting

Quality Setting

Alert Pre-Buffer Recording (seconds)

Alert Post-Buffer Recording (seconds) Dry Contact

Optical Pan-Tilt-Zoom

Image Settings for Video Properties

- The NVR software supports the configuration of motion detection areas or video intelligence using the web client (browser) with appropriate license.
- The NVR software support configuration of the following actions for sensor alarms based on the input state:

Camera Recording (alarm pre-buffer + sensor input state trigger time + alarm post buffer)

Camera Start Recording (alarm pre-buffer + continuous recording) Camera Stop Recording (alarm post-buffer)

PTZ to Preset

- The NVR software supports the setup of recording scheduler for the connected cameras using the web client (browser).
- The NVR software supports the ability to execute auto-discovery of supported devices over any of the supported network interface cards for the connected cameras using the web client (browser). The NVR allows the administrator to select the applicable supported devices to add to or remove from the recorder.
- The NVR software shall support the ability to auto-detect available logical Linux hard drive partitions (XFS) using the admin client. The software supports the ability to dynamically setup one or more Storage Sets to properly load-balance the storage and associated cameras to ensure maximum performance. Specifying the percentage of total storage that is allocated for protected vault media quota is also available from the NVR software.
- The NVR supports as well a rich thin client

The rich thin client shall provide users with an intuitive interface that utilize many of the features that the NVR offers from a standard web browser.

Live Video Playback PTZ Control Fixed Views

Sites

Clips

Event Monitor Event Setup Diagnostics Search

Logs

Event Timeline Devices DockViews

2.17 Electrical power requirements

Input: Two hot-plug high-efficient 600W PSU

Voltage: 100-240 VAC, 50-60 Hz

Heat Dissipation: Energy Smart: 1600 BTU/hr maximum

High Output: 2000 BTU/hr maximum

2.18 Environmental conditions

Operating Temperature: 10° to 35° C Storage Temperature: -40° to 65° C

Operating Relative Humidity 10% to 80% non-condensing

Storage Relative Humidity 5% to 95% non-condensing

E- HANDS FREE EMERGENCY PHONE (HEP)

- A complete two-way communication kit should be provided and installed at each lift lobby at basements levels and at pedestrian accesses to ground floor at basements levels, as shown in the drawings.
- The HEP kit should be vandal proof made of 2mm stainless steel and should be designed to be used in harsh places/environments.
- The HEP should be powered.
- The HEP kit to include the following:
 - Microphone
 - Speaker
 - Call Push button
 - Call connected LED

The kit should be clearly labeled at the top by “EMERGENCY PHONE” and should have a clear sign mentioning “PUSH FOR HELP” above the Call push button and a “CALL CONNECTED” sentence above the LED.

F- VoIP EMERGENCY CALL SYSTEM

A VoIP emergency call station will be installed at security, reception and guard’s desks.

The call station shall have the following specifications:

- Handsfree Operation
- Stainless Steel, Vandal Resistant
- Desk mounted
- LED indicator
- PoE powered
- Volume adjustments for microphone and speaker
- Automatic Noise Canceling
- 2 Amp relay contacts
- Push to call button shall be connected in parallel with a hold up – foot rail operated unit.
- Automatic polling and programming software included
- Remotely programmable
- Network downloadable firmware

- Programmable to dial up to 5 numbers on busy or ring no answer
- Extended temperature range (-40°F to 140°F)

G- VIDEO MANAGEMENT SOFTWARE (VMS)

1. Description:

VMS Server incorporates an industry-standard relational database used to manage and maintain a single record of authorized users/passwords, associated recorders/cameras, roles and permissions, aggregated alarm and event journal and current client license status.

VMS Server also includes the Server Configuration utility that is used to manage the services, server components, database and settings for the site or system.

VMS Client is the user interface for security officers and administrators to monitor and manage their IP and analog security video system. This software application includes all interfaces required to view live and recorded video, search for video using SmartSearch technology, monitor and manage system events and alarms, create and edit user-defined layouts, views, tours, salvos etc, export clips, view journal reports, add/delete recorders and other peripherals connected to the system and administer user accounts and privileges.

2. Functionality:

2.1 Event Unification and Merging of Video Management and Access Control Software:

- VMS shall support the ability to share common resources with the Access Control Software. Both software products must support the optional add-on unification license to enable co-existence on the same platform.

The unified software will be the Security Management Software SMS.

- VMS when unified with access control software shall allow events to be acknowledged in one client and having it be updated in real-time on the other client.
- VMS when unified with access control software shall allow access control alarms to appear on VMS maps, VMS event viewer and in VMS reports to provide a true cross-platform two-way seamless integration of video and access control.
- VMS when unified with access control software shall display in the VMS device list all of the integrated objects.
- VMS when unified with access control software shall capture in the VMS journal database and activity list all of the actions on integrated objects to allow the VMS report to support Video, Access Control and associated third party activities.

2.2 System performance:

- Each instance of VMS client shall support up to 4 connected monitors
- VMS client installed on a hardware platform meeting the recommended specification shall support the simultaneous display of up to 64 video streams across all connected monitors.

- Each instance of VMS client shall support the simultaneous connection of up to 2 supported CCTV or equivalent keyboards.
- VMS client shall support the completion of a motion search over 1 week of available recorded IP video of a scene containing an average level of motion throughout, regardless of codec or resolution of the recorded video, within 2 minutes.
- VMS shall support event and message volumes up to a maximum of 5 transactions per second.
- VMS shall support a maximum total database size of 524,272 TB when running SQL Server 2012 Standard Edition (approximately 525,000,000 million records).

2.3 Localization:

- VMS client shall automatically detect and support / display the time / date format configured in the Windows operating system.
- VMS client shall be able to support many languages. Users shall be able to select the desired language to display when launching the application. No additional installation of the application shall be required. The manufacturer shall make a list of supported languages available on their website. The supported languages shall include:

Arabic English (US) **French (Standard)**

2.4 Graphical User Interface GUI

- VMS client shall be written with Windows Presentation Foundation (WPF) technology to maximize the quality and quantity of video displayed on connected monitors. VMS client shall employ Windows 7 style menus and tab-based navigation to ensure ease-of-use for operators.
- VMS client shall provide end users and administrators with functionality in the following areas:

Camera Management / Organization

Video Live Viewing & Playback

Audio Live & Playback

Video Overlay of On-Screen Display

Video / Analytic / Alarm Rule Search & Export

Still Image Capture

Event / Alarm Management Advanced Integrated Mapping Virtual Matrix

CCTV Keyboard Support

Reporting

User Management / Permission Controls

Recorder Management

Storage Video Vault

Dynamic Bandwidth Management

Integrated Web Browser

Event Unification

Object Associated

Access Control Device Management /Organization

Maintenance / Software /License Upgrades

SDK

- VMS client interface shall be an intuitive user interface that is similar to Microsoft's Office Application Suite with its easy navigation.
- VMS client shall provide a GUI that minimizes the number of operator mouse clicks or keyboard strokes and include "right-click" pop-ups with highlighted default selections for common operations.
- VMS client interface shall be user-customizable.
- VMS client shall support the ability of the end user to create a customized application layout for the client software. The client application shall support multiple application layouts that can be assigned to each role.
- Each application layout can have multiple tabs in the same window. The panes can have multiple tabs so that different objects such as cameras and tours can be displayed in the same pane. Each pane shall have the ability to be moved to a specific screen.
- VMS client shall provide a GUI with organized ribbon bar that supports the expanded feature set for unification of security for video, access control, etc.
- VMS client shall support dynamically display menu items and controls which are applicable to the system configuration for improved user experience.
- VMS client shall support dynamic views and ability to add recorders directly within the Recorders dynamic view.

2.5 Camera Management / Organization

- VMS client shall provide users both a Device View and a user-defined Site View of the following system components:
 - Recorders Workstations Cameras Monitors
 - CCTV Keyboards and controllers
 - General purpose devices
 - General purpose monitoring points
 - Camera devices Door Controllers Doors
 - Readers Inputs Outputs
- Device icons in VMS Client shall provide clear visual indications of whether the devices are online or offline.
- VMS shall support custom camera names that are alias used by VMS client. It shall maintain the original camera names assignment associated by the recorder.

- The Site View shall be completely user-customizable, enabling the organization of devices, tours, salvos into user-defined, multi-level folders, similar to Windows Explorer-style file organization.
- A Site View folder may contain an object of any type within VMS.
- VMS client shall allow the user to hide, “unpin” or customize the display location of the Device and Site View panes within their Application Layout.

2.6 Advanced Integrated Mapping

- VMS client shall support maps to allow visual management of a unified security system. The maps shall be created by importing AutoCAD files (e.g. DWG, DXF) and standard raster image files (e.g. JPG, PNG).
- VMS client shall be able to support up to 10,000 object/icons (e.g. recorders, cameras, card readers, doors, etc.) for each map. The icons shall allow for monitoring object state and locations as they relate to the site.
- VMS client shall be able to restrict displaying only unmapped objects for selection.
- VMS client shall be able to provide a navigation button to easily go back to or select a specific map from a drop-down menu.
- VMS client shall be able to display health monitoring information on the map icons.
- VMS client shall be able to create single layer, multi-layer, and nested maps with the ability to turn on/off layers to show/hide the associated icons. Maps images shall support ability to pan and zoom.
- VMS client shall be able to have maps open in the same tab for easier navigation.
- VMS client shall be able to enable hover over a map icon and have the associated camera(s) pop-up a live video window. When right-clicking on a map object in view mode, it shall display that objects standard context menu to enable further interaction. Support ability to automatically close opened windows when in hover mode.
- VMS client shall be able to drag-and-drop cameras, tours, salvos onto a monitor object on the map and have it displayed onto that remote or local monitor.
- VMS client shall be able to include field-of-view cones to identify expected coverage for devices
- VMS client shall be able to expand a pane to reveal the current virtual matrix configuration when a camera is dropped onto the pane on a video wall when virtual matrix is enabled.
- VMS client shall be able to bubble-up alarms and events through numerous layers of maps to support seamless alert notifications within any map.
- VMS client shall be able to create custom map icons.
- Maps shall be automatically stored centrally to allow sharing with any VMS client that is granted permission.

2.7 Video Live Viewing and Playback

- VMS client shall support the simultaneous display of MJPEG, MPEG-4, H.264 and ACC video streams within a single video view.
- VMS client shall provide a common user interface and functionality associated with every camera in the system, regardless of the recorder it is connected to or the video codec used.
- VMS client shall group the available layouts into three types and each one can be available by setting the preferences via System Values:
Standard Wide Screen Portrait
- VMS client shall allow video streams to be displayed in any of the following views:
 - 1x1 (Single Camera Standard Format)
 - 2x2 (4 Cameras Standard Format)
 - Guard (6 Cameras Standard Format – 1 Large with 5 Small)
 - 3x3 (9 Cameras Standard Format)
 - 2+8 (10 Cameras Standard Format – 2 Large Top plus 8 Small)
 - 4x3 (12 Cameras Standard Format)
 - 4x4 (16 Cameras Standard Format)
 - 12+1 (13 Cameras Standard Format – 1 Large Center plus 12 Small)
 - 5x5 (25 Cameras Standard Format)
 - 6x6 (36 Cameras Standard Format)
 - 8x8 (64 Cameras Standard Format)
 - 1x1 (Single Camera Wide Format)
 - 1x3 (3 Cameras Wide Format)
 - 2x2 (4 Cameras Wide Format)
 - 2+3 (5 Cameras Wide Format)
 - 2x3 (6 Cameras Wide Format)
 - 2+2x2 (6 Cameras Wide Format)
 - 1+3x2 (7 Cameras 1 Portrait Format and 6 Wide Format)
 - 3x4 (12 Cameras Wide Format)
 - 4x4 (16 Cameras Wide Format)
 - 1x1 (Single Camera Portrait Format)
 - 3x1 (3 Cameras Portrait Format)
 - 1+4x2 (9 Cameras 1 Portrait Format and 8 Wide Format)
- VMS client shall allow the user to create saved views combining a view, with user selected cameras, tours or PTZ presets.
- VMS shall be able to name and save different camera window displays as salvos or fixed views. Names shall be a maximum of 200 characters long.

- VMS shall provide for each live window pane a popup menu, available via right mouse click, to access the settings for the pane.
- VMS client shall allow the user to review motion or embedded analytic searches from stream-based recording with simple “jump to next” result buttons.
- VMS client shall provide the user with time filter that enables the ability to quickly perform multi-day searches.
- VMS client shall provide the user with ability to customized On-Screen Display text that is displayed within video panes. The Camera/Recorder color and font size shall be changed independently of the Date/Time color and font size to allow for clearer and legible text against various background scenes.

2.8 Instant View

- VMS shall provide the ability on a live video stream to easily open a new tab that is paused for the same camera to quickly setup the display layout for investigative purposes.
- VMS shall support Instant View to be displayed side-by-side or to send it to another display monitor.

2.9 Instant Playback

- VMS shall provide the ability to play, fast forward, rewind directly from video recorded into a recorders database as well as jump to any point in time where the feature is supported by the recorder. Supported instant playback speeds shall be:
 - Fast Forward x16
 - Fast Forward x8
 - Fast Forward x4
 - Fast Forward x3
 - Fast Forward x2
 - Clock Speed (x1) Frame Forwards Frame Backwards
 - Clock Speed Rewind (x1) Fast Rewind x2
 - Fast Rewind x3
 - Fast Rewind x4
 - Fast Rewind x8
 - Fast Rewind x16
- VMS client shall provide the ability to quickly jump back to any user- specified date / time on all visible cameras without interrupting or obscuring video viewing.
- VMS client shall provide the user the ability to select some or all of the video panes in a Saved View and view recorded video on those panes, while simultaneously displaying Live video on other panes within the same view.
- VMS client shall provide the ability to view a single camera in multiple panes of a single Video View.

- VMS client shall provide the ability to view live and recorded video on the same camera within a single application layout.

2.10 Timeline Control

The VMS shall support the following timeline control scroll bar feature:

VMS client shall provide the ability to enable the timeline bar on any surveillance view by selecting the timeline icon.

The timeline bar shall display a corresponding data stream bar for each media stream displayed in the surveillance window.

The navigation control for the timeline bar shall be divided into years, months, days, hours, minutes and seconds.

The video control buttons are located in the center of the timeline and can be used for instant playback, with a vertical bar representing the current time.

2.11 Still Image Capture

- The VMS shall support the following still image capture feature:
- VMS client shall provide the ability to capture an image from any paused video stream and directly from the raw video stream.
- The captured image can be all or part of the paused stream image.
- The captured image is launched in its own pop-up window in the VMS client. From there the operator can:
 - Save the image in a variety of formats. Copy the image to the clipboard.
 - Email the image via SMTP.
 - Print the image (actual size or fit-to-page)
 - Open the image in an external application (e.g. MSPAINT.EXE).
- VMS client shall support video overlay onto snapshots.

2.12 Mechanical & Digital PTZ

The VMS shall support the following mechanical and digital PTZ functions:

- VMS client shall provide Digital PTZ capability on all connected IP fixed cameras. Digital PTZ capability shall include Picture-in-Picture display.
- VMS client shall provide virtual PTZ controls that support ability to create virtual presets, mouse wheel zoom, and Picture-in-Picture display. PTZ shall be utilized on clip streams to enable cropping and magnifying the video pane during normal surveillance.
- VMS client shall provide three options for controlling IP PTZ cameras: CCTV keyboard, on-screen display icons and mouse-based drag and point.
- The on-screen display icons for PTZ controls shall include the ability to pan, tilt, and zoom, adjust the focus and iris of the camera, call preset positions and run set patterns where the feature is supported by the underlying camera, encoder or recorder.

- VMS shall enable the user to activate 1 to 96 preset camera positions through a transparent control diagram overlay on the live video display of the associated camera. Where supported by the camera.
- VMS shall enable the user to activate 1 to 10 pre-programmable preset sequences through a transparent control diagram overlay on the live video display of the associated camera. Where supported by the recorder.
- VMS client shall be able to use virtual PTZ controls on dome cameras during playback to better utilize the megapixel forensic video.

2.13 Call-ups

- VMS client shall provide an interface for operators to define video tours of related cameras.
- Video Tours shall support user configurable dwell-times.
- A tour may initiate a preset on a camera.
- VMS client shall provide an interface for operators to define video salvos.
- VMS client shall provide an interface for operators to define fixed video views.
- A fixed video view may contain a video tour.
- VMS client shall provide a call-up list to make the defined callups easily accessible to operators.
- All callups shall have the option of being assigned a user-configurable or auto-assigned reference number to enable triggering of the callup via a supported CCTV keyboard.

2.14 Send to Commands

- VMS client shall provide a Send to command feature to transfer any tabbed layout or object such as a specific camera, recorder, surveillance window, or web site onto any accessible monitor on the security network. The credentials of the recipient shall dictate the ability to access the information sent from another VMS client system. This feature shall be used to send tabbed layouts to guards at security desks (location: receptions - ground floor level)
- VMS client shall provide confirmation message regarding the Send to command to provide acknowledgement that the operation was either successful or that the attempt had failed.

2.15 Video Search and Export

2.15.1 Date / Time Search

- VMS client shall provide an easy-to-use wizard interface to simplify the configuration of a date/time search across multiple cameras/recorders within a maximum of 3 screens.
- The Date / Time search shall allow the user to simultaneously search as many connected cameras across many different recorders, as specified by the operator.
- VMS client shall allow the user to additionally request any audio associated with the video on the specified camera(s).

- VMS shall automatically download the first media clip from a successful search and start playing the video
- VMS provides 'direct export' mechanism from the Surveillance view. The operator selects a start and end time via the Surveillance view and all on- screen cameras are exported in a single operation to the specified destination.
- VMS shall provide the VMS client the ability to search across online, near- line archived and standby fail-over storage. When the search criteria spans beyond the online forensic video, the software shall continue the search seamlessly across archived near-line storage. If any fail-over occurred, the software search will seamless span across the standby storage of any fail-over mode recorder.
- VMS client shall be able to playback audio streams independently from the video streams, mix-match them with different cameras from the same or different servers for search results from recorders.
- VMS client shall include thumbnail search results for those recorders versions that support it to provide a simplified visual snapshot of the recorded video. The thumbnails will be spread across the desired specified search time period and can be drilled down quickly when double-clicking on a particular image.

VMS client shall include data visualization that enables data from all searches and reports to be graphically charted as bar charts and timelines. Ability to easily drilling down through the data to single events for a wider view for analyzing data patterns.

2.15.2 Motion Search

- VMS shall provide a mechanism to search for motion on a particular camera based on the following criteria:
Camera
Start date & time End date & time Motion search region
- VMS client shall enable users to select inactive or active regions of interest to simplify the configuration of the search criteria.
- VMS shall automatically download the first media clip from a successful search and automatically start playing the video.
- VMS shall download and play clips from further search results as directed by the operator, and support ability to jump to next and previous clips.
- From any motion search result, VMS client shall allow the user to add additional, related cameras to the View and shall automatically synchronize the date/time of the added cameras to the original search result ("Investigate mode").
- VMS client shall enable the operator to set the sensitivity of the motion search setting.

2.15.3 Video Intelligence Analytic Search

The VMS shall support the following video intelligence analytic search functions:

- VMS shall support the integrated video analytics included with the recorders.
- VMS shall utilize the information available from the recorder to apply the following Analytic Search criteria on the recorded video:

Object Detection to locate objects that move into a region of interest for the first time.

Object Direction to locate objects moving in a certain direction through a region of interest.

Object Linger to locate objects lingering in a region of interest for a minimum time period.

Object Enter to locate objects entering a field-of-view through a doorway or threshold.

Object Exit to locate objects exiting a field-of-view through a doorway or threshold.

Object Abandoned/Detected to locate objects when they become stationary, then moved or removed, over a set time period.

Queue Length to identify when a queue reaches a certain length when searched over a certain time period.

Crowd Formation to identify when a certain number of people or objects are found in a region of interest when searched over a certain time period.

- Recorders must have one or more analytic channel licensed in order to support integrated video analytics engine and allow the VMS to apply the Analytic Search criteria.
- VMS shall support dwell video analytics from cameras on recorders which capture people that are mostly stationary within a smaller and more defined ROI for a predetermined amount of time and percentage overlap. This analytic is generally utilized in retail to help identify customer activity in a display or end-cap area.
- VMS shall support dwell video analytics from cameras on recorders which capture people that are moving around within a larger ROI for the predetermined amount of time and percentage overlap. This analytic is generally utilized to help identify loitering in particular areas.
- VMS shall support Alarm Persistence Notification to enable ability to receive cached alarms for up to 14 days in Recover Mode from recorders that may have lost connection to the VMS server.

2.15.4 Clip Storage / Export

- VMS client shall allow the user to export clips of video from one or multiple cameras across multiple recorders in a single export.
- VMS client shall allow the user to assign custom name and export clips to a location of their choice: the client PC, VMS server or an Administrator- specified network storage location.
- VMS client shall provide the user the option of exporting video clips in their native format or in an appropriate non-format which can be played using a standard player.
- When exporting clips in Native format, VMS client shall provide the user the option of exporting a player application along with the video clips to ensure that exported video can be reviewed on any standard PC without installing VMS client.

- VMS shall support exporting “tamper-protected” video clips using dual-authentication mechanism (password protection and check-sum validation). VMS Unified Client and Player shall include a “Verify” button to visually demonstrate that a video clip has not been tampered with.
- VMS shall support custom watermarking images to be overlaid on for non- native exported video clips such as AVI/MP4.
- VMS shall allow ability to view the video clip as it is being downloaded from any of the supported recorders.
- VMS player shall enable the user to playback up to 64 simultaneous video clips regardless of video codec (MJPEG, MPEG-4, H.264 or ACC) in any of the following layouts:

Single Pane (1x1) Single Pane Wide (1x1)

2+3 (2 large panes, 3 smaller panes)

2x2

2x3

3x3

3x4 (widescreen video on widescreen monitors)

4x3 (widescreen monitors)

4x4

5x5

6x6

8x8

Guard (1 large pane, 5 small panes)

12 + 1 (1 large pane, 12 small panes)

2 + 8 (2 large panes, 8 smaller panes)

- VMS player shall enable the user to have full video playback controls within exported clips. Video playback controls shall include:

Fast Forward x4

Fast Forward x3

Fast Forward x2

Clock Speed (x1) Frame Forwards Frame Backwards

Clock Speed Rewind (x1) Fast Rewind x2

Fast Rewind x3

Fast Rewind x4

2.16 Events and Event Monitoring

- VMS shall support unlimited operator configurable events, including the action-based trigger of events.

- The system shall provide 8 event priority levels with pre-defined colors and labels.
- The system shall allow an event to be configured to:

Be sortable by event name, date/time, priority, state, and any other displayable information.

Require or not require operator acknowledgment.

Display an operator-defined text message upon event activation. Allow the operator to associate an audio wave file with the event. Run imports and exports.

Run reports and remove report results.

- VMS client shall provide an Event Viewer tab that displays a sortable list of active alarms or events within the system. The Event Viewer tab shall have the ability to be incorporated into an Application Layout with other tabs (Video Surveillance tabs, Site View, Device View, etc) or to occupy all of one connected monitor.
- VMS shall be configurable to display all events (alarms) in color based on the user-specified priority of the event.
- VMS shall support audible alarm annunciation at operator workstations (operator configurable audio (WAV) files associated with alarms).
- VMS shall be able to trigger one or more individual preset actions in the response to system events (or alarms) enabling users to automatically position cameras on relevant areas of interest.
- VMS shall be able to trigger one or more fixed views in the response to system events (or alarms) enabling displays of up to 64 cameras to be automatically presented on specified single or multiple monitors, including virtual matrix monitors, to easily show all the video related to the event.
- VMS Event Viewer tab shall be capable of displaying the following features:
 - System clock.
 - Date/time when the event was received by the server
 - Count of the active events. Clear event.
 - Clear all events
 - Event action message (automatically display selected message for event).
- VMS Event Viewer tab shall provide the ability to view video associated with an event within the same GUI.
- Event related video shall by default begin displaying video 30 seconds prior to the time of the event.
- VMS Event Viewer shall provide VMS client standard video controls (FFW, RW, Frame forward, etc) to easily review video prior to the pre-alarm time and after the post-alarm time without leaving the Event Viewer tab.
- Events configuration shall allow the user to enable “Event Breakthrough” which shall bring the Event Viewer tab to the forefront of a user’s Application Layout when a specified event occurs.

- VMS shall allow configuration of events to be created in a flow chart format, quickly viewed and events cloned from one device to another via a simple drag-and-drop method for simplified event configuration.
- VMS shall allow configured events to be quickly viewed and events cloned from one device to another via a simple drag-and-drop method for simplified event configuration.

2.17 Scheduling

- VMS shall provide users with ability to manage the execution of events or journal triggers which are to be activated only during specified time ranges in a scheduler.
- VMS shall allow ability to select and build schedules by Day, Week (Sunday- to-Saturday), Work Week (Monday-to-Friday), and Month using the schedule editor's calendar control.
- Schedules are assigned to actions through the Event/Schedule Setup editor.
- When a schedule is active (current date/time is within the specified time interval), only the associated events shall be triggered while all others will not be triggered. Alerts will continue whether or not the schedule is active.
- VMS shall dynamically update the status of all schedules on the schedule show all page.

2.18 Virtual Matrix

- VMS client shall allow the user to configure the system as a Virtual Matrix – controlling which cameras, tours or salvos are displayed in each pane of each monitor connected to the Client.
- Virtual Matrix control shall be via CCTV keyboard or PC keyboard and mouse.
- VMS client shall allow for the creation of an unlimited number of Virtual Matrix profiles. Each Profile shall have its own unique name, camera pseudo-numbering, salvo pseudo-numbering and monitor pseudo-numbering scheme for maximum flexibility of system configuration.
- VMS client shall allow sending call-ups (cameras, tours, etc.) to specific virtual matrix monitors using the right-click “Send To” surveillance command.
- The Virtual Matrix Editor shall auto-assign camera pseudo-numbers and gives the user the ability to manually edit these auto-assigned values.
- The Virtual Matrix Editor shall include a “Preview” function that visually displays how the video panes will be numbered across all defined monitors.
- The Virtual Matrix Editor shall auto-assign video pane numbers across all defined monitors and shall allow the user to manually modify these assignments – including defining a fixed start number for each monitor.

2.19 Reporting

- VMS shall be capable of displaying a log of all activity that occurs in the system, from object state changes and operator logon/logoff to video alert information.
- VMS shall provide a scrolling list of lines or tiles showing current activity on the system.

- VMS shall display activity in real-time as data is being transmitted by connected cameras and recorders.
- VMS shall allow for a “freeze” function that permits an activity to be selected and temporarily prevents the display of subsequent activities which would push the selected activity off the screen.
- VMS shall provide reports on the following:
All System Messages
All Configuration Changes
State Changes Operator Login System Activity System Error Video Alarms Video Clip Access

Objects Created Objects Deleted Objects Changed References Added References Removed
- VMS shall, for every operator logged into any Client, log which every video search that is executed, including which cameras were searched over what date/time period.
- VMS shall, for every operator logged into any Client, log all video exports, including the camera names and the start and stop date/time of the video clips exported.

2.20 Event Management

- VMS shall support dual phase acknowledgement with the ability to acknowledge an event, investigate the incident to determine what occurred, and then log a message either as a predetermined drop-down or user input field to ensure a seamless event workflow.
- VMS shall support using motion meta-data or embedded video intelligence to provide a bounding box that indicates what caused the alarm to be fired for easy visual identification within the Event Viewer.
- VMS shall support ability to customize how individual events are configured with regard to Acknowledge and Clear options that are assigned to event priorities.
- VMS shall support an Event Viewer that enables the user to acknowledge and/or clear events individually or collectively by group. When the event is acknowledged, it shall be automatically removed from the Active pane and then added to the Acknowledged pane for further review.

2.21 Object Association

- VMS shall support ability to allow any device within the security system (e.g. camera, door, etc.) to be linked to as many as five other objects. It shall utilize linking of unrelated video objects with the intent of enabling incident building capability.
- Object associated within the VMS shall enable a Review option on the context menu of associated objects which will open a guard view that displays the source and associated objects. The association will be made with the Reports, Event Viewer and Activity List to simplify the task of reviewing events in the Event Viewer and objects in the maps. Hovering over the device icon on the map and

clicking on the event could call-up associated video cameras and automatically synchronize the playback to the time of the event for easier investigation.

2.22 User Management / Permission Controls

- VMS shall protect access to objects via role based security permissions.
- VMS shall provide the following four pre-configured roles to facilitate easy initial system configuration:
 - Administrator – Full system access
 - Power User – High level access but the users cannot edit users and roles or add new devices to the system
 - Investigator – Secured user who can manage searches, clips and camera views. No access to device level features
 - Guard – Basic access. Users can primarily view information but not modify settings
 - Viewer – Basic View only role.
- VMS shall allow further user defined roles to be created and customized to the user's needs
- For any individual user or group of users, the Role Editor shall allow the user to control users' access to any of the following functions:
 - Disable or enable access to any of the Menu-Ribbon bar functions, including Video Search, etc
 - Disable or enable access to export clips as non-native AVI/MP4
 - Add, edit or delete any object from the system (e.g., cameras, recorders, keyboard, clips, folders, etc)
 - Display / hide any camera, recorder, keyboard, monitor or other object in the system
 - Operate manual PTZ controls on an IP PTZ camera
 - View recorded video on any connected camera or recorder
 - Listen to audio on any connected camera
 - Execute Time/Date or Motion searches on selected cameras or recorders
 - Export video from selected cameras or recorders
- Within VMS, objects shall be displayed to the operator based on his/her assigned operator privilege. The operator shall only be able to monitor/command those objects for which he or she has been assigned privilege.
- When an operator logs out of a workstation and a new operator logs on, the objects displayed on the workstation screen shall be dynamically updated to display only those objects for which the new operator has privilege.
- VMS client shall allow the association of a default Application Layout to each defined Role, so that when an operator assigned to that role logs into any VMS client, the default Application Layout is displayed.
- VMS shall allow operators to be created and associated with a Windows

Logon account

- VMS shall support single sign on of users using the Windows account of the logged on user

2.23 Integrated Web Browser

- VMS client shall include an integrated Web Browser tab that can be combined with other user interface components (Video Views, Site View, Event Viewer, etc) into an Application Layout. The Web Browser tab shall allow operators to continue monitoring their security system while also receiving weather or news updates from web-based information sources.
- Access to the Web Browser tab can be restricted via roles and permissions.

2.24 Data Storage / Encryption

- All programmed information, as well as transactional history, shall be automatically stored in the database for later retrieval and backup. VMS shall support configurations where the VMS database(s) may be installed on a hard drive on VMS, on an independent database server, or in an existing corporate database server.
- VMS shall allow activity history to be written to a database. The system shall have the capacity to store a minimum of 50 million transactions. There shall be a method of backing up the activity history on external media and then restoring and replaying it.
- VMS shall support AES 256-bit encrypted communications between server and VMS client.

2.25 Database Backup / Restore

- VMS shall provide a means to collect, save and restore the system data. VMS can backup an existing database or restore a database from a specified folder location for the system SQL instance.
- VMS shall provide this utility within the existing Server Configuration application.

2.26 Health Monitoring

The VMS shall support a health monitoring dashboard that will enable the Client to quickly identify the status of the devices on their system. Identifying the cause can be achieved by drilling down through flagged items.

- VMS health dashboard shall offer the status of system recorders (e.g. Normal, Reboot, Protection Status - Monitor, Protection Status - Failover, Alarm Recovery Completed, Sensor Alarm).
- VMS health dashboard shall offer the status of Recorder Storage (e.g. Normal, No Volumes, Volumes Missing, Volume Corrupt, Volume Failed, New Volume, volume Re-added, Unhealthy Disk, Disk Temperature, Raid Degradation, Disk Full).
- VMS health dashboard shall offer the status of system camera alerts (e.g. Unknown, Normal, Video Loss).

- VMS health dashboard shall offer the status of video channel storage alerts (e.g. Normal, Maximum Retention, Minimum Retention).
- VMS health dashboard shall be able to exclude disabled devices to eliminate non-applicable items.
- VMS health dashboard shall display devices within tabs on device view for improved organization.
- VMS health dashboard shall display a summary of the active health alerts in the system.
- VMS health dashboard shall provide date and timestamp of the alerts/malfunctions that occurred to confirm time of failures.

2.27 Redundancy

- A complete redundancy of all underlying data and hardware shall be assured.
- System shall be fault tolerant with no restarts for continuous operation.

H- NETWORK TIME PROTOCOL SERVER (NTP server):

Security systems and other systems on the network require time synchronization and accuracy in order to log events with legally traceable time.

System shall be a centrally controlled master time system, UL listed, fully installed, programmed, tested and left in first class operating condition.

A central control unit shall synchronize all peripheral (both free-running and slave) timekeeping devices and displays. The central control shall additionally have capabilities of automatically receiving and processing GPS based time reference communications from the atomic clock and controlling pre-programmed operations such as audible shift change signals and energy management loads.

- a. The NTP server should be housed in a 1U high mount rack inside the SMDF at the control room.
- b. Should be equipped with a 0.6" high, bright six digit display of time. The time display should be configured to show either local or UTC time.
- c. NTP server should operate on a TCP/IP network, serving NTP/SNTP time-packets directly to systems on the network.
- d. It should allow time synchronization from an NTP time source enabling the control and synchronization of other systems across the structured TCP/IP cabling network.
- e. The NTP server should have a standard user configurable serial ASCII data port with a wide range of data and message formats available at programmable intervals or on request. It should be supplied with four RS232+RS485 outputs.
- f. A precision one pulse per second signal of 100mS duration should be available at RS232 levels. The leading edge of the signal is within 50uS of UTC when locked to GPS.
- g. Each RS232+RS485 serial interface should be configured for many different pre-programmed data message formats for specific CCTV, security and embedded equipment time synchronization.
- h. Should have an internal PSU 100-250v 50/60Hz ac. i. Should have a 1 year backup battery.

- j. Operating temperature: 0-50°C
- k. Relative humidity: 0% to 95% non-condensing
- l. Accuracy-basic:
 - Stand-alone operation: 0.1sec/day
 - Synchronized to MSF or DCF within 30ms of UTC
 - Synchronized to GPS within 50uS of UTC

I- INTEGRATION

The unified video management and access control software / SMS shall be interfaced with the following systems:

1. Fire alarm system FAS
2. Structured cabling network
4. Access Control System

Integration shall allow a full duplex communication between the 2 interfaced systems.

Integration shall be a software integration or a hardware integration where software integration is not possible.

Interface with FAS

The security management system shall be interfaced with the FAS system through the use of fire alarm system control modules installed near the access control units.

As per NFPA requirements, all secured Emergency Exits and Fire rated Shutters shall be directly interfaced by hardwire to the Fire Alarm System.

All Emergency Exits monitored or not shall be compliant with NFPA Standards and therefore be "Fail Safe" wired.

In case of an emergency exit control by the security system, the FAS have priority over Security. When zone in alarm has been detected all doors that are used as safety accesses will automatically unlock if the FAS requires so.

The FAS shall also report the zone in alarm to the security system.

In case of confirmed fire, the FAS shall send an order to the controlled doors located at egress paths in the affected zone to unlock them.

A Software interface is also required with the FAS to primarily provide information on doors that are unlocked due to fire; this information shall be issued by FAS.

The software interface with FAS allows also the control and the local surveillance of each fire alarm zone. The system shall be able to display images (pop-up), from zone in alarm on any CCTV monitor of fire brigade.

The security management system shall be able to automatically print a report of occupants in the fire area

The contractor shall coordinate all interfaces needed with the FAS.

Sequence of operation shall be coordinated with FAS designer and in compliance with the NFPA standards.

- Interface with other systems

The SMS must include solutions for the integration of the following open systems protocols but not limited to:

1. Lontalk
2. Modbus
3. SNMP
4. XML – SOAP
5. OPC
6. EIB / KNX
7. TCP / IP

The SMS shall also provide the ability to program ASCII communication drivers for communication to other systems and devices.

The SMS will provide tools that allow the integration with all interfaced systems. These tools are:

1. Read-Only Database connections

A read-only database connection allows an interfaced system to view the contents of the SMS database. Once the connection is set up, the interfaced system can view any object within the database such as users and cards.

2. Scripting Tool

This tool is used to allow certain changes to be made within the SMS database.

The tool links to a table in the interfaced database and changes are affected in the SMS database based on custom scripts that provide the instruction for tasks to be carried out.

The system will be enhanced with a synchronization tool, which searches for a file containing changes. The synchronization tool then compares these changes to information contained within the database and instructs to automatically make any necessary changes.

3. Real-Time Event Exporting

This tool is ideal for sending information to an interfaced system that can then filter and act on event information as it occurs. For example, a CCTV system could filter on an access-granted event for a specific user and use this information to switch to a camera.

4. Command Import

Creates personnel information for a preformatted CSV file.

5. User Export Function

This allows all users to be exported from the SMS system, together with their respective images.

6. User Export Function

This allows all users to be exported from the SMS system, together with their respective images.

7. OPC Server

The OPC Server supports Data Access (DA) and Alarm and Event (AE) interfaces. It supplies Data Access interface to allow retrieval of information on doors and card

holders and the control of door's programmed state, on Alarm and Events interface outputs the events as a tidal separated string.

J- SERVER REQUIREMENTS

The system server shall meet the following minimum requirements:

1. The server Processor shall be: Intel Xeon Quad Core
2. The server shall have Dual Hard Disk Drives: Primary drive = 500 GB -9000 Runtime
Secondary drive = 500GB – Data Backups Drive Speed: 15, 000 RPM or greater.
3. The server shall have the following memory: 24GB dedicated to system.
4. The server shall have the following Network Adapter Card:
Intel Gigabit ET Quad Port Adapter, Gigabit Ethernet NIC, PCIe x4
5. The server shall have DVD Drive.
6. The server shall have an integrated video subsystem.
7. The server shall have a PS/2 or USB style mouse.
8. The server shall have an appropriate backup device.
9. The server shall support the following Operating Systems:
Windows Server 2012 Standard and Windows Server 2012 R2 Standard (64-bit)
10. The server shall support the following Database: SQL Server 2012 Standard and Enterprise (64-bit)
11. The server shall have Web Server IIS v6.0 or higher

K- CLIENT WORKSTATION REQUIREMENTS

The client workstations shall meet the following minimum requirements:

1. The client workstation Processor shall be: Intel Xeon E5-1603, 2.8 GHz
2. The client workstation shall have a Hard Disk Drive of 1 TB, Drive Speed: 7200 RPM or greater.
3. The client workstation shall have the following Memory: 12 GB
4. The client workstation shall have the following Network Adapter Card:
1 GB NIC or greater network card, rated at 100/1000 MB/sec
5. The client workstation shall have a DVD Drive.
6. The client workstation shall have two or three monitors.
The client workstation shall have the following video card:
1 GB NVIDIA Quadro 600
7. The client workstation shall have a keyboard and a PS/2 or USB style mouse.
8. The client workstation shall support the following Operating Systems: Windows 7 Professional SP1 (64-bit)
Windows 8 Professional SP1 (64-bit)

L- MONITORS

The video monitor described shall be an industrial grade, high-resolution color video monitor. The monitor displays shall be designed for professional use; displays with built-in TV tuners used for home/commercial use are not acceptable.

12. 24-Inch LED Monitor

The 24-Inch Monitor shall have the following specifications:
Full High Definition 1920x1080 Resolution

Professional grade panel for 24/7 operation

Anti-Glare Panel Surface

Number of pixels: 1920 (H) x 1080 (V)

- Viewing area: 531mm x 299mm
- Brightness: 250 cd/m²
- Contrast Ratio: 1000:1
- Backlight Type: LED
- Viewing Angle (H/V): 170°/160°
- Response Time: 5ms
- Panel Aspect Ratio: 16:9
- Video Formats: 480p, 576p, 720p, 1080i, 1080p
- Panel Life: 30000 hours
- PIP (Picture-in-Picture): Selectable, sizeable, swappable, moveable
- Speakers: 2, internal (3W)
- Front Panel Controls: Power, left/right, up/down, menu, input
- Video Input: DVI, BNC, HDMI, S-Video, VGA
- Audio Input: 3.5mm stereo jack
- Sync Format: NTSC/PAL
- Operating Temperature: 0°C to 40°C
- Storage Temperature: -20°C to 60°C
- Operating Humidity: 20% to 80%, non-condensing
- Operating Humidity: 10% to 90%, non-condensing

13. 55-Inch LED Monitor

The 24-Inch Monitor shall have the following specifications:

- Full High Definition 1920x1080 Resolution
- Professional grade panel for 24/7 operation
- Anti-Glare Panel Surface
- Number of pixels: 1920 (H) x 1080 (V)
- Viewing area: 1209.6mm x 684mm
- Brightness: 450cd/m²
- Contrast Ratio: 4000:1
- Backlight Type: LED
- Viewing Angle (H/V): 178°/178°
- Response Time: 6.5ms
- Panel Aspect Ratio: 16:9
- Video Formats: 480p, 576p, 720p, 1080i, 1080p
- Panel Life: 50000 plus hours
- PIP (Picture-in-Picture): Selectable, sizeable, swappable, moveable
- Front Panel Controls: Power, left/right, up/down, menu, input
- Input/Output Interfaces
 - Video 1 S-video; 1 component video; 1 video in; 1 video out; 1 display port;
1 HDMI; 1 DVI in; 1 VGA out; 1 VGA in
 - Audio 1 audio out L/R; 1 PC audio in; 2 audio in L/R; 1 speakers L/R Control 1 RS-232 input; 1 RS-232 output
- Sync Format: NTSC/PAL
- Operating Temperature: 0°C to 40°C
- Storage Temperature: -20°C to 60°C

- Operating Humidity: 10% to 90%, non-condensing
Operating Humidity: 10% to 90%, non-condensing

PART 3 EXECUTION

3.1 INSTALLATION

A- Network Video Recorder (NVR)

- The Network Video Recorder must be installed, programmed, and tested in accordance with the manufacturer's instructions.
- In order to ensure a complete, functional Network Video Recorder, for bidding purposes, where information is not available from the Owner upon request, the worst-case condition shall be assumed.
- Interfaces shall be coordinated with the Owner's representative, where appropriate.
- All necessary back boxes, racks, connectors, supports, conduit, cable, and wire must be furnished and installed to provide a complete and reliable Network Video Recorder installation. Exact location of all boxes, conduit, and wiring runs shall be presented to the Owner for approval in advance of any installation.

All conduit, cable, and wire shall be installed parallel and square with building lines, including raised floor areas. Conduit fill shall not exceed forty percent (40%). All wires shall be gathered and tied up to create an orderly installation.

B- Video Management Software (VMS)

- The software shall be entered into VMS computer systems. The Contractor shall be responsible for documenting and entering the initial database into the system. The Contractor shall provide the necessary blank forms with instructions to fill in all the required data information that will make up the database. The database shall then be reviewed by the Contractor and entered into the system. Prior to full operation, a complete demonstration of the computer real-time functions shall be performed. A printed validation log shall be provided as proof of operation for each software application package. In addition, a point utilization report shall be furnished listing each point, the associated programs utilizing that point as an input or output and the programs which that point initiates.
- Upon satisfactory on-line operation of the system software, the entire installation including all subsystems shall be inspected. The Contractor shall perform all tests, furnish all test equipment and consumable supplies necessary and perform any work as required to establish performance levels for the system in accordance with the specifications. Each device shall be tested as a working component of the completed system. All system controls shall be inspected for proper operation and response.
- Tests shall demonstrate the response time and display format of each different type of input sensor and output control device. Response time shall be measured with the system functioning at full capacity. Computer operation shall be tested with the complete data file.

The Contractor shall maintain a complete log of all inspections and tests. Upon final completion of system tests, a copy of the log records shall be submitted as part of the as-built documentation.

C- All the system cabling listed below shall be provided and installed by the CCTV system subcontractor and shall be in accordance with the system manufacturer's recommendations:

- Cabling between cameras and IDFs
- Cabling between cameras and HEPs

D- Data cables shall be:

- Category 6A with LSZH flame retardant outer sheath
- Cable construction must have a cross web for best cross talk performance.
- Conductor must be of 23 AWG
- Must meet TIA-568-B.2-1 standard
- Temperature operation during operation: - 20deg C to + 75deg C
- All UTP cables must originate from the same manufacturer.
- Any cabling related to the system and proposed by the Manufacturer should be LSZH.

E- Conduits:

- Material is to be of rigid unplasticized PVC, high impact, resistant to chemical corrosion, self-extinguishing. Conduits shall have a compression resistance of 1250N. Material shall operate in a temperature range of -5°C to 60°C. Conduits shall be marked at intervals of 1 to 3 meters.

Inside and outside surfaces of conduits shall be free from burrs, flash and other similar defects.

Wall thickness of conduits shall be uniform.

- Conduits shall comply with BS 6099-2-2.
- Conduit sizes shall be in accordance with applicable electrical codes, minimum size (25 mm).

3.2 TESTING

The Contractor shall demonstrate the functionality of the entire system upon completion of installation, documenting the result of all tests and providing these results to the Owner. The entire system shall be tested in accordance with the following:

- The Contractor shall conduct a complete inspection and test of all installed equipments.
- The Contractor shall provide staff to test all devices and all operational features of the system for witness by the Owner's representative and the Authority Having jurisdiction. All testing must be witnessed by the Owner's representative, prior to acceptance.

The testing and certification shall take place as follows:

- The entire system shall be tested in conjunction with the manufacturer's representative.
- All deficiencies noted in the above test shall be corrected.
- Test results shall be submitted to the consultant or Owner's representative.

- The test and correction of any deficiencies shall be witnessed by the owner's representative, and note.
- The Owner's representative shall accept the system.
- The system test shall be witnessed by the Authority Having Jurisdiction. Any deficiencies noted during the testing must be corrected.

The contractor shall describe the detailed testing procedure related to the CCTV system and the relation between the CCTV system with other interfaced systems.

3.3 TRAINING

- A- As a minimum training sessions will consist of the following:
1. General project information and review will be by the General Foreman or Superintendent of the Trade.
 2. Specific system training will be by a Factory Trained Representative.
 3. Provide a complete review of the project and systems including, but not limited to the following:
 - Review each Record Drawing (use of typical is acceptable).
 - Note equipment layouts, locations and control points.
 - Review the system.
 - Review system design operation and philosophy.
 - Review alarms and necessary responses.
 - Review standard troubleshooting techniques for each system.
 - Review areas served by equipment.
 - Identify color codes used.
 - Review features and special functions.
 - Review maintenance requirements.
 - Review operation and maintenance manuals.
 - Respond to questions (record questions and answers).
 - After training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.
- B- During the instruction period the Owner and Maintenance Manual will be used and explained.
- C- The Owner and Maintenance Manual material will be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No.1 of 2).
- D- Provide name, address and telephone number of the Manufacturer's representative and Service Company for all items supplied so that the source of replacement parts and service can be readily obtained.
- E- Include copies of Manufacturer's and installer's warranties and maintenance contracts and performance bonds properly executed and signed by an authorized representative.
- F- Include copies of all test reports and certifications.

END OF SECTION