

MECHANICAL SPECIFICATIONS

SECTION 23 34 00

ROOF PLANT HEAT EXTRACTION - VENTILATION SYSTEM

Item	Detail
Project	Council for Development & Reconstruction - CDR
System	high-level heat-extraction ventilation to the roof condensing-unit plant
Design Basis	Drawing # M-V-101
Revision	Rev 00
Date	July 2026
Prepared by	A CHEHAB Architects & Engineers

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SECTION 23 34 00

PART 1 - GENERAL

1.1 Scope of Work

The Contractor shall supply, fabricate, deliver, install, connect, test, adjust, balance and commission the complete roof-plant heat-extraction ventilation system serving the outdoor condensing units, complete in all respects and ready for operation, including:

- High-temperature centrifugal extraction fans and their motors, starters and mountings.
- Galvanized-Iron plenum boxes over the condensing units, with full-face wire-mesh intake panels.
- Galvanized-Iron ductwork, fittings, transitions, turning vanes, access doors, supports and hangers.
- Drainable (storm) make-up louvers to the external openings and discharge louvers to the void openings.
- Manual volume-control dampers and fire dampers at wall penetrations.
- Flexible connectors, anti-vibration mounts, gaskets, sealants and acoustic treatment.
- Controls, field sensors, wiring and BMS interface for staged fan operation.
- Decommissioning and removal of the existing roof exhaust fans; retention and re-commissioning of the existing fresh-air supply fans and one standby.
- Testing, adjusting and balancing (TAB), commissioning, and demonstration of the intake-temperature acceptance criterion.
- Shop drawings, material submittals, as-built drawings and Operation & Maintenance manuals.

The Contractor shall provide all labour, materials, tools and accessories necessary to complete the installation whether specifically mentioned herein or not.

1.2 System Description and Design Basis

The system removes the heat rejected by the roof condensing units by capturing it at high level, above the units, and discharging it through the void (internal-garden) openings to atmosphere. No opening may be cut in the roof. The design basis (report CDR-M-CALC-001 Rev 4) is:

Parameter	Design value
Condensing units served	50 (air-cooled, ≈ 15.57 kW rejection each)
Total heat to remove	≈ 824 kW
Outdoor design temperature	38 °C
Maximum condenser-intake air temperature	46 °C (acceptance criterion)
Total design extraction airflow	$\approx 133,100$ CFM
Extraction fans	11 fixed-speed high-temperature centrifugal
Capture	plenum box over each unit with full-face wire-mesh intake
Make-up air	3 retained fresh-air supply fans + 1 standby fresh air fan + passive through louvers
Discharge	to the external louvers

Capacities, dimensions and duct sizes are as scheduled on the drawing # CDR-M-V-101. Where a quantity is stated in this Section it is the design intent; the Contractor shall verify against the approved drawings and site survey before fabrication.

1.3 Applicable Standards

Materials, fabrication, installation, testing and commissioning shall comply with the latest editions of:

- SMACNA - HVAC Duct Construction Standards (Metal and Flexible), and Air Duct Leakage Test Manual.
- ASHRAE Handbook - HVAC Systems and Equipment.
- AMCA 210 / 300 - fan performance and sound testing; ISO 5801 - fan performance testing.
- ASTM A653/A653M or EN 10346 - hot-dip galvanized steel sheet.
- IEC 60034 - rotating electrical machines; local electrical authority regulations.
- Project drawings and specifications.

Where conflicts occur, the more stringent requirement shall govern.

1.4 Submittals

Prior to fabrication or procurement, submit for the Engineer's review and approval:

- Certified fan performance curves showing airflow, static and total pressure, efficiency, absorbed and motor power, operating point, sound power (LwA) per octave band, and confirmation of continuous operation at $\geq 60^{\circ}\text{C}$.
- Motor and starter data; electrical loads and staggered-start / staging arrangement.
- Material data sheets for ductwork, plenums, mesh panels, louvers, dampers, flexible connectors, insulation and supports.
- Controls submittal: sequence of operation, points list, sensor locations and interface.
- Shop drawings (Article 1.5).

1.5 Shop Drawings

Detailed shop drawings, coordinated clash-free with architectural, structural and other services, shall be submitted before fabrication and shall include: general-arrangement plans; duct layouts, sizes, elevations and routing; sections and elevations; fan, plenum, louver, damper and flexible-connection details; wire-mesh panel details; supports, hangers and structural fixings; access doors and maintenance clearances; equipment tags and airflow directions on ducts & fans; and builders' work.

The Contractor shall verify all dimensions on site before fabrication. No fabrication, procurement or installation shall commence until the relevant shop drawings are approved. Approval shall not relieve the Contractor of responsibility for accuracy, coordination or proper functioning of the installation.

1.6 Quality Assurance and Warranty

- Fans shall be from a manufacturer regularly producing high-temperature centrifugal fans, AMCA-certified for air performance and sound.
- The complete installation shall be warranted against defects in materials and workmanship for twelve (12) months from Taking-Over, and shall be demonstrated to meet the acceptance criterion of Article 3.9.
- The Fan maximum width or depth shall not exceed 800mm in order to move it inside the building.

PART 2 - PRODUCTS

2.1 Galvanized Iron (general)

Ductwork, plenums, reinforcement, supports and accessories shall be hot-dip galvanized iron to ASTM A653/A653M or EN 10346, grade DX51D or approved equivalent, coating class Z275 (275 g/m²) minimum, free from dents, rust and distortion. Cut edges, holes, scratches and welds shall be repaired with zinc-rich cold-galvanizing paint (≥ 90 % zinc in dry film). Exposed fasteners shall be hot-dip galvanized A2-70. Dissimilar metals shall not be in direct contact unless separated by an insulating barrier.

Duct gauge to be 22 for all sizes except for any duct dimensions equal or bigger than 1000mm where the gauge will be 20.

2.2 Centrifugal Extraction Fans

Fans shall be centrifugal, backward-curved type, selected to the duties scheduled on the drawings (each ≈ 12,100 CFM at ≈ 350 Pa external static; 11 running).

- Suitable for continuous operation in air at not less than 60 °C.
- Fixed-speed (no VFD); capacity is matched to load by staging.
- Dynamically-balanced impeller; AMCA-certified for air and sound performance.
- Galvanized or corrosion-resistant casing; inspection door; drain where required; lifting lugs; factory nameplate.
- Complete with flexible connector, anti-vibration mounts, inlet/outlet flanges and mounting base.

Motors shall be IE3 efficiency minimum, IP55, Class F insulation, continuous duty (S1), 400 V / 3-phase / 50 Hz, with a starter suitable for direct-on-line or soft start. Fans shall be started in a staggered sequence to limit combined inrush; simultaneous starting of all fans shall not be permitted.

Fans to be controlled by temperature sensor installed at high level. Fans operate if temperature crosses 44 deg Celsius.

2.3 Retained Fresh-Air Supply Fans

Four of the existing axial fresh-air supply fans (8,000 CFM each) shall be retained, cleaned, relocated as per drawings and re-commissioned as powered make-up fresh air fans, 3 of them as duty and 1 as standby.

2.4 Galvanized Steel Ductwork

Ductwork shall be factory-fabricated to SMACNA - straight, square, smooth internally, burr-free, accurately dimensioned, with continuous reinforcement and turning vanes in square elbows. Provide all fittings, transitions, access doors, flanged joints, stiffeners, sealants, gaskets, supports and hangers. Sheet thickness shall be to SMACNA for the duct size, pressure class and reinforcement spacing, and not less than 22 gauge (0.8 mm); the large mains (≈ 1000 mm) shall be not less than 20 gauge (1.0 mm).

Note: the system is under suction; large panels shall be cross-broken/beaded and braced with tie-rods to prevent inward deflection (maximum deflection L/240). Sealants, gaskets and flexible connectors shall be rated ≥ 60 °C.

2.4.1 Leakage

Ductwork shall meet SMACNA Leakage Class 6, Seal Class A. All transverse joints, longitudinal seams and flanges shall be sealed with an approved non-hardening, ≥ 60 °C-rated duct sealant. Visible leakage is not permitted. Leakage testing may be requested by the Engineer; failed sections shall be repaired and retested at the Contractor's expense.

2.5 Plenum Boxes

A galvanized-iron plenum box (minimum 1.2 mm) shall be provided over each condensing unit, sized 200 mm larger than the unit on each side. Each plenum shall have internal stiffeners, reinforced corners, a full-face wire-mesh intake (Article 2.6), a flanged/spigoted duct connection to the branch, a removable access panel, structural supports and lifting points. The plenum shall not choke the unit's own discharge fan; the clear height above the unit shall suit the unit discharge (minimum 800mm, maximum 1,200mm). Plenums shall withstand the operating (negative) pressure without permanent deformation.

2.6 Wire-Mesh Intake Panels

The intake face of each plenum shall be a removable, framed coarse wire-mesh panel (not a diffuser or grille), acting only as a bird/debris guard - it is not a filter and shall not restrict airflow:

- Welded steel mesh, hot-dip galvanized (Type 304 stainless as an approved alternative in the coastal environment).
- Coarse aperture 20 mm; wire diameter 2.0mm; open area $\geq 80\%$ (face velocity ≈ 1 m/s or less).
- Galvanized steel angle frame $25 \times 25 \times 2$ mm with at least one intermediate stiffener; $\geq 60^\circ\text{C}$ EPDM gasket; galvanized/stainless fixing bolts.
 - Zinc-rich repair coating to all welds; panel removable and re-fittable for cleaning.

Fine or insect-grade mesh shall not be used (it blinds over with plant debris and chokes the airflow).

2.7 Volume-Control and Fire Dampers

Manual volume-control dampers (galvanized frame, blade and shaft; bronze or nylon bearings; locking quadrant and position indicator; suitable for continuous operation at $\geq 80^\circ\text{C}$; handles accessible after installation) shall be provided for balancing as indicated.

2.8 Flexible Connectors

Fire-resistant flexible connectors, suitable for continuous $\geq 80^\circ\text{C}$, minimum 150 mm long, shall be installed between every fan and the rigid ductwork.

2.9 Duct Insulation and Acoustic Lining

Acoustic lining (or external acoustic treatment) might be needed where required to meet the noise criteria of Article 3.7. Lining shall be erosion-resistant at the design velocity and rated for the extract temperature.

2.10 Supports, Hangers and Vibration Isolation

Supports (galvanized channels, threaded rods, expansion anchors, brackets and reinforcement) shall be independent of equipment and shall not induce excessive stress into ducts. Fans shall be mounted on anti-vibration isolators selected for the fan speed and weight; flexible connectors shall isolate the ductwork. Vibration at the fan bearing housing shall not exceed 4.5 mm/s RMS; where exceeded, the Contractor shall rebalance and rectify at no cost.

2.11 Identification

Provide engraved identification labels for all fans, dampers and plenums (with tag numbers matching the drawings), and airflow-direction arrows on the ductwork.

PART 3 - EXECUTION

3.1 Installation

- Ductwork shall be installed level and plumb, independently supported, free from sagging, protected during construction, and shall impose no load on connected equipment. Support spacing shall be to SMACNA.
- Plenum boxes shall be installed centrally over each unit at the clear height that suits the unit discharge, sealed and supported independently of the units.
- Louvers shall be sealed weather-tight to the structural openings; drainable louvers installed with drainage paths clear.
- Fans shall be installed on their isolators with flexible connectors; rotation verified before running.

3.2 Controls and Sequence of Operation

The extract fans are fixed-speed; capacity is matched to load by temperature interface:

- **Temperature back-up (override):** temperature sensors at representative condenser intakes (including the hottest corner clusters) and one under the ridge bring on further fans if any intake approaches 46 °C, holding the last stage until the temperature drops. Setpoint ≈ 44 °C.
- **Overnight turndown:** when the compressors are off (building unoccupied), the extract fans switch off automatically - no separate time schedule required.

3.3 Testing, Adjusting and Balancing (TAB)

After installation the Contractor shall carry out complete TAB, measuring fan airflow, static and total pressure, speed, motor voltage/current/power, air velocity and air temperature. Manual dampers shall be adjusted until the design airflow is achieved, within: fan airflow ± 5 %, branch airflow ± 10 %. Submit balancing reports giving design vs measured values, damper settings, fan operating points, electrical readings, ambient conditions and calibrated-instrument certificates.

3.4 Noise and Vibration

The completed installation shall operate without objectionable noise or resonance. The Contractor shall provide acoustic treatment and vibration isolation as necessary to achieve, at no additional cost:

- At the plant equipment: not more than 75 dB(A) at 1 m from any fan (hearing-protection zone acknowledged for maintenance).
- At the nearest occupied space and at the internal garden / void boundary: not more than 55 dB(A) (or the Project noise limit / NR 45, whichever is lower).
- Vibration transmitted to the structure: none objectionable; fan-bearing vibration ≤ 4.5 mm/s RMS.

Particular attention shall be given to regenerated noise at the void discharge louvers; attenuators shall be provided on the fan discharges if required to meet the boundary limit.

3.5 Commissioning

The Contractor shall commission the complete system in the presence of the Engineer: visual inspection; start-up and rotation check; vibration and noise measurement; verification of damper operation, airflow and electrical loading; verification of the control staging and interlocks; and functional testing under full operating conditions, including simulation of the overnight turndown and the temperature-override stages.

3.6 Acceptance Criterion

The system shall be accepted only when, with all 50 condensing units at full load on a design summer day, the measured air temperature entering the condenser intakes - including the hottest corner clusters and the air just under the ridge - does not exceed 44 °C. Where any location exceeds 44 °C, the Contractor shall investigate and rectify (staging, damper balancing, plenum capture, make-up delivery or void venting) until the criterion is met throughout.

ELECTRICAL SPECIFICATIONS

ROOF PLANT HEAT EXTRACTION - VENTILATION SYSTEM

Item	Detail
Project	Council for Development & Reconstruction - CDR
System	Electrical System for high-level heat-extraction ventilation to the roof condensing-unit plant
Design Basis	Drawing # E-103
Revision	Rev 00
Date	July 2026
Prepared by	A CHEHAB Architects & Engineers

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SECTION 1
BASIC ELECTRICAL REQUIREMENTS

1.1 GENERAL REQUIREMENTS

1.1.1 INSTALLATIONS GENERALLY:

- A. Carry out electrical work in accordance with the Drawings, Specification and Regulations, ensuring compliance with design and performance requirements, to provide safe and protected systems with equipment readily accessible for operation, maintenance and repair.
- B. Installations are to be complete, ready for operation and fully integrated and coordinated with all other work.
- C. Installations are to be carried out by qualified personnel.
- D. Provide accessories necessary to complete the installations, of the types specified or recommended for the purpose by the manufacturer of the equipment or accessories.

1.1.2 EQUIPMENT SPACES AND ROOMS: check that dimensions, structure, ventilating and cooling arrangements and other provisions in equipment spaces and rooms are suitable for installation, operation and maintenance of proposed equipment. Note any discrepancies on the shop and construction drawings. The Contractor is responsible of planning the erection of the electrical equipment such that it is not interfering with any other trade in the building.

1.1.3 POWER SUPPLY: liaise with the Local Power Authority to confirm:

- 1. Characteristics of supply and system earthing
- 2. Location of incoming supply shown on the Drawings
- 3. Space requirements and associated builder's work for the Authority's installations.
- 4. Make necessary arrangements at the earliest opportunity to ensure connection as and when required, and inform the Engineer in the event of any foreseen delay.

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

1.2 DESIGN CONDITIONS

- A. Nominal characteristics of power supply and distribution are as follows:
 1. Medium voltage : 20 kV, 3 phase,
 2. Low voltage : 380 V, 3 phase, 4 wire, solidly earthed neutral
 3. Frequency : 50 Hz,
 4. Earthing System : TNC/TN-S
- B. DISTRIBUTION SYSTEMS are to be supplied or derived from the voltage system previously described, as shown on the Drawings, or as otherwise specified.
- C. EQUIPMENT is to be designed for the system voltage and frequency previously described, unless otherwise specified. Special provisions are to be made for equipment sensitive to power supply frequency and voltage variations and for equipment operated at other voltages/frequencies or by direct current sources.
- D. KWH-METERING will be at low voltages, as shown on the Drawings.
- E. Where design and operating conditions, different from the above are required for particular equipment, they are described in the specification of the equipment concerned.
- F. REGULATIONS: carry out electrical work in accordance with the current issue of the local codes of practice, local power authority regulations and IEC Regulations for Electrical Installations, where not in contradiction with the local codes of practice and regulations, here in referred to collectively as 'the Regulations'.
- G. CONFLICT should an instance occur in this specification or on the drawings in which material or construction methods called for are less than minimum requirement of the Regulations, the Engineer shall be immediately informed in writing. Consequent to Engineers approval, supply the materials and perform the work as through called for to minimum code standards.
- H. STANDARDS: All works shall comply with the standards
 1. IEC / BS Standards for electrical systems and installations
 2. ISO Standards
 3. NFPA 101 – Life S NFPA 72 – National Fire Alarm and Signaling Code.
 4. BS 5839-1:2017 – Fire detection and fire alarm systems for buildings: Code of practice for design, installation, commissioning and maintenance.
 5. Lebanese Civil Defense Regulations and the Lebanese Code for Fire Safety of Buildings. Where standards conflict, the most stringent requirement shall apply unless otherwise directed by ICRC.

1.3 THE DRAWINGS

- A. EQUIPMENT LOCATIONS shown on the Drawings indicate the approximate locations and general layout of equipment. Exact and final locations and layouts

together with dimensions, weights, mounting methods and accessories, where relevant are to be shown on the shop and construction drawings. All protecting device shall show: the short circuit current value for single and three phase current, the voltage drop, the indirect protection function in case of a fault with respect to the earthing system.

- B. WIRING LAYOUTS shown on the Drawings are to be used as a guide only to defining basic positions, circuiting, loading and switching arrangements. Actual layouts and details of routing of circuits are to be shown on the shop and construction drawings.
- C. WIRING LAYOUTS shown on the Drawings for work not included in the Electrical work are shown for convenience and reference only.
- D. SYMBOLS: in order to provide sufficient detail and a minimum degree of clarity on the drawings, the symbols used for the various electrical devices, particularly wall mounted devices, take up more space on the drawings than the device does on the wall. Because of drafting limitations these locations must be considered as being symbolic rather than exact physical locations of the devices.
- E. The devices shall be installed with prime regard for convenience of operation and the best use of the wall space for this and other purposes rather than string the devices out along the wall so as to coincide with the scaled locations of the symbols. In locating the outlets, follow the criteria provided on detail drawings where provided, and co-ordinate with furniture. Submittal of detail drawings is required for this purpose before execution. Do not scale from design drawings.

1.4 EQUIPMENT AND MATERIALS

- A. AVAILABILITY: confirm availability of equipment and materials proposed for use in the work prior to submission for approval. If, after approval, equipment or materials cease to be available, submit alternative items of equal quality and type for approval.
- B. ACCEPTANCE BY AUTHORITY: confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other authorities having jurisdiction and are acceptable to them. Inform the Engineer of any modifications necessary to comply with the Local Power Authority's requirements.
- C. MANUFACTURERS' STANDARDS: equipment is to be the latest standard product of the manufacturer. Component parts are to be the product of a single manufacturer, unless otherwise approved and provided that components made by other manufacturers are of a standard design and are interchangeable.
- D. APPROVED MANUFACTURERS: listing of approved manufacturers in the Specification does not necessarily constitute approval of their standard products as equal to those specified. Ascertain that listed manufacturers are able to supply equipment and material in conformity with the Specification.
- E. FACTORY ASSEMBLY: equipment generally is to be supplied in complete factory assembled units ready for installation on site. Dis-assembly necessary for transportation or other purposes is to be arranged to limit site work to simple re-assembly and inter-wiring of control and power cabling.

- F. **STORAGE OF MATERIALS:** equipment and materials are to be stored in an approved location, under cover, free from humidity, dust, debris and rodents. Equipment sensitive to heat and humidity is to be kept in climatically conditioned areas until installed and handed over.
- G. **DEFECTIVE EQUIPMENT:** the Employer reserves the right to operate operable defective equipment during the Defects Liability Period until it can be removed from service for repair or replacement.
- H. **WARRANTY:** where required by the Specification, provide a warranty, signed by the manufacturer (including his agreement to replace promptly, defective equipment or parts thereof, as instructed by the Engineer) covering materials and workmanship for the period stated in the Specification, starting at substantial completion. The Contractor is to assign the benefits of such warranty to the Employer.
- I. **SPARE PARTS:** not later than the date of substantial completion, provide spare parts required by the Specification, together with suitable means of identifying, storing and securing same.
- J. **TOOLS AND INSTRUMENTS:** not later than the date of substantial completion, provide sets of tools and instruments required by the Specification, together with suitable means of identifying, storing and securing same.
- K. **LABEL AND IDENTIFY** all equipment, instruments, controls and electrical devices etc. to indicate duty service or function, to the satisfaction of the Engineer. Labels are to be laminated plastic or anodised aluminium discs with black surface and white core with incised lettering in English or Arabic to the satisfaction of the Engineer. Alternative methods of labelling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent surfaces or as approved by the Engineer.
- L. **EQUIPMENT NAMEPLATES** are to be non-corroding, robust metal, inscribed in English, and firmly fixed to equipment at factory. Nameplates are to indicate name and address of manufacturer, model, serial number, basic characteristics and ratings of equipment and are to include elementary diagrams etc., all in accordance with the Standards.
- M. **FIREPROOFING:** Where cables, cable trays, busducts or conduits pass through floors and fire rated walls, pack space between wiring and sleeve full with materials and seal with approved caulking compound.

1.5 SUBMITTALS

- A. Approval of submittal: Approval of a submittal does not relieve the contractor from the specifications and contractual obligations. Each submittal should show a schedule of compliance sheet, addressing each point mentioned in the specifications and/or in the BOQ, these points should be numbered and each number should be highlighted with the relative number on the original certified catalogue. Any deviation or omission from the specifications shall be clearly stated in a compliance sheet.
- B. Coordination: Transmit each submittal sufficiently in advance of performance of related construction activities to avoid delay, and allow for 2 weeks time for review.
- C. Submit all required data in 4 copies minimum.
- D. Submittal Preparation: Place a permanent label or title block on each submittal (including shop drawing) for identification. Indicate the name of the entity that prepared each submittal on the label or title block.
 - 1. Include the following information on the label for processing and recording action taken:
 - a. Project name.
 - b. Date.
 - c. Reference number for the submittal with revision number if the same submittal has been submitted before.
 - d. Name and address of the Architect.
 - e. Name and address of the Contractor.
 - f. Name and address of the subcontractor.
 - g. Name and address of the supplier.
 - h. Name of the manufacturer.
 - i. Number and title of appropriate Specification Section.
 - j. Drawing number and detail references, as appropriate.
- E. Product Data: Collect Product Data into a single submittal for each element of construction or system. Product Data includes printed information, such as manufacturer's installation instructions, catalog cuts, standard color charts, roughing-in diagrams and templates, standard wiring diagrams, and performance curves.
 - 1. Mark each copy to show applicable choices and options. Where printed Product Data includes information on several products that are not required, mark copies to indicate the applicable information. Include the following information:
 - a. Manufacturer's printed recommendations.
 - b. Type of usage and location.
 - c. Reference number in contract documents (Specifications, drawings)
 - d. Compliance with recognized testing agency standards.
 - e. Application of testing agency labels and seals.
 - f. Notation of dimensions verified by field measurement.
 - g. Notation of coordination requirements.

2. Provide complete original catalogues of product when relevant or when requested.
 3. Include Installation and Operation manual with each applicable submittal.
- F. **SAMPLES:** Submit full-size, fully fabricated Samples cured and finished as specified and physically identical with the material or product proposed. Samples include partial sections of manufactured or fabricated components, cuts or containers of materials, color range sets, and swatches showing color, texture, and pattern.
- G. **Operation and Maintenance Manuals:** Include Operation and Maintenance manual for each equipment. Identify each equipment and include the local supplier's name and full address, the manufacturer's manual, in addition to recommended spare parts.
- H. **Organize the Operation and Maintenance Manuals by system and sub-system.** Describe for the whole system and each sub-system separately, the proper normal operation, shut down, access, routine preventive maintenance and describe intervention needed in case of failure.

1.6 SHOP DRAWINGS

- A. Submit newly prepared information drawn accurately to scale. Highlight, encircle, or otherwise indicate deviations from the Contract Documents. Do not reproduce Contract Documents or copy standard information as the basis of Shop Drawings. Standard information prepared without specific reference to the Project will be rejected.
- B. Submit Builder's Work drawings showing Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
- C. Shop drawings shall be prepared electronically editable on Autocad similar to the edition of the original drawing. Layers, sizes and all other drawing requirements shall be followed as per instructions of the Architect/Engineer. These shall be made and presented to suit for the elaboration of composite drawings.
- D. Shop Drawings include fabrication and installation Drawings, setting diagrams, schedules, patterns, templates and similar Drawings. Include information as required by individual sections, in addition to the following information:
 - a. Dimensions, distances, invert levels, operating clearances, location of access required.
 - b. Identification of products and materials included by sheet and detail number.
 - c. Accessories, connections to other services, electrical connections, etc.
 - d. Notation of coordination requirements.
 - e. Sheet Size: Except for templates, patterns and similar full-size Drawings, submit general layouts on 1/50 scale, and details on 1/20.

- f. Submittal: Submit 4 blue- or black-line prints for the Architect's/Engineer review. The Architect/Engineer will return one print.
 - g. Do not use Shop Drawings without an appropriate final stamp indicating action taken.
 - h. Submit electronic copy after approval of drawing.
- E. Shop drawings are to be checked thoroughly and coordinated to avoid interference with structural elements, finishing requirements and the work of other trades (electrical requirements for mechanical equipments).

1.7 COORDINATED COMPOSITE DRAWINGS

- A. Participate in site meetings to coordinate shop drawings between all construction trades.
- B. Submit coordinated composite drawings showing interference of all trades on one sheet, including composite sections and elevations.
- C. Submit Composite drawings showing reflected ceiling plans to coordinate and integrate installation of air outlets and inlets, light fixtures, communication system components, sprinklers, drainage pipes, water supply and other ceiling-mounted items

1.8 AS BUILT DRAWINGS

- A. As-Built Drawings: On completion of the works of each area, system or floor, submit four set of prints of each applicable drawing for the mechanical and plumbing installation, showing the exact position of all apparatus, plant, duct and pipe work runs, valve positions, grille and diffuser locations, etc. with all appropriate labeling to the Architect/Engineer's requirements. All as-built drawings must conform in all respects to the pattern of the Contract Drawings, and to the approval of the Architect/Engineer.
- B. As-Built drawings shall be submitted directly after approval of the installation, and prior to testing and commissioning. A draft copy shall be submitted before closing shafts, ceiling or any obstructing element.
- C. The words "As Built Drawing" shall be clearly indicated on all drawings adjacent to the title cover. As-built drawings will be subject to Architect/Engineer approval. Contractor to submit hard copies and also soft copies of all as built drawings on CD ROMS to the Architect/Engineer after the approval of the as built drawings.

1.9 OPERATION AND MAINTENANCE MANUAL

- A. Before Final Handing over submit a draft copy of a complete Operation and Maintenance manual that include:
 - 1. A documentation Directory
 - 2. Emergency information
 - 3. Operating manual
 - 4. Maintenance Manual
 - 5. Test reports
 - 6. As built drawings
- B. Documentation directory: Submit an index of all O&M documents in a well-organized manner identified to ease the access of information and reflecting the hierarchy of the project: System, sub-system, Equipment, component.
- C. Emergency information: a document that should be readily available for emergency situation that include, for each system, information needed for type of emergency, with the notification activity and the responsibility of the personnel.
- D. Operating manual: A document that contains all information needed for day-to-day operation and management of the building systems. Two parts required: one intended for the building manager focused on the systems and one for the building operators focused on the technical information of the equipment, with the normal operation, access and shut down of equipment.
- E. Maintenance Manual: In addition to manufacturer supplied maintenance manuals, provide for each equipment:
 - 1. Description of equipment
 - 2. Recommended maintenance procedures and their frequency.
 - 3. Recommended list of spare parts with their number and reference.
 - 4. Original purchase order number, supplier's name, address and phone number.
 - 5. Intervention needed in case of failure and Installation information.
- F. Testing reports: Include test results from the testing and commissioning process.
- G. Construction documents include AS-built drawings, specifications, approved submittals, schedule of equipment, warranty certificates, ...

1. SPECIAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

2.1 REQUIREMENTS

- A. **CONSTRUCTION:** electronic components of communication systems, security systems and special systems and electronic components forming part of the power generation and distribution system are to be solid-state integrated construction, unless otherwise approved.
- B. **TEMPERATURE LIMITS:** manufacturer is to indicate maximum and minimum ambient temperatures acceptable for the equipment to operate continuously and normally and beyond which electronic components may suffer permanent damage.
- C. **ALTERNATIVE ELECTRONIC EQUIPMENT** may be submitted for approval, provided such equipment meets or exceeds the functional capabilities and/or performance parameters of the equipment specified. Proposals for alternative equipment will be considered only if accompanied by the following information:
 - 1. List of operational characteristics and performance parameters.
 - 2. List of differences in operation and performance between proposed and specified
 - 3. equipment.
 - 4. List of changes required and resulting implications.
 - 5. Drawings indicating changes required to system wiring.
 - 6. Statement of advantages of proposed equipment over that specified.
- D. **PROTECTION:** solid state equipment under normal conditions of operation is to withstand any surges which might be produced by sudden mains or standby power switching operations. Protective devices are to be provided to protect against surges, failure of output stages due to open circuit, short-circuit or impedance mis-match. In the absence of IEC standards comply with IEEE standard 472 (ANSI/IEEE C37.90 "Guide for Surge Withstand Capability Tests". System/equipment which may be adversely affected by short duration power blackouts shall be capable of riding through such a disturbance by having an internal battery back-up to the memory / microprocessor, etc.
- E. **INDICATOR LIGHTS** shall be Light Emitting Diodes (LEDs).
- F. **ELECTROMAGNETIC RELAYS** and control/small power transformers are to be designed to withstand the 500 V a.c. test voltage between winding and winding or winding and core.
- G. **DUST COVERS**, easily removable for inspection and servicing, are to be provided for all relays and sensitive elements.
- H. **OUTDOOR EQUIPMENT**, electronic or other, is to be designed for maximum ambient temperature or direct sun and is to be protected/enclosed, as applicable, against dust and weather conditions.

- I. **EXTERNAL INTERFERENCE:** carry out field investigations and tests to determine possible ninterference from outside sources. Design electronic equipment to ensure trouble-freeoperation.
- J. **SEGREGATION OF WIRING:** design wiring so that low current circuits are segregated frompower wiring, using different conduits and wireways for the purpose. Composite wiring is acceptable for the same system in accordance with the relevant codes. Cable insulation is tobe same grade for all conductors in a common enclosure.
- K. **POWER SUPPLY UNITS** for low current systems which are fed from the LV supply are to be independently fused on the live conductor and are to have front panel mains indicator light,on/off switch and standard cartridge type fuse holder. Blown fuse indicator lamp is to beprovided when fuse does not have an indicator.

2. TESTS ON SITE, RECORDS, TRAINING AND MAINTENANCE

2.1.TESTS ON SITE

- A. **GENERALLY:** carry out inspection and acceptance tests on site on each complete system,before final placement into service, in accordance with the Regulations and Standards, asdescribed in the Specification and required by the Engineer.
- B. **TEST SCHEDULES AND PROCEDURES** are to be submitted for approval and are to includedetails of testing equipment to be provided.
- C. **WITNESSING:** inspection and acceptance tests are to be carried out in the presence of theEngineer and, when required, by an authorized representative of the Local Power Authority.
- D. **VISUAL INSPECTION:** visually check proper installation, connections and nameplate databefore testing.
- E. **INSULATION RESISTANCE:** test the feeders, lighting and power circuits, motors and otherpower equipment of low voltage installations with a megger of not less than 500 V d.c. forinstallations rated up to 500 V (r.m.s. value of a.c. supply) and 1000 V d.c. for installationsrated above 500 V up to 1000 V, and as required by the particular Section of the Specification.
- F. **INSULATION RESISTANCE:** unless otherwise specified or approved, test the circuit insulationresistance related to communications and security systems with a megger of not less than500 V operating voltage, with equipment disconnected.
- G. **CONTINUITY:** test all feeders and circuits for continuity.
- H. **OPERATIONAL TESTS:** carry out operational tests on all equipment and complete systems toverify proper performance in compliance with the Specification. Tests are to be carried outunder normal operating conditions for not less than 3 days, and as required by the Engineer.

- I. **SPECIFIC TESTS:** carry out specific tests required by the Specification and any other tests required by the Engineer to verify compliance of the installations with the Specification.
- J. **LOAD BALANCE:** upon completion of the building and immediately prior to final inspection and take-over, check load balance on all feeders and at distribution centers, panels, etc. Conduct tests by turning on all possible loads in the building and checking the load current balance. If load unbalance exceeds 15%, rearrange and reconnect circuits to balance the load after Engineer's approval.
- K. **VOLTAGE CHECKS:** perform voltage checks throughout the building and if directed by the Engineer, adjust the transformer tap settings where a transformer is provided on the supply end, or report to power authority for adjustment necessary.
- L. **CURRENT CHECKS:** In cooperation with the mechanical sub-contractor, take clip-on ammeter readings on all phases of all mechanical equipment motors with motors operating under full load conditions. Test readings shall be submitted to the Consultant.

2.2.RECORDS

- A. **GENERALLY:** not later than the date of substantial completion, provide the Engineer with four copies of all approved as-installed drawings, test records, manufacturers' guarantees and warranties, operating and maintenance manuals and other records required by the Specification.
- B. **PRESENTATION OF RECORDS** is to be in A4 size plastic covered, loose leaf ring binders or other approved binders with hard covers, each indexed, divided and appropriately covered and titled. Drawings larger than A4 size are to be folded in the binders so that they may be unfolded without being detached.
- C. **AS-INSTALLED DRAWINGS** are to contain the complete assembled information included on the construction drawings, prepared in the same manner, and up-dated to indicate the systems, labeling, referencing, mounting methods, routing etc. as installed. Submit completed drawings for approval. Provide the Engineer with one set of transparencies in addition to the four copies required.
- D. **TEST RECORDS** are to include test certificates of type tests, routine tests, site tests, commissioning and performance tests and all other tests on equipment and installations described in the Specification and required by the Engineer. Information is to include test procedures and results, conditions under which tests were carried out including set points, temperatures and the like, dates, location and attendance by authorized representatives etc.
- E. **OPERATING AND MAINTENANCE MANUALS** are to contain the following:
 - 1. Technical description of each system and item of equipment installed, written to ensure that the Employer's staff fully understand the scope and facilities provided.
 - 2. Diagrammatic drawings of each system indicating principle components and items of equipment.
 - 3. Schedules (system by system) of equipment installed giving manufacturer, catalogue list numbers, model, rating, capacity and operating characteristics; each item is to

have a unique code and number, cross- referenced to the diagrammatic drawings and layout drawings.

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

2.3. TRAINING

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

2.4. MAINTENANCE

- A. MAINTENANCE CONTRACTS: where required by the Specification, submit supplementary proposals for annual maintenance contracts. The proposals are to:
1. Include for maintaining the installations in efficient working order including routine and emergency service checks, adjustments, lubrication and the supply and replacement of damaged parts etc.
 2. Set out the terms of the offer, the work to be carried out, the guarantees of performance and the price of the work or part thereof for the first twelve months after substantial completion.

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

SECTION 2
CONDUITS, WIREWAYS, SUPPORTING SYSTEMS AND RELATED
ACCESSORIES

1. GENERAL

1.1 DESCRIPTION OF WORK

Raceways including conduits, wireways, cable trays and related installations and accessories necessary to support and protect cables, feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.

1.2 REGULATIONS AND STANDARDS

Conduits, wireways, cables trays and fittings are to be designed, constructed and installed to give safe installation and reliable mechanical protection for wires and cables in accordance with the Regulations. Standards of products are to be as specified. Local production is prohibited if not tested and approved by a legal authority.

1.3 TECHNICAL DATA

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

- A. Manufacturer's catalogues with specifications of raceways including conduits, trunking etc. and related accessories.
- B. Samples of each type of raceway and accessory.

1.4 SHOP AND CONSTRUCTION DRAWINGS:

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

- A. Exact routing of conduits, trunking etc. With indication of boxes, accessories and expansion joints, size of conduits and boxes
- B. Typical assembly details of installation of trunking, trays etc.
- C. Construction details of pull boxes.
- D. Typical installation details including connection of conduits to metal enclosure. Connections of flexible conduits, vapour-tight installations in cold rooms, liquid tight flexible metallic outdoors etc. and earthing connections.

1.6. APPROVED MANUFACTURERS:

Obtain conduit, wireways and related accessories from one of the following or other equal and approved:

- A. UNIVOLT (Austria)
- B. EGA Tubes (England)
- C. DIELECTRIX (England)
- D. DECODUCT (UAE)
- E. GEPICO

2. PRODUCTS AND SYSTEMS

2.1 CONDUITS AND ACCESSORIES

2.1.1 RIGID & FLEXIBLE METAL CONDUIT

- A. **MATERIAL:** steel, cold rolled and annealed, non-threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside. Black enameled or hot dipped galvanized, L= 3m, screwed on both ends to NF-C-68-100. Locally manufactured conduits shall not be accepted.
- B. **LIQUID- TIGHT FLEXIBLE METALLIC CONDUIT:** is to have PVC jacket extruded over core.
- C. **FITTINGS GENERALLY:** thread less, hinged clamp type, hot dipped galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
- D. **STRAIGHT CONNECTORS:** one piece body, female type, hot dipped galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
- E. **ANGLE CONNECTORS:** of 45 or 90 degree and terminal connectors are to be as specified for straight connectors, except that body is to be two-piece with removable upper section.

2.1.2 RIGID HEAVY GAUGE PVC CONDUIT

(Locally manufactured conduits shall not be accepted).

- A. **MATERIAL:** Rigid heavy gauge conduit shall be manufactured from un-plasticized polyvinyl chloride (uPVC), rigid type, suitable for forming bends using approved PVC accessories. The conduit shall have high mechanical strength, high impact resistance, high temperature resistance, flame retardant, non-hygroscopic and non-porous properties.
The conduit shall have a minimum compressive strength suitable for heavy-duty applications and shall withstand mechanical stresses associated with underground, screed, duct bank, and exposed surface installations. The conduit shall comply with the requirements of CEE 26, BS 4607, BS 6099, DIN 49026, NFC 68-107, or other equal and approved standards, conforming to IEC 423.
- B. **FITTINGS GENERALLY:** All fittings, accessories, bends, couplers, junction boxes, and related components shall be heavy-duty type, manufactured from unbreakable, non-flammable, self-extinguishing moulded plastic material, compatible with the conduit system and approved by the conduit manufacturer.
- C. **ASSEMBLY:** All fittings, accessories, bends, couplers, junction boxes, and related components shall be heavy-duty type, manufactured from unbreakable, non-flammable, self-extinguishing moulded plastic material, compatible with the conduit system and approved by the conduit manufacturer.

Conduits, boxes, fittings, and accessories shall be assembled using the manufacturer's recommended installation methods and approved cementing compounds. Where suitable connectors or spouts are available, smooth bore male PVC bushes and sockets shall be used to ensure proper cable protection and a continuous smooth internal surface.

All joints shall be secure, mechanically sound, and watertight where required by the installation conditions.

2.1.3 FLEXIBLE MEDIUM GAUGE PVC CONDUIT

- A. MATERIAL: Flame retardant, heat resistant, non-hygroscopic heavy gauge PVC conduit with high impact and mechanical resistance. The conduit shall be ribbed/corrugated around its circumference to provide flexibility and suitable protection for cables. The conduit shall be non-porous and comply with applicable approved standards.

3. FIELD AND INSTALLATION WORK

3.1 CONDUIT AND WIREWAYS GENERALLY

- B. USE: unless otherwise specifically indicated all light and power circuits, communications, signal and low current systems wiring are to be drawn inside conduits or wireways up to the various electric power consuming equipment as shown on the Drawings. Separate conduit and wireways installations are to be used for LV cables/wires normal light and power circuits, emergency light and power circuits and communication, signal and other low current systems wiring.
- C. BOXES: junction, pull and splice boxes of ample capacity are to be provided as indicated or required. Boxes are to remain permanently accessible.
- D. TOOLS AND ACCESSORIES: for forming and installing conduit and wireway systems are to be purpose made for the particular application and used in accordance with manufacturer's instructions.
- E. FIXING: conduits and wireway installations are to be concealed as much as possible.
- F. SIZES: Unless otherwise specified conduits and wireways sizes, not shown on the Drawings, are to be selected in accordance with the tables on design drawings and in relation to the number and size of conductors. Minimum size of conduit for all applications is to be 20 mm diameter, unless otherwise shown on the Drawings.
- G. MECHANICAL CONTINUITY: conduits and wireways are to be effectively joined together and connected to electrical boxes, fittings and cabinets to provide firm mechanical assembly. Earthing jumpers are to be installed on steel conduits where required to ensure effective electrical continuity irrespective of whether a protective earth conductor is required or not.

3.2 RACEWAY APPLICATIONS AND INSTALLATIONS GENERALLY

- A. **RIGID HEAVY GAUGE PVC CONDUIT:** Is to be used generally for underground installations, in screed, duct banks, and surface installations for lighting, power, and low current circuits.
- B. **FLEXIBLE HEAVY GAUGE PVC CONDUIT:** Is to be used for lighting, power, and low current circuits in under-tile and wall installations, and for connection to fixtures installed in false ceilings, unless otherwise specified or indicated on drawings.
Note: RIGID HEAVY GAUGE PVC CONDUIT: is to be used in all floors except roof or whererequested by NFC 15-100.
- C. **FLEXIBLE STEEL CONDUIT:** Is to be used for connections to motors, vibrating equipment, non-rigidly fixed equipment, and fixtures installed in false ceilings.
- D. **RIGID STEEL CONDUIT:** is to be used for exposed installations in technical areas and whererequested by NFC 15-100.
N.B: The rigid steel PVC coated conduit shall be used for exposed installations at pumpsrooms.
- E. **EXPOSURE TO DAMAGE:** Conduits considered subject to undue risk of mechanical damage or corrosion shall be brought to the attention of the Engineer.
- F. **CROSSINGS:** Conduits shall not cross pipe shafts, vents, or openings.
- G. **CLEARANCES:** Install conduits at least 100 mm clear of, and preferably above, pipes of other non-electrical services.
- H. **SLEEVES:** Obtain approval for sleeve positions where conduits pass through reinforced concrete. Additional openings in finished slabs shall be drilled and not broken. Sleeves shall be rigidly fixed to maintain position and alignment during construction
- I. **EXPANSION FITTINGS:** Provide expansion fittings in conduit runs exceeding 30 m in length and at structural expansion joints.
- H. **WATERPROOF CONSTRUCTION:** Conduits shall not pass through waterproof construction unless approved by the Engineer. Approved special fittings shall be used where required..
- J. **MAKE GOOD:** All openings for conduits passing through walls, floors, and ceilings shall be sealed with cement or equivalent fire-resistant material for the full thickness.
- K. **BENDS:** Conduit runs between outlets and fittings shall not contain more than the equivalent of two quarter bends (180° total).
- L. **BENDING** Conduits shall be bent without damage or reduction of internal diameter. Field bending methods shall be approved.
- M. **CUT ENDS** Cut ends shall be reamed to remove burrs and sharp edges..

- N. **CONDUITS ENTERING COLD STORES** Conduits entering cold stores shall be made vapor tight to prevent external vapor entry
- O. **DRAINING:** Arrange conduits to allow condensed moisture drainage to a screwed plug at the lowest point. arrange conduits so that condensed moisture can drain to screwed plug at lowest point.
- P. **BEFORE WIRING,** Conduits shall be swabbed through before wiring. Cables shall not be drawn until conduits and draw boxes are fixed in position.
- Q. **CAPPING:** Conduits shall be properly capped until wiring conductors are installed.
- R. **CONDUIT AND FITTINGS INSTALLED OUTDOORS** Conduits and fittings installed outdoors shall be watertight and highly resistant to corrosion. Use suitable fittings, threaded and hubbed boxes, gaskets, screw-on covers, and accessories.
- S. **TERMINATIONS:** Rigid conduits shall not be terminated or fastened directly to motor frames or bases.
- T. **FLEXIBLE CONDUIT FOR MOTORS AND VIBRATING EQUIPMENT:** Length and bending radius shall allow feeder cable movement without damage to conductors or insulation.
- U. **FLEXIBLE CONDUIT FOR SLIDE RAIL MOUNTED MOTOR** Flexible conduit shall have sufficient slack to allow full movement of the motor along the slide rail.
- V. **PULLING WIRE:** Install 3 mm galvanized stranded steel wire or equivalent strength cord with wooden blocks fixed at ends in empty service conduits.
- W. **STANDARD ELBOWS** Standard elbows shall be used for conduit sizes equal to or greater than 20 mm.
- X. **TAGS:** Provide identification tags on conduits entering or leaving floors, walls, and ceilings, and at suitable intervals throughout the installation.

3.3 PVC CONDUITS

- A. **COUPLING OF CONDUIT** and/ or termination into spouted fittings are to be made watertight and permanent using special cement.
- B. **TERMINATION:** connect conduits terminating in switchgear, fuseboards, trunking, adaptable boxes or non-spouted enclosures etc, with smooth bore male PVC bushes and sockets.
- C. **ENDS OF CONDUIT** end conduit fittings are to be cleaned and jointed using PVC cement recommended by manufacturer.
- D. **SEMI-PERMANENT ADHESIVE:** use in joints requiring expansion couplers.

3.4 EMBEDDED CONDUITS

- A. CONDUITS IN CONCRETE SLABS: place conduits parallel to main reinforcing steel.
- B. CONDUITS IN PARTITIONS OR SIDE WALLS: horizontal or cross runs are to be avoided.
- C. PULL-BOXES are not to be used. If unavoidable, pull-boxes may be approved if located inconspicuously.
- D. CONDUITS IN FLOOR OF BEDS ON GRADE: encase in concrete, minimum thickness 50 mm or to thickness allowed by architectural detail.
- E. E. PVC CONDUITS IN REINFORCED CONCRETE STRUCTURES are generally to be installed after placing reinforcement and before concreting, if protected against damage, or are to be placed in grooves formed in the concrete, if approved.

3.5 EXPOSED CONDUITS

- A. CONDUITS ON WALLS: run neatly, horizontally or vertically.
- B. SUPPORTS: use approved clamps, hangers or clips fastened by machine screws to expansion sleeves in inserts or to lead anchors.
- C. SPACING OF CLAMPS OR CLIPS for supporting steel conduits is not to be greater than:

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

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

<u>Conduit Size</u> <u>mm (inches)</u>	<u>Maximum Spacing of Supports</u> <u>meters</u>
20 (3/4)	0.50
25-50 (1-2)	0.50
63-75 (2-1/2-3)	0.75

- E. BENDS AND FITTINGS: firmly fasten conduit at each side of bends and within 900 mm of each outlet box, junction box, cabinet or fitting.
- F. OUTLETS: do not run more than one conduit to any surface wall outlet. Install junction box on home run near to ceiling level and tap-off vertical conduit to outlet box below.

3.6 CABLE TRAY

PART 1 - GENERAL

1 01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions and Division-1 (General requirements), apply to work of this section.
- B. General Provisions for Electrical Work, Section 16010, applies to work of this Section.

1 02 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all cable trays in accordance with Drawings and Specifications.

1 03 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of cable trays of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, DIN/VDE, IEC, NEC, UL, NEMA, IEEE, and ANSI Standards pertaining to cable trays. Provide cable trays products and components which have been listed and labeled.

1 04 SUBMITTALS

- A. Product Data: Submit manufacturer's data for cable trays.
- B. Samples:- Submit 30 cm length of each size of cable tray complete with its accessories and fittings.
- C. Shop Drawings: Submit dimensioned layout drawings on architectural backgrounds of cable trays including, but not limited to, offsets and connections. Show accurately scaled cable trays with locations of supports and fittings, including fire stops and weather seals. Indicate relationship of cable trays to other associated equipment.

PART 2 - PRODUCTS

2 01 CABLE TRAY

A. GENERAL

1. A complete cable support system with all required straight sections, fittings, connectors and accessories.
2. All trays and system components as defined by and in conformance with approved Standards or latest applicable revisions.
3. Cable Support System: Ladder type; width as required or as shown on the drawings; radius of fittings, 60 cm or as shown on the drawings.
4. Fittings such as elbows, tees, crosses, etc., with a tangent, or straight section beyond the curvature to accept one type of universal splice plate to simplify field erections.
5. Usable Minimum Clear Loading Depth: 8 cm.
6. Straight Sections: 3.7 - 4 meters in length.
7. Cable Support System: Aluminum: 6063T6 alloy for extruded parts and 5052 alloy for parts fabricated from sheet.
8. Cable trays shall be perforated and manufactured from mild steel and to be galvanized after fabrication the galvanization must be hot dip galvanized
9. Minimum thickness of cable trays shall be 1.5 mm thickness for cable tray 30 cm width and below and shall be 2mm thickness for 40 cm width and above .
10. Cable trays shall be manufactured with plain return flanges
11. Adequate supports shall be provided to prevent stress on cables where they enter or leave the tray. Where cable trays extend transversely through partitions and walls additional protection in the form of fire-proof non-combustible barriers shall be provided.
12. All cables shall be fastened securely by purpose made straps or saddles to the cable trays.
13. Cable trays shall be connected by means of flexible tinned straps to the nearest bare earthing conductors and at maximum of 30 meters spacing.
14. Cable trays must be specially reinforced to have high load bearing capabilities across wide spans, maximum deflection should not exceed

0.5% in the longest span. Also it shall be mechanically designed to give high torsional rigidity and good resistance against lateral loading.

15. Where the supported cables run in either a vertical or horizontal direction, manufactured bends or sets shall be provided in order that a continuous cable tray be provided throughout the length or run.
16. Bends in either vertical or horizontal directions should be dimensioned such that cables may not be curved less than 15 times its diameter.
17. Perforate-type cable tray shall be used above the suspended ceiling. It shall be manufactured from mild steel 1.5 mm or 2 mm thick, finished hot-dip galvanized with a 20 mm return flange on both edges. Edge height 80mm.
18. Ladder-type cable tray shall be used to support heavy cabling as indicated on the drawing or as directed by the Engineer. The tray shall be designed ladder-like, offering free circulation of air around cable and minimum moisture and dust-gathering surfaces. Rungs shall be welded to the ladder profiles. Rung width shall not be less than 30 mm, and center distance between rungs shall not exceed 250 mm.

Cables are to be prevented from falling down the ladder system by 50 mm height edges along the whole length of the ladder.

19. All components and accessories shall be hot-dip galvanized steel after manufacture to give resistance to corrosion.
20. Same typical details of trays, ladder and perforated type are shown in the drawings.
21. Cable tray width shall be chosen according to the number and diameter of cables laid on the tray. Main feeders shall be laid such that their outer radius are spaced a distance equal to the diameter of the largest cable.
22. All Cable trays shall be covered with cover.

B. SAFETY FACTOR

1. Cable Tray at 2.5 meters Span: Capable of sustaining a working (allowable) load of 68 kg per linear 30 cm with a safety factor of 2, when tested as a simple beam and in accordance with approved load test method; test specimen to be a single section of cable tray.
2. In addition to and concurrent with the above working load, a 90kg concentrated load applied at mid span to result in no permanent deformation of the tray.
3. Design to be such that all like parts are interchangeable and that trays may be readily assembled and joined without the use of special tools.

- C. Fittings: at least the same thickness and cross sectional area of side members and (rungs, bottom) as straight sections.
- D. Connectors: High pressure rigid plate type connected by ribbed-neck or square-neck plated steel bolts and free-spinning lock type nuts not requiring a washer; ribbed-neck or square-neck portion of bolt to grip the tray side member and connector plate metal to prevent bolt from rotating during tightening of nut.
- E. Where necessary, provide expansion guides and connectors per manufacturer's thermal contraction and expansion table; install fixed hold down clamps approximately midway between expansion connectors; install expansion guides at all other support locations to allow thermally induced movement of the tray.
- F. Resistance of the connection between adjacent sections of cable trays: not more than 0.00033 ohms; use bonding jumpers of suitable ampacity at all expansion connections and at all adjustable points.
- G. LADDER TYPE TRAY SECTIONS
 - 1. Construct with rungs (transverse members) at least 2.5 cm wide, spaced 30 cm on centers.
 - 2. Bearing Surface of Transverse Members: Minimum of 1.9 cm .
 - 3. Rungs (transverse members) assembled to the side rails by welding to insure integrity of fault ground path for the life of the system and maximum structural capability; non-welded joining of rungs to side rails are not acceptable.
- H. LIGHT DUTY TRAYS
 - 1. Aluminum with a maximum overall depth of 10 cm and a minimum usable loading depth of 8 cm.
 - 2. Capable of sustaining working (allowable) load of 36 kg per 30 cm on a 2.5 meter simple span.
 - 3. Safety factor of 1.5 mid-span deflection not to exceed 1.25 cm.
 - 4. Trough Type Trays:
 - a. Three piece construction consisting of two longitudinal members (side rails) with a corrugated bottom welded to the side rails.
 - b. Peaks of the corrugated bottom with a minimum flat cable bearing surface of 7 cm and spaced 15 cm on center.
 - c. To provide ventilation in the tray, the valleys of the corrugated bottom to have 6 cm x 10 cm rectangular holes punched along the

width of the bottom.

- I. All cable trays shall be heavy duty type unless otherwise indicated on the drawings.

2 02 ACCEPTABLE MANUFACTURERS

Obtain cable trays and related accessories from one of the following or other equal and approved:

- A. METAKSAN
- B. CANKANAL
- C. SFSP
- D. KIRAC

PART 3 - EXECUTION

3 01 INSPECTION

- A. Examine conditions under which cable trays are to be installed. Notify Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3 02 INSTALLATION

- A. Install cable trays and accessories as indicated in accordance with manufacturer's written instructions, requirements of applicable standards and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of cable trays work with other work.
- C. Install integral fire stops where cable trays penetrates fire-rated walls and floors. Seal between cable trays and opening and around opening with fire-rated sealant not less than wall, or floor, fire ratings.
- D. At floor openings provide concrete curb, 10 cm wide and 10 cm high, around cable trays and seal with non-combustible material.
- E. Provide electrical bonding and equipment earthing (grounding) connections for cable trays. Tighten connections to comply with tightening torques specified by manufacturers to assure permanent and effective connections and grounds.
- F. Anchor mounting hardware firmly to walls, floors, or ceilings, to ensure enclosures are permanently and mechanically secured. Provide all hardware

and accessories for proper mounting.

- G. Route cable trays as required and make final field measurements before ordering cable tray.
- H. Where there is insufficient elevation or lateral change in direction to accommodate fittings directly connected, adjustable vertical connectors or adjustable horizontal connectors with straight section in between may be used. Avoid slopes that would cause cable to bend on smaller radii; than that allowed by cable manufacturer.
- I. Provide hangers, rods, straps, special brackets, and other means of supporting cable tray as required.

3 03 FIELD QUALITY CONTROL

- A. Prior to installing cables in cable trays, test for electrical continuity of bonding, and earthing connections, and to demonstrate compliance with earthing requirements.
- B. Electrically energize cable tray systems and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.

SECTION 3
BUILDER'S WORK

1. GENERAL

- A. **BUILDER'S WORK GENERALLY:** materials and workmanship, unless otherwise specified, are to be in accordance with the relevant requirements of the Specification for Structural and Architectural work.
- B. **DESCRIPTION OF WORK:** cable and duct trenches, equipment foundations, bases and supports, ducts and duct banks, manholes, hand-holes and earth pits, chases, holes and the like, sleeves, bolts, brackets and fixings including grouting.
- C. **COORDINATION:** confirm locations and dimensions of all builder's work required for electrical work. Submit shop and construction drawings or other data to the Engineer for checking before proceeding with the work.
- D. **ROUTES FOR SERVICES BELOW GROUND:** agree precise locations with the Engineer, set out clearly and accurately and locate with temporary marker posts.

2. PRODUCTS AND MATERIALS

2.1 COMPONENTS

- A. **POLYVINYL CHLORIDE (PVC) DUCTS** for outdoor power and lighting cable installations are to be non-sparking type, suitable for direct burial in ground, minimum tensile strength 500 kg/cm², impact strength 5 kg/cm², supplied in standard 6 m lengths, with one end of each length tapered. Ducts are to be nominal size shown on the Drawings, with minimum wall thickness 3.2 mm for 100 mm ducts and 4.7 mm for 150 mm ducts.
- B. **DUCT SUPPORTS:** pre-formed, non-metallic of approved type. Supports containing metal are to have the metal non-continuous and not forming a magnetic loop in any manner.
- C. **COVERS FOR TRENCHES** in electrical rooms and the like, unless otherwise specified or shown on the Drawings, are to be flanged chequered steel plates with angle or channel-section frames, suitably reinforced to support anticipated loads, and finished with zinc chromate primer and two coats grey enamel.
- D. **COVERS FOR MANHOLES AND HANDHOLES:** to BS 497, chequered cast iron or cast steel, recessed type, and of suitable duty for the particular application.
- E. **BRACKETS, SUPPORTS, RAILS AND TRACKS** for supporting electrical installations are to be galvanized steel, fixed with expansion bolts of approved size and material. Plastic inserts and lead anchors are not acceptable unless approved for specific light duty installations.

2.2 COMPOSITE CONSTRUCTION

- A. **EQUIPMENT FOUNDATIONS AND BASES:** reinforced concrete, as approved by the Engineer after submission of design calculations. Dimensions, levels and surface finishes are to be suitable for equipment installed, as shown on the Drawings or in accordance with approved shop and construction drawings.

- B. **CONCRETE ENVELOPE FOR DUCT BANKS** for power distribution systems and outdoor lighting cable installations crossing water, gas and sewage mains, under roadways and where required or shown on the Drawings, is to be reinforced concrete Class B using sulphate- resisting Portland cement. Reinforcement is to consist of 12 mm diameter longitudinal bars at approximately 300 mm centers along bottom and sides of duct bank with 10 mm diameter U- shaped transversal bars at 400 mm centers. Length of concrete envelope is to extend at least 300 mm beyond each side of crossing etc.
- C. **CABLE MANHOLES AND HANDHOLES:** reinforced concrete Class B using sulphate- resisting Portland cement, with approved waterproof membrane on external surfaces, and with cable supports where necessary, pull- eyes, and drain pit and drain pipe as required. Dimensions and reinforcement are to be as shown on the Drawings or in accordance with approved standard details shown on shop and construction drawings.

3. WORKMANSHIP

3.1 GENERALLY

- A. **CABLE TRENCHES:** width is to be as small as practicable with sides vertical. Remove mud, rock projections, boulders and hard 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 stand 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 300 mm thick
 - 2. Lay approved concrete tiles to fully cover cable duct, extending minimum 50 mm beyond sides of duct and placed 300 mm below ground level
 - 3. Provide warning tape or galvanized steel mesh along duct runs at a depth 200 mm below ground level.
- C. **UNDERGROUND CABLE DUCT ASSEMBLIES:**
 - 1. From duct assembly to required line and level, using duct supports spaced to prevent sagging of ducts and breaking of couplings and watertight seals, and secured with cords (not tie wires) where necessary
 - 2. Provide 1% slope to duct banks for draining to exterior manhole, hand-hole or other location as instructed
 - 3. Join ducts using waterproof cement, to manufacturer's recommendations, to give waterproof and sand-proof joint with at least 80 mm overlap
 - 4. Provide 3 mm galvanized steel wire inside empty ducts, for future pulling of cables, extending 1 m beyond duct banks at both ends securely fixed to wooden bungs sealing the ducts.
- D. **ENDS OF DUCTS:** ducts ending in cable manholes or hand-holes are to be neatly cut and reamed and set behind chamfered precast concrete duct end blocks or terminated with appropriate bell- mouth bushing set in concrete wall. Duct not ending in cable manholes or handholes are to be properly capped.

- E. **SEALING ENDS OF DUCTS:** conduits and ducts, active or spare, at entry into building or manhole, are to be completely sealed with approved plastic moulds or wooden bungs to prevent entry of rodents, gas, and 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 hardened concrete or drill holes larger than 10 mm diameter without prior approval.
- J. **HOLES AND CHASES IN PRECAST CONCRETE:** do not cut or drill precast concrete without prior approval.
- K. **HOLES IN STRUCTURAL STEELWORK:** do not cut or drill structural steelwork without prior approval.
- L. **HOLES AND CHASES IN MASONRY** must not exceed:
 - 1. Size of holes : 300 mm square
 - 2. Depth of vertical chases : 1/3 wall thickness or, in cavity 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 and do not exceed specified dimensions
 - 4. Cut chases in straight lines and horizontally and vertically only; do not set back to back; offset by a distance not less than wall thickness.
 - 5. **PREFORMED HOLES IN MASONRY:** submit proposals for bridging over holes for ducts etc. which width exceed 460 mm.

3.2 INSPECTION AND CLEANING

- A. **INSPECTION OF DUCT SYSTEMS:** directly buried ducts and underground duct assemblies are to be inspected in the presence of the Engineer, before backfilling or concreting. Steel mandrel or other approved device, diameter equal to 90% of inside diameter of duct and 500 mm long, is to be pulled through entire run of duct and is to pass through without getting stuck. Ducts which do not allow mandrel to be pulled through are to be repaired or replaced to the satisfaction of the Engineer.

- B. CLEAN DUCTS with stiff bristle brush pulled through each duct prior to pulling in cables.

SECTION 4

WIRING DEVICES AND DISCONNECTS

1. GENERAL

1.1. DESCRIPTION OF WORK

Wiring devices, lighting switches, socket outlets, cord outlets, automatic and manual lighting control equipment, dimmers, outlet boxes and plates, disconnect switches etc.

1.2. STANDARDS

components are to be standard manufactured items, uniform and modular, complying with one set of approved Standards.

1.3. EQUIPMENT DATA

submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each item.

1.4. SHOP AND CONSTRUCTION DRAWINGS

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

- A. Exact indication of position of each item and outlet box and fitting on layout drawings, with box and equipment types and sizes.
- B. Installation details of special items including LV transformers, isolating switches, fans etc.
- C. Wiring diagrams of special items.

1.5. SAMPLES

submit samples of each type of device for approval, unless otherwise agreed in writing by the Engineer.

2. PRODUCT AND SYSTEMS

2.1 FITTINGS

2.1.1 OUTLET BOXES AND PLATES GENERALLY

- A. **SURFACE OR RECESSED BOXES** are to be suitable for type of related conduit or cable system. Shapes and sizes of boxes are to be compatible standards as switches, socket outlets and lighting fixtures selected and of various types and mounting methods required.
- B. **UNUSED OPENINGS** in outlet boxes are to be closed with knock-out closers manufactured for the purpose.
- C. **BLANK PLATES:** blank plates are to be installed on outlet boxes on which no apparatus is installed or where apparatus installed does not have suitable cover for box. Blanks plates for wall outlets are to be attached by a bridge with slots for horizontal and vertical adjustment.
- D. **FLOOR OUTLETS AND PLATES** are to be water-tight and impact resistant.

2.1.2 METALLIC OUTLET BOXES

- A. **RECESSED AND CONCEALED BOXES:** galvanized pressed steel, with knock-outs for easy field installation. Special boxes are to be punched as required on Site.
- B. **EXPOSED SURFACE MOUNTED BOXES:** galvanized cast iron with threaded hubs.
- C. **OUTDOOR SURFACE OR RECESSED BOXES:** galvanized cast iron with threaded hubs and PVC gaskets to ensure water tightness and with stainless steel or non-ferrous, corrosion resistant screws.
- D. **FLOOR BOXES:** watertight, cast iron or cast metal alloy with corrosion resistant finish, adjustable mounting, standard duty, round or square, factory drilled and tapped for required conduit sizes, and with brass cover and flange with brushed finish free from markings other than required for mounting screws.
- E. **FLAME- PROOF BOXES:** malleable iron or cast iron, with gas threaded hubs, special covers with silicon rubber gaskets, gas tight, and water- tight. Boxes are to comply with the Regulations for explosive areas.
- F. **MANUFACTURERS:** obtain metallic outlet boxes from same manufacturer as conduit or other approved, and to the satisfaction of the Engineer.

2.1.3 MOULDED PLASTIC OUTLET BOXES

- A. TYPE: boxes and covers used with PVC conduit systems are to be heavy gauge pressuremoulded plastic, minimum 2 mm thick, self extinguishing, with softening point not less than 85deg. C. Boxes are to have provision for securely terminating conduits and are to be manufacturer's standard for required application.
- B. FITTINGS: boxes are to have brass inset threads to receive cover screws and for mounting devices or accessories, push- fit brass earth terminals, and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets are to be providedfor weatherproof installations.
- C. MANUFACTURERS: obtain moulded plastic outlet boxes from:
 - 1. Egatube (England)
 - 2. M.K. (England)
 - 3. Legrand (France)
 - 4. B Tichino (Italy)
 - 5. Gepico
 - 6. Elettrocanali

Or other equal and approved.

2.1.4 PLATES AND CORD- OUTLETS

- A. DESIGN: square, rectangular or round, designed to cover outlet box and to closely fit electricaldevice, and with polished chromium plated recessed head fixing screws. Combination platesare to be used for grouped outlets and devices.
- B. CORD EXTENSION PLATES are to have threaded cord grip bushings of same material and finishas plates.
- C. PLASTIC PLATES: heavy gauge, break resistant, pressure moulded plastic, white color, forgeneral use:
 - 1. Manufacturer (common area): Legrand or other equal and approved
 - 2. Ref: 75005, 75006, 75007, unless otherwise mentioned on drawings.
- D. CABLE/ CORD OUTLET is to be used for up to 45 A, 250 V rating for connection of power/control cable of fixed appliances. Plate is to have threaded cord grip to anchor cable securelyto cover. Box is to include fixed terminal block and cable clamp for termination of cable/cordwithin.

2.1.5 SWITCHES

- A. GENERALLY: quick- make, quick- break type with silver alloy contacts in arc resisting mouldedbase, with toggle, rocker or push- button as specified, for inductive or resistive loads up to fullrated capacity, and arranged for side and/or back connection.

- B. TYPES: single, two- way or intermediate, single pole or double pole, as shown on the Drawings.
- C. GENERAL LIGHTING SWITCH: 10 A 220 V a.c., rocker operated, grid- switch with plastic plate, for indoor installations in general, unless otherwise indicated.
 - 1. Man: Legrand or other equal and approved.
Ref: unless otherwise mentioned on drawings:
One way one gang 74010
One way greater or equal to two gang 74000
- D. PUSH BUTTON SWITCH, Ref unless otherwise mentioned on drawings:
 - One gang 74040
Two or larger than 74030.
- E. MANUAL (Modular) SWITCH: 2 pole, for fractional single and three phase motors and appliances, to interrupt motor and induction loads, rated 20 A at 415 V a.c., toggle operated, with positive indication of on/off position of contacts.
 - 1. Man: Merlin Gerin or other equal and approved.
 - 2. Legrand
 - 3. Vimar
 - 4. Gewiss
 - 5. Bticino

2.1.6 SOCKET OUTLETS

- A. GENERALLY: to have injection moulded plastic base with self- adjusting, non- expanding contacts to prevent permanent distortion, arranged for side and/or back connection and with screw terminals accepting at least three parallel branch- circuit wires.
- B. TYPES: general-purpose socket outlets are to conform to standard German practice concerning layout & rating).
- C. DUPLEX SOCKETS are to be mounted in parallel under one common plate with break off feature for two-circuit connection.
- D. WEATHERPROOF SOCKET OUTLETS are to be any of the types indicated, enclosed in surface mounted cast metal box and with cover comprising spring- retained gasketed hinged flap. Enclosure is to be pre- designed box and cover for type of socket outlet specified.
- E. GERMAN STANDARD SOCKET: single phase, three wires for plug with 3 mm round pins at 19mm centers, with grounding in accordance with standard German practice and rated 10/16 A, 250 V a.c.
- D. MANUFACTURERS: obtain moulded plastic outlet boxes from:
 - 1. Legrand
 - 2. Vimar
 - 3. Gewiss

arrangement, thickness of finishing, window trim, paneling and other architectural features.

- B. MOUNTING HEIGHTS for outlet boxes and similar equipment are to be uniform within the same or similar areas. Mounting is to be as shown on the Drawings or as approved by the Engineer. Unless otherwise shown or instructed, mount lighting switches and socket outlets generally at 1200 mm and 300 mm from finished floor level respectively- to be coordinated with the architect. Mount switches with long dimension vertical and operating handle, if of the toggle type, up when in the on position.
- C. SINGLE POLE SWITCHES are to switch the phase wire. Do not run neutral wire through switches having neutral shunt or bridge.
- D. ADDITIONAL OUTLETS to those shown on the Drawings are to be provided as required by equipment manufacturers for control or other wiring.
- E. EXPOSED OUTLET BOXES: securely fasten to wall with machine screws to permanent inserts or lead anchors.
- F. RECESSED OUTLET BOXES: make neat openings, to the satisfaction of the Engineer, allowing for thickness of finishing and use extension rings if required. Repair damaged finishing to original condition before installation of fittings or plates.
- G. APPEARANCE: install exposed boxes and plates plumb, square and parallel to finished wall surface. Exposed plates covering recessed boxes are to rest neatly on wall surface without gaps, and fully covering the box.
- H. GROUPED OUTLETS: arrange neatly so that use of fittings is convenient and clear.
- I. WATERPROOF AND EXPLOSION- PROOF FITTINGS: follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.
- J. DAMAGED FITTINGS: reject damaged fittings or plates with damaged finish. Protect fittings and plates against damage after installation and handed over.
- K. CONNECTION OF APPLIANCE
 - 1. Where appliance is designed to adapt directly to outlet box, extend electrical wiring to incoming terminals inside appliance.
 - 2. Where appliance is not designed to adapt to outlet box, install connecting wiring in flexible conduit firmly fixed to outlet box cover plate and to terminal box on appliance.

3.1.1. INSPECTION AND TEST ON SITE

- A. VISUAL INSPECTION: fittings and equipment are to be inspected for fixing and workmanship.

- B. MEGGER TESTS are to include switch and socket outlet tests together with insulation resistance of wiring installations.
- C. OPERATION: devices are to be tested for operation and are to perform as intended at full load without any signs of heating.
- D. EQUIPMENT is to be insulation tested and observed, under full- load for not less than 3 days operation, with respect to undue heating and performance in general.

SECTION 5

DISTRIBUTION, SUBDISTRIBUTION AND FINAL BRANCH CIRCUIT PANELBOARDS

1. GENERAL

1.1 RELATED DOCUMENTS

- A. DESCRIPTION OF WORK: panelboards for distribution and subdistribution of electric power, for protection of circuits and for monitoring and control of circuits including fixing and supporting materials and materials for termination of feeders, sub-circuits and branch circuits.
- B. STANDARDS: panelboards generally are to comply with the requirements of IEC 60439-1.
- C. DESIGNATIONS: panelboards are designated on the Drawings and in the Schedules as follow:
 - 1. PB or SDB (except where mentioned in the B.O.Q that the SDB shall follow M.D.B. specifications).
 - 2. Final branch circuit panelboards, power panelboards and subdistribution panelboards respectively, for secondary lighting and power distribution with either miniature circuit breaker (MCB) or moulded case circuit breaker (MCCB) protection on subfeeder or branch circuits, as shown on the Drawings.
- D. EQUIPMENT DATA: submit data for approval including, but not limited to, the following:
 - 1. Manufacturers' catalogues indicating specific equipment selected.
 - 2. Types of panelboards and circuit breaker characteristics including duties and ratings compensation at and above 40 deg. C ambient conditions and corresponding temperatures within the enclosures.
 - 3. Dimensions of panels and specific contents of each panelboard.
 - 4. Integrated equipment tabulations for coordinated short-circuit series combinations of circuit breakers (cascading and discrimination).
- E. TESTS AND CERTIFICATES: submit complete certified manufacturer's type test and routine test records in accordance with the Standards.
- F. SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:
 - 1. Exact composition of each panelboard, indicating busbar rating, frame or continuous rating and trip ratings of circuit breakers
 - 2. Typical installation details of panelboards, indicating main feeder and branch circuit conduit connections, terminal provisions, tags, labels, mounting methods and materials used.
- G. All protecting device shall show: the Short circuit current value, the voltage drop, the indirect protection function in case of a fault with respect to the earthing system.
- H. ELECTRICAL CLOSETS are to be checked for clearances, spaces and ventilation, for the installation of proposed equipment, prior to starting construction.

- I. APPROVED SWITCHGEAR & CONTROLGEAR MANUFACTURERS: subject to compliance with the specifications and drawings, obtain main distribution board equipment, from one of the following:
 1. Merlin Gerin, Télémecanique (Schneider) (France).
 2. Moeller (Germany)
 3. ABB (ITALY)
- J. APPROVED ENCLOSURE AND BUSBAR SYSTEM MANUFACTURERS: subject to compliance with the specifications and drawings, obtain main distribution board enclosure and busbar system, from one of the following; subject to TTA or PTTA licensing conditions set by the manufacturer with respect to compatibility with switchgear and controlgear brand, type and make:
 1. Merlin Gerin (Schneider, France).
 2. Moeller (Germany)
 3. ABB (ITALY)
 4. Holec (Holland)
 5. Logstrup (Ireland)
 6. Eaton.

2. PRODUCTS AND SYSTEMS

1.1 DISTRIBUTION, SUBDISTRIBUTION PANELBOARDS

A. GENERAL REQUIREMENTS

1. RATED INSULATION VOLTAGE is to be in accordance with the respective Standards.
2. PANELBOARDS are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 529, and are to be factory designed and assembled.
3. EARTHING BAR is to be provided in every panelboard.
4. PROTECTION is to be fully rated throughout the systems.
5. SERIES (CASCADE) AND DISCRIMINATION COORDINATED PROTECTION. All calculation notes shall show the conformity of the protective devices to the « cascading » and discrimination characteristics and levels.
6. CIRCUIT BREAKERS are to be non-fused type.
7. CIRCUIT BREAKER ARRANGEMENT: panelboards are to have one main incoming circuit breaker or switch disconnector and the required number of branch circuit breakers, arranged as shown on the Schedules, including spare circuit breakers and spaces for future expansion. Three or four-phase panelboards are to be designed for sequence phase connection of branch circuit devices. Electrical circuits for sockets up to 32A shall be protected with an earth leakage circuit breaker with 30mA sensitive trip, same protection shall be applied to the lighting circuit of the toilets unless class II and/or extra low voltage (12 volts) lighting fittings are used with Class II isolation transformers.

B. PANELBOARD ENCLOSURES

1. TYPE: general purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown on the Drawings, comprising box, trim, or trim and door to approved manufacturer's standards and sizes.

2. **CONSTRUCTION:** box, trim and doors where required, are to be electro-galvanized sheet steel of gauges not less than specified and in accordance with the Standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the Standards, but are not to be less than 100 mm on all sides. Enclosure is to have pre-designed angles or threaded end studs to support and adjust mounting of interior panelboard assembly. Enclosures shall have glazed doors.
3. **TRIMS** are to cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims are to be fixed to cabinet/box by quarter-turn clamps engaging flange of box (use of screws engaging holes in flange of box is not acceptable). Screws where used are to be oval-head, countersunk and flush. Trims for flush mounted panelboards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panelboards are to be exactly sized to form flush fit to box.
4. **DOORS** are to have concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high are to have vault-type handle and multiple point latch mechanism. Locks are to be keyed alike. Enclosures shall have glazed doors.
5. **FINISH:** inner and outer surfaces of cabinet/boxes, trims, doors etc. are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, ageing and corrosion and of standard grey colour to the approval of the Engineer.
6. **DIRECTORIES** under glass, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors are specified. Directories are to be typed to identify panelboards and clearly indicate circuit number and description of load.
7. **OUTDOOR ENCLOSURES** are to be heavy duty sheet steel cabinets, minimum 1.5 mm thick, fully weatherproofed (IP 55), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

C. BUSBARS

1. **TYPE:** one piece, 98% pure electrolytic copper, based on maximum total temperature rise of 40 deg. C over an ambient of 50 deg. C at full continuous rating. Bolted contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminium is not to be used for busbars or panelboard parts.
2. **DESIGN:** busbars are to be shrouded/insulated and rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Busbars are to be full size without reduction. Busbar System and blank plates are to allow installation of future circuit devices, where indicated on the Drawings.
3. **RATING:** busbar rating is to be at least equal to main-circuit breaker frame size plus 20%. Where no main circuit breaker is required, busbars are to have main lugs or disconnect switch, with nominal rating equal to standard circuit breaker frame sizes, and as shown on the Drawings.
4. **SHORT-CIRCUIT DUTY:** busbars are to carry maximum short-circuit duty of main protective device, which is to be at least maximum short-circuit at point of application for one second, without showing any signs of degradation.

justified by the contractor.

8. **TRIPPED POSITION:** when tripped automatically by overcurrent condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.
9. **INTERCHANGEABLE TRIPS:** thermal-magnetic trip circuit breakers 100 A frame size to 600/630 A frame size are to have interchangeable trip units.
10. **SEALING:** circuit breakers with non-interchangeable trip units are to be sealed. Circuit breakers with interchangeable trip units are to have trip unit covers sealed to prevent tampering.
11. **COMPENSATION:** thermal overcurrent trips are to be ambient temperature compensated between 25 and 50 deg. C.
12. **ELECTRONIC TRIPS UNITS,** unless otherwise specified or shown on the drawings are applicable to circuit breakers 400 A frame size and larger, are to be solid state with long time delay settings between 0.4 and 1.0 times maximum trip rating, short time delay range of 2 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 2 to 11 times continuous rating (fixed at 11 times continuous rating for circuit breakers 250 A frame and lower). Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified and is to be adjustable between 0.2 and 0.6 normal phase current pick-up. Maximum adjustable time delay shall be 0.4 seconds, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.
13. **RESIDUAL CURRENT OPERATED EARTH LEAKAGE TRIP DEVICES (RCDs)** are provided as add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth fault current, in addition to overcurrent and short circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be 30 mA, and for main breakers ratings are to be as shown on the Drawings. Circuit breakers are to include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be held closed against earth faults.
14. **CURRENT LIMITING CIRCUIT BREAKERS:** moulded case type without fusible elements. When operating within current limiting range, the I_{2t} of let-through current is to be less than 1/2 cycle wave of symmetrical protective short-circuit current as compatible with breaker construction.
15. **CURRENT LIMITING CIRCUIT BREAKERS** are to have, on each pole, adjustable inverse time-delay over-current characteristics for overload protection and instantaneous trip for short-circuit protection. Operation of main contacts is to be based on electromagnetic repulsion forces between contacts created by fault current. Ratings are specified at rated voltage for an rms value of prospective short-circuit current.

E. MINIATURE CIRCUIT BREAKERS (MCBs)

1. **TYPE:** thermal magnetic non-adjustable type, tested in accordance with IEC 947.2 & IEC 898. Breaker type and short circuit interrupting ratings are mentioned on design drawings.
2. **MINIMUM SHORT-CIRCUIT BREAKING CAPACITIES** are to be as shown on drawings. Contractor to check and confirm those levels (according to final equipment location: Transformers, MDBs, Panel Boards,....)

3. **CONSTRUCTION:** MCBs are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panelboard enclosure and humidities up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials.
Guaranteed duties and characteristics are to be submitted for temperatures above 40deg. C. MCBs and combinational devices are to be modular, of unified profile and mounted to a standard DIN rail.
4. **OPERATION:** under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at times normal rated current (curve C characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milliseconds.
5. **RATINGS:** preferred rated currents are to be 6, 10, 16, 20, 25, 30, 40, 50, 60, 80 and 100 A, calibrated at 40 deg.C, available as 1+N, 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg.C, and loading is not to exceed 70% of circuit breaker rating.
6. **RESIDUAL CURRENT DEVICES** for earth leakage protective circuit breakers are to be add-on devices, or built-in and integral with the standard circuit breaker. Nonadjustable sensitivities of 30 mA, 100 mA and 300 mA are to be available for all ratings of 1+N, 2-pole and 4-pole circuit breakers.
7. **AUXILIARIES,** where required or shown on the Drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.

F. MOULDED CASE SWITCH (MCS)

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

G. MODULAR CONTRACTORS FOR SECONDARY PANEL BOARDS

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

1.2 PANELBOARDS

- A. **ARRANGEMENT:** to comprise set of homogeneous branch circuit breakers with unified profile and base, one main circuit breaker or switch-disconnector (as shown on drawings) as indicated on drawings. Circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.
- B. **INDOOR ENCLOSURE:** sheet steel, minimum 1.0 mm thick for box/cabinet and minimum 1.5mm thick for front shield, trim and door. Fixings for flush trim are to be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) are to be at least 100 mm wide. Larger gutters are to be provided where tap-off insulated split connectors are required. Knockouts are to be provided in top or bottom of enclosures and are to provide a neat and uniform conduit/cable terminal arrangement.

C. FINAL BRANCH CIRCUIT PANELBOARDS SDB- TYPE MCB

1. INTERNAL ASSEMBLY: to comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for single and three phase panels. Assembly is to be complete with earthing bar and one piece insulated bolt-on/comb-type phase busbar. Busbars are to be single-phase and neutral or 3-phase and neutral with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards. Panelboards are to comply with NFC and IEC standards. If the busbars rating exceeds 100 Amp (where the frame size of the main breaker is larger than 100 Amps), comb busbars shall not be used but still clause 2.1.C. of this specification shall apply.
2. SINGLE PHASE TYPE PANELBOARDS are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.
3. SINGLE PHASE TYPE PANEL BOARD MAIN CIRCUIT BREAKER OR SWITCH-DISCONNECTOR is to be double-pole, with or without earth leakage device (RCD), as shown on the Schedules.
4. SINGLE-POLE + NEUTRAL (1 + N) AND DOUBLE-POLE (2P) MCBs for 240 V service, are to have trip ratings between 6 A and 50 A, with ICU (n)/ICS as required in the Schedules.
5. THREE PHASE TYPE PANELBOARDS are to be suitable for up to 415 V a.c. maximum service voltage, 3 phase and neutral, with MCBs on branch circuits and 4 pole switch-disconnector or circuit breaker, main incoming, as shown in the Schedules or on the Drawings.
6. FOUR-POLE BRANCH CIRCUIT BREAKERS are to have trip ratings between 6 A and 100A, with ICU/ICS as required in the Schedules.
7. THREE PHASE TYPE PANELBOARD MAIN SWITCH-DISCONNECTOR OR CIRCUIT BREAKER is to be four-pole, with or without earth leakage device (RCD), as shown on the schedules.
8. SHORT-CIRCUIT RATING: THREE PHASE panelboards may only have integrated equipment (series) short-circuit rating in accordance with calculations.

3. FIELD AND INSTALLATION WORK

1.1 INSTALLATION

A. FIXING GENERALLY:

1. Align, level and securely fasten panelboards to structure
2. Fix surface mounted outdoor panelboards at least 25mm from wall ensuring supporting members do not prevent flow of air.
3. Do not use connecting conduits to support panelboards
4. Close unused openings in panelboard cabinets.

B. PANELBOARD INTERIORS: do not install in cabinets until all conduit connections to cabinet have been completed.

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

D. TRIM: fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.

E. PROTECTION: treat concealed surfaces of recessed cabinets with heavy field application of water-proof compound prior to installation.

1.2 INSPECTION AND TESTS ON SITE

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

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

C. INSULATION CHECK TESTS: carry out insulation tests on all busbars, between phases and between phases and earth/cabinet, and between neutral and earth. Record all readings, using 500 V megger for equipment on 240 V systems, and 1000 V megger for equipment on systems up to 600 V, for 1-minute, with circuit breakers in open position.

D. ROUTINE TESTS ON SITE are to be carried out, in accordance with the Standards, on all panelboards assembled from standardized components of the manufacturer outside the works of the manufacturer.

SECTION 6

MAIN DISTRIBUTION BOARDS

1. GENERAL

1.1 RELATED DOCUMENTS

- A. DESCRIPTION OF WORK: main distribution board (s) (MDBs) for low voltage (LV) distribution, mounting frames, fittings, cables termination accessories and supports.
- B. STANDARDS:
 - 1. Switchgear and control gear assembly are to comply, with IEC EN 60439-1.
 - 2. Circuit breakers are to comply with IEC 947- 2 as specified.
 - 3. Other components, where not otherwise specified, are to comply with the relevant IEC standards.
- C. EQUIPMENT DATA: submit for approval detailed description of main distribution boards and major components supported by manufacturer's catalogues, indicating compliance with the Standards, equipment characteristics, details of construction, operating data, dimensions and weights etc. Give details of miscellaneous items including incoming and outgoing feeder terminal arrangement, connections at busbars, isolating, earthing, interlocks, control devices, digital indicating and metering instruments etc.
- D. TEST AND CERTIFICATES: submit complete certified manufacturer's type and routine test records, in accordance with the Standards.
- E. SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:
 - 1. Plans and elevation with indication of built- on equipment, exact dimensions and weights.
 - 2. Arrangement of boards inside rooms allocated, indicating spaces and clearances.
 - 3. Arrangement of equipment inside board.
 - 4. One- line diagram of power system showing current ratings of switchgear and types and locations of protective gear (relays, instruments, CT s, VT s etc.)
 - 5. All protecting device shall show: the Short circuit current value, the voltage drop, the indirect protection function in case of a fault with respect the earthing system.
 - 6. Schematic and elementary diagrams of control circuits.
 - 7. Foundation details, grouting holes, installation details.
 - 8. Arrangement of incoming and outgoing feeders, terminal fittings, instruments, busbar connections etc.
- F. TECHNICAL LITERATURE: submit the following for approval prior to placing orders for equipment manufacture:
 - 1. Schedule of circuit breakers application, indicating type, range, features and characteristics, short-circuit ratings, time- current curves etc.
 - 2. Method of setting of protective devices for overload, short- circuit and earth-fault current as coordinated with upstream and downstream systems based on

3. Test methods on site and references.

- G. **SPARE PARTS:** provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the followings:
 - 1. One set of fixed and moving contact for every type of replaceable (consumable) contact set.
 - 2. One operating motor and/ or coil for each type of electrically operated circuit breaker
 - 3. Two sets of each type of indicating lights, fuses, LEDs etc.
- H. **TOOLS AND INSTRUMENTS:** provide tools and instruments required for normal routine inspection and maintenance and testing of circuit breakers and protective devices as appropriate for type of switchgear supplied.
- I. **APPROVED SWITCHGEAR & CONTROLGEAR MANUFACTURERS:** subject to compliance with the specifications and drawings, obtain main distribution board equipment, from one of the following:
 - 1. Merlin Gerin, Télémecanique (Schneider) (France).
 - 2. Moeller (Germany)
 - 3. ABB (ITALY)
- J. **APPROVED ENCLOSURE AND BUSBAR SYSTEM MANUFACTURERS:** subject to compliance with the specifications and drawings, obtain main distribution board enclosure and busbar system, from one of the following:
 - 1. Merlin Gerin (Schneider, France).
 - 2. Moeller (Germany)
 - 3. Siemens (Germany)
 - 4. Holec (Holland)
 - 5. Logstrup (Ireland)

connections to be tinned, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to maximum 30 °C. Above average ambient temperature of 50 °C outside enclosure. Connections and buswork are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance.

- K. **CONNECTIONS:** from busbar to switchgear are to be rated to carry full continuous current rating of switchgear frame and are to be insulated.
- L. **FULL SIZE NEUTRAL:** is to be continuous through all sections. Neutral bus is to be insulated and separate from earth bus and connected to it with removable links.
- M. **EARTH BUS:** is to extend full length of board, firmly fixed to each section in accordance with the Regulations and standards, complete with two main earthing lugs (one at each end), and required number of feeder protective earth connectors.
- N. **SWITCHBOARD TYPE:** switchboard(s) are to be of the front accessible wall aligned, with fixed main circuit breaker sections (type and rating as shown in schedules) and fixed group mounted outgoing MCCB distribution section(s), busbars section(s), feeders' section(s). All compartments shall have glazed doors except for busbars & cable compartments. If each functional unit is arranged in a separate compartment, a solid door shall be provided for each compartment where the disconnecting element's toggle shall be extended to outside the compartment.
- O. **FIXED MAIN CIRCUIT BREAKER SECTION:** is to individually accommodate main circuit breaker, main cable entry with terminal fitting assembly and metering compartment. Where required an additional cable pull section is to be provided, depending on actual configuration shown on the Drawings. Where placed against a wall, accessibility is to be possible from front and sides or only from front of section.
- P. **FRONT ACCESSIBLE FIXED, FEEDER MCCB (or ACB) DISTRIBUTION SECTIONS – FEEDER SECTIONS – BUSBARS SECTION:** are to rear align with main section(s) and be of uniform depth, with all devices removable from the front and mounted on a panelboard type base. Construction is to allow all connections and maintenance to be made without rear access. Cables are to be accommodated in extra wide vertical section(s). Sides, top and rear are to be covered with removable screw-on plates having formed edges all around. Front plates are to be sectionalized and removable, covered by times, and secured by self-tapping screws. If Plexiglas (or any other material) is used for segregation, it has to be fire retardant. Busbars are to be accommodated in separate horizontal and vertical sections. The electrical link from the busbars to each distribution MCCB (or ACB) could be by rigid or flexible insulated busbars (the electrical link within the same functional unit have to be done by rigid busbars, flexible busbars and cables are not allowed) unless the MCCB or ACB's frame size is greater than 600 Amperes. In this case, the electrical link shall be rigid busbars.

1.2 MOULDED CASE CIRCUIT BREAKERS (MCCBs)

- A. **MCCBs GENERALLY** are to be thermal-magnetic type for ratings below 400 A frame size, unless otherwise shown on the Drawings. MCCBs 400 A and larger are to be

electronic solidstate trip type. All circuit breakers are to be 4 poles (protected) unless otherwise shown on drawings.

- B. CONSTRUCTION: totally enclosed, moulded case, constructed from high quality, hightemperature resistant, tropicalized, moulded insulating materials, for normal operation at 70°C within enclosures, to approved standards, provided with quick-break, trip- free switching mechanism manually operated by front toggle type handle and automatically tripped under over-current and short circuits conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Contacts are to be non-construction. Cable terminals are to be solderless anti-turn box lug or clamp type with set screws suitable for copper or aluminum cables.
- C. THERMAL MAGNETIC CIRCUIT BREAKERS: are to include, on each pole, a bimetallic inverse time-delay over-current trip element for small overloads and instantaneous magnetic overcurrent trip elements for operation under short- circuit conditions. Circuit breakers 250 A frame size or where shown on drawings, shall have adjustable short time trips (Im).
- D. THERMAL OVERCURRENT TRIPS: are to be compensated to allow for ambient temperature higher at breaker than at protected circuit or device. Compensation is to be applicable between 25 and 50 °C. In case of adjustable thermal settings, range of adjustment is not to exceed maximum trip rating shown on the Drawings.
- E. ELECTRONIC TRIP CIRCUIT BREAKERS: unless otherwise specified on drawings, electronic trip circuit breakers are to have solid state trip units with long time delay setting range at least between 0.4 and 1.0 times maximum trip rating, adjustable short time delay (range 2 to 10 times maximum trip rating) with adjustable clearing time and instantaneous protection adjustable from 2 to 11 times continuous rating (fixed at 11 times continuous rating for circuit breakers 250A frame and lower). Solid state trip units are to be insensitive to changes in ambient temperature between -20 and + 55 °C. Earth fault protection is to be built into trip unit where specified, and is to be adjustable between 0.2 and 0.6 normal phase current pickup. Maximum adjustable time delay of 0.4 seconds, and is to be suitable for connection to external current sensor. Push- to- trip button is to be provided on cover for testing the trip unit.
- F. TRIPPED POSITION: when tripped automatically by over-current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.
- G. INTERCHANGEABLE TRIPS: Circuit breakers 100 A to 630 A frame sizes are to have interchangeable thermal and electronic trip units.
- H. SEALING: non- interchangeable trip circuit breakers are to have sealed covers. Circuit breakers with interchangeable trips are to have trip unit covers sealed to prevent tampering.
- I. CIRCUIT BREAKER RATINGS: are to be non-current limiting, fully rated (100%) with continuous duty at site conditions, and with frame size and interrupting capacity to IEC 947- 2, sequence II (rated service short- circuit) breaking capacity, and maximum trip rating as shown on the Drawings. Interrupting capacities at specified voltage and

frequency are to meet IEC 947-2 test sequence I, II and III for circuit breakers of utilization category A for circuit breakers with frame size 630 A and less. Interrupting capacities at specified voltage and frequency are to meet IEC 947-2 test sequence I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability) for circuit breakers with frame size 1500 A and larger including air circuit breakers (ACB).

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

1.3 AIR CIRCUIT BREAKERS (ACBs)

A. GENERAL:

- a. The ACBs shall comply with IEC 947-2.
- b. The ACBs are to be electronic solid-state trip type. All circuit breakers are to be 4 poles (protected) unless otherwise shown on drawings.
- c. The breaking capacity performance certificates shall be available for category B to the above mentioned standards. The test shall be carried out with a breaking performance during operation (I_{cs}) and admissible short time withstand (I_{cw}) equal to the ultimate breaking capacity (I_{cu}).
- d. The ACBs must be able to be supplied both from the top and bottom terminals without reduction in performance and without jeopardizing their functionality.
- e. All ACBs shall be fully tropicalized (T2) as standard.
- f. The ACBs shall comply with the isolating function requirements of IEC 947-2 section 7.1.2.
- g. The ACBs shall have a rated service voltage of 690V AC (50/60Hz) and a rated voltage of 1000V.
- h. The ACBs shall have a rated impulse withstand voltage of 12KV.

B. CONSTRUCTION:

- a. The air circuit breakers shall be designed to be maintained;
- b. They shall be available in fixed or drawout models and in three or four poles versions. On four poles version, from 800 up to 4000 Amps, the neutral pole shall have the same current rating as the other poles and half of the current rating from 5000 to 6300 Amps.
- c. The main contacts of the air circuit breakers shall be encased in a reinforced polyester casing and offer double insulation from the operators on the breaker front face. The circuit breaker also shall offer total insulation of the control part with respect to the power part.
- d. The operating mechanism shall be of the opening-closing-opening (O.C.O.) stored energy spring type with a closing time of less than or equal to 80ms.
- e. The springs are charged manually by operating the front lever or using a motor operator. In the case of motor charged spring, the maximum time to charge the springs shall not exceed four seconds, it shall also be possible to charge the springs manually.
- f. Contacts shall be designed to be maintenance free in normal usage.

- Instantaneous (INST)
 - Adjustable from 2 times up to:
 - At least 20 times the rated current for sensor ratings up to 2000 Amps;
 - At least 10 times the rated current for sensor ratings above 2000 Amps.
- c. Control functions:
- In order to optimize the operation, maintenance and monitoring of the breaker in complete safety, the following standard control items shall be supplied as an integral part of the control unit:
- Local overcurrent LED indication with 2 levels – LED steady or flashing – on the front face and one volt free output contact shall indicate as a pre trip alarm;
 - Two NO and two NC output contacts plus one CO fault trip contact (SDE) shall be available;
 - Thermal memory: The control unit shall optimize the protection of the equipment or the circuit conductors in the event of repeated overloads or faults by using thermal integration to memorize temperature rises;
 - Safety: internal overheating of the control unit shall be signaled.
- d. Options:
- Without increasing the volume it shall be possible to combine the following functions into the air circuit breaker control unit:
- Load monitoring and control: Two adjustable settings with output contacts shall be available. These settings to be related to the long time protection setting;
 - Zone selective interlocking for the short time and earth fault protection;
 - Earth fault protection;
 - Remote indication of one particular fault as selected by a switch on front face;
 - Fault trip indication – indicating the element (long time, short time/instantaneous, earth fault protection if supplied) that has caused the circuit to trip, indicated locally by a led;
 - Measurement:
 - A digital display ammeter shall indicate the RMS value of the circuit breaker phase currents with a switch on the front face for selection;
 - A bar graph shall display the load indication of each phase;
 - The highest value of phase current shall be stored and displayed on demand.
 - Communication:

The data or action needed for the control and indication functions shall be available on a BUS via a specific modular system, ie:

 - Circuit breaker state;
 - Control unit settings;
 - Cause of circuit breaker trip;
 - Circuit breaker operation.

D. **CIRCUIT BREAKER RATINGS:** are to be non-current limiting, fully rated (100%) with continuous duty at site conditions, and with frame size and interrupting capacity to IEC 947- 2, sequence II (rated service short- circuit) breaking capacity, and maximum trip rating as shown on the Drawings. Interrupting capacities at specified voltage and frequency are to meet IEC 947-2 test sequence I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability) for air circuit breakers (ACB).

E. **ACCESSORIES:**

a. **Electrical accessories:**

All electrical accessories including the motor spring charging mechanism shall be field adaptable without adjustment or the necessity for any tool (except a screwdriver). They shall be fitted into a compartment which under normally loaded conditions has metalwork energized from the main poles exposed with it. Thus any adaptation carried out shall not increase the breaker volume. It shall be possible to connect all auxiliary wiring from the face of the air circuit breaker; this wiring shall be taken through a set of disconnecting contacts, so that all auxiliary wiring is automatically disconnected in the isolated position.

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

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

All indicators must be clearly visible.

1.4 DIGITAL POWER METERING INSTRUMENTS

A. **GENERALLY:** Power meters shall combine the following functions in a signal unit:

1. True RMS measurements up to the 9th harmonic for voltage, current, frequency, power and power factor.
2. Measurement of power quality, i.e. the level of harmonic distortion (THD) in voltage and current.
3. Metering of active and reactive energy.

B. **MEASUREMENTS**

1. Phase to neutral voltages (V1N, V2N, V3N): 115 to 500 VAC, $\pm 1\%$ accuracy.
2. Phase to phase voltages (U12, U23, U31): 115 to 500 VAV, $\pm 1\%$ accuracy.
3. Currents (I1, I2, I3 and IN): 15 to 2500 A, $\pm 1\%$ accuracy.
4. Maximum Current.
5. Frequency: 45 to 65 HZ, $\pm 0,02\%$ accuracy.
6. Power factor: $\pm 1,5\%$ accuracy.
7. Active Power: $\pm 1,5$ accuracy.
8. Reactive Power: $\pm 1,5\%$ accuracy.
9. Apparent Power: $\pm 1,5\%$ accuracy.
10. Active energy consumed.
11. Reactive energy consumed.
12. Apparent energy consumed.

13. Reset of meters (including maximeter).
 14. Harmonic distortion of currents I1, I2, I3 and IN: $\pm 1\%$ accuracy.
 15. Harmonic distortion of voltages V1N, V2N, V3N, U12, U23 and U31: $\pm 1\%$ accuracy.
 16. Assignment of output relays for power (active, reactive, apparent), demand power and power factor.
 17. Measurement shall be available on the front panel of the power meter, by an LCD screen.
- C. Mechanical Characteristics:
2. Degree of protection IP 40.
 3. Vibrations FC test: 2 to 13,2 HZ-1 mm and 13,2 to 100 HZ-0,7 g.
 4. Operating temperature: -20 to +55 °C.

1.5 WIRING

- A. ARRANGEMENT: wiring is to be modularly and neatly arranged on master terminal boards with suitable numbering strips and appropriate cartridge type fuses where required. Terminal boards shall be WAGO or approved equal.
- B. CONNECTIONS: are to be made at front of terminal boards and with no live metal exposed.
- C. METAL CASES: of instruments, control switches, relays etc. Are to be connected, by bare copper conductors not less than 2.5 mm² section, to nearest earthing bar.
- D. CONTROL WIRING: copper. PVC insulated, 85 °C, 600 V grade, and PVC sheathed for multicore cables running from the control terminal blocks to outside the panel. Finely stranded copper conductor, silicon rubber insulated cables are to be used inside the panel.
- E. FERRULES: wires are to be fitted with numbered ferrules of approved type at each termination.

1.6 MISCELLANEOUS

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

2. MAINS FAILURE AUTOMATIC TRANSFER SWITCHES (ATS)

- A. TYPE: wall or floor mounted, Form as indicated on drawings as per IEC EN 60439-1 but with separate sections for outgoing distribution on feeders, galvanized sheet steel cubicle of equal construction to control cubicle, comprising contactors with manual by-pass switches or withdrawable air circuit breakers (as specified on drawings) and controls necessary for automatic transfer of power supply from normal source to standby source, voltage sensing control relay and time delay relays to signal generators start and stop, auxiliary switches and indicating lights etc. as necessary for the required operation of the system. Contactors and by-pass switches ratings and specifications are specified on drawings.
- B. The busbars shall be rigid and fully sized. The electrical link from the busbars to each switchgear or control gear shall be by flexible insulated busbars unless the switchgear or control gear's frame size is greater than 600 Amperes. In this case, the electrical link shall be rigid busbars (the electrical link within the same functional unit have to be done by rigid busbars, flexible busbars and cables are not allowed).

- J. **WIRING:** moisture and heat resistant, silicon rubber insulated, stranded copper conductors, modularly and neatly arranged on master terminal blocks, with suitable numbering strips and appropriate cartridge type fuses where required. Flexible wiring is to be used on all hinged/draw-out components.
- K. **CONNECTIONS:** are to be made at a front terminal block with no live metal exposed. Power cables are to terminate on fixed insulated copper connectors suitably sized to receive specified cables. Cable glands and gland plates are to be provided.
- L. **METAL CASES:** of instruments, control switches, relays etc. are to be connected by flexible protective conductors, of not less than 2.5 mm² section, to nearest earthing bar or terminal.
- M. **EARTHING:** earthing bar is to be provided for connection of protective earthing conductors, using set-screw or bolted anti-turn pressure termination's.
- N. **FERRULES:** wire ends are to be fitted with numbered ferrules of approved type at each termination.

3. FIELD AND INSTALLATION WORK

3.1 INSTALLATION

- A. **EQUIPMENT BASES:** ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and equipment manufacturer's drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
- B. **CABLE TRENCHES:** ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.
- C. **BUILT-IN ITEMS:** ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.
- D. **EQUIPMENT:** install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.
- E. **SUPPORTS AND TERMINATION'S:** install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.
- F. **RELAYS:** set in accordance with manufacture's instructions and in accordance with an approved scheme.
- G. **MAKE GOOD:** damaged painted surfaces, clean and apply rust inhibiting prime coat and two finishing coats of approved enamel upon delivery of equipment to site, or as required by the Engineer.

3.2 INSPECTION AND TESTS ON SITE

- A. **EQUIPMENT:** inspect- equipment upon delivery to site and report any damage to the Engineer.
- B. **SWITCHGEAR:** inspect and check switchgear for completeness, component ratings, types,sizes, and wiring connections. Check phasing of busbars, contacts and clearances.
- C. **TEST:** after installation and before hand over, carry out all tests required by the governingcodes and any other tests the Engineer may require to check compliance of installation withthe Specification, including insulation resistance tests and operational tests.
- D. **MAIN AND CONTROL CIRCUITS:** using 1000 V megger (2000 Megohm range), check insulationresistance between phases, between phases and earth/ enclosure and between neutral andearth.
- E. **PRIMARY INJECTION TESTS:** provide portable test equipment to test time-delaycharacteristics of circuit breakers by simulating an overload or faults condition. Measure andrecord all test results and ambient conditions and compare with manufacturer's data.
- F. **INSTANTANEOUS TRIP ELEMENTS:** test by high current primary injection, using high- currentprimary injection test- sets and report all readings.
- G. **ROUTINE TEST ON SITE:** are to be carried out on every main distribution board in accordancewith the Standard specified (IEC 439) for FBAs (feeder branch assembly) assembled fromstandardized components outside the works of the manufacturer. Routine tests are also to becarried out on every FBA, delivered to site, if requested by the Engineer.

SECTION 7

MOTOR-CONTROL CENTERS

GENERAL

1.1 SUMMARY

- A. This Section includes motor-control centers for use on AC circuits rated 600 V and less.

1.2 SUBMITTALS

- A. Product Data: For products specified in this Section. Include dimensions, ratings, and data on features and components.
- B. Shop Drawings: For each motor-control center specified in this Section. Include dimensioned plans, elevations, and component lists. Show ratings, including short-time and short-circuit ratings, and horizontal and vertical bus ampacities.
 - 1. Schedule of features, characteristics, ratings, and factory settings of individual motor-control center units.
 - 2. Wiring Diagrams: Interconnecting-wiring diagrams pertinent to class and type specified for motor-control center. Schematic diagram of each type of controller unit indicated.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- D. Maintenance Data: For products to include in the maintenance manuals specified in Division 1.
- E. Load-Current and Overload-Relay List: Compile after motors have been installed and arrange to demonstrate that selection of protections suits actual motor nameplate full-load currents.

1.3 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.

1.4 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.

1.5 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. PRODUCTS

- A. Enclosures: Free standing cabinets as indicated. Unless otherwise indicated to meet environmental conditions at installed location. Unless otherwise mentioned on the drawings, Motor control centers shall be FORM 2B to IEC EN 60439-1.
 - 1. Ingress Protection: IP55 (provide anti-condensation heaters and submit thermal study to justify the panel's cooling method.
 - 2. Compartments: Modular; individual doors have concealed hinges and quick-capture 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.

1.1. BUSES

- A. Material: Tin Plated copper.
- B. Ampacity Ratings: As indicated for horizontal and vertical main buses.
- C. Neutral Buses: Full size, insulated and isolated from cabinet.
- D. Equipment Ground Bus: Non-insulated, horizontal copper bus (400 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.

1.2. FUNCTIONAL FEATURES

- A. Description: Modular arrangement of motor controllers, control devices, overcurrent protective devices, transformers, panel boards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center as indicated.
- B. Motor-Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.
 - 1. Units have short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.
- C. Overcurrent Protective Devices: Types of devices with features, ratings, and circuit assignments indicated.
- D. Transient Voltage Surge Suppressors: Connected to motor-control center bus.
- E. Spaces and Blank Units: Compartments fully bused and equipped, ready for insertion of units.
- F. Spare Units: Type, sizes, and ratings as indicated, and installed in compartments indicated "spare."

3.1 MAGNETIC MOTOR CONTROLLERS

- A. Description: full voltage, nonreversing, across the line, unless otherwise indicated.
- B. Control Circuit: 220 V; obtained from integral control isolation power transformer, unless otherwise indicated. Include a control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
- C. Combination Controller: Factory-assembled combination controller and disconnect switch with overcurrent protection.
 - 1. Moulded case nonfusible Disconnect: heavy-duty, nonfusible switch.

2. Moulded case circuit-Breaker Disconnect: motor-circuit protector (magnetic trip only)with field-adjustable short-circuit trip coordinated with motor locked-rotor amperes.
- D. Overload Relay: Ambient-compensated type with inverse-time-current characteristic.Provide with heaters or sensors in each phase matched to nameplate full-load current ofspecific 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 andrunning sequences.
- G. Contactor: To IEC standards 947-4-1, AC-3 or AC-4 rated as required by the application, incoordination type 2 with motor circuit breaker, thermal relay and motor nameplate data.
- H. Solid-State, Reduced-Voltage Controller: Suitable for use with polyphase, medium inductionmotors.It shall comply with IEC 801-2, level 3 and IEC 801-4 level 4 for immunity to interference anddirective 89/336/EEC for EMC requirements and IEC 664 for clearances and creepagedistances.
 1. Adjustable acceleration rate control uses voltage or current ramp, and adjustablestarting torque control has up to 500 percent current limitation for 20 seconds.
 2. Surge suppressor in solid-state power circuits provides 3-phase protection againstdamage 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 lightload.
 5. Motor running contactor operates automatically when full voltage is applied to motor.

3.2 SOFT STARTER MOTOR SET

- A. Description: Soft starter drive controller, providing a soft starting and stopping ofasynchronous squirrel cage motors.The soft starter microprocessor shall control the torque during starting and stopping withoutany need for a tachogenerator.It shall comply with IEC 801-2, level 3 and IEC 801-4 level 4 for immunity to interference anddirective 89/336/EEC for EMC requirements and IEC 664 for clearances and creepagedistances.
- 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 currents (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 starters shall be fitted with soft-touch membrane keypad switches, LED pilot lights and multi-fault memory.
- G. Communication port for J bus communication protocol.

3.3 VARIABLE-SPEED PUMPING SET

- A. Description: Variable speed drive controller, listed and labeled as a complete unit and arranged to provide soft starting of a recognized standard, induction motor by adjusting output voltage and frequency.
It shall comply with IEC 801-2, level 3 and IEC 801-4 level 4 for immunity to interference and directive 89/336/EEC for EMC requirements and IEC 664 for clearances and creepage distances.
- B. Design and Rating: Match type pumps; and type of connection used between motor and loads such as direct or through a power-transmission connection.
- C. Isolation Transformer: Match transformer voltage ratings and capacity to system and motor voltages; and controller, motor, drive, and load characteristics.
- D. Output Rating: 3-phase, 0.5 to 320 Hz, with torque constant as speed changes.

- E. Starting Torque: 100 percent of rated torque or as indicated.
- F. Speed Regulation: Plus or minus one percent.
- G. Ambient Temperature: 0 to 40 deg C.
- H. Efficiency: 95 percent minimum at full load and 320 Hz.
- I. Isolated control interface allows controller to follow 1 of the following over an 11:1 speedrange:
 - 1. Electrical Signal: 4 to 20 mA at 24 V.
- J. Internal Adjustability: Include the following internal adjustment capabilities:
 - 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3. Acceleration: 2 to 22 seconds.
 - 4. Deceleration: 2 to 22 seconds.
 - 5. Current Limit: 50 to 110 percent of maximum rating.
- K. Self-protection and reliability features include the following:
 - 1. Input transient protection by means of surge suppressors.
 - 2. Snubber networks to protect against malfunction due to system voltage transients.
 - 3. Motor Overload Relay: Adjustable and capable of NEMA 250, Class 10 performance.
 - 4. Notch filter to prevent operation of the controller-motor-load combination at anatural frequency of the combination.
 - 5. Instantaneous overcurrent trip.
 - 6. Loss of phase protection.
 - 7. Reverse phase protection.
 - 8. Under- and overvoltage trips.
 - 9. Overtemperature trip.
 - 10. Short-circuit protection.
- L. Automatic Reset/Restart: Attempt 3 restarts after controller fault or on return of power afteran interruption and before shutting down for manual reset or fault correction. Restartingduring deceleration will not damage controller, motor, or load.
- M. Power-Interruption Protection: Prevents motor from reenergizing after a power interruptionuntil motor has stopped.
- N. Status Lights: Door-mounted LED indicators to indicate the following conditions:
 - 1. Power on.
 - 2. Run.
 - 3. Overvoltage.
 - 4. Line fault.
 - 5. Overcurrent.
 - 6. External fault.

- O. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate controller output current, voltage, and frequency.
- Q. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller outputs and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch indicator lights set and indicate mode selection.
- R. 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.
- S. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
- T. The variable speed pumping set control system to be as described in section 16481 "Motors and Starters - Variable Speed Pumping Set".

3.4 FEEDER OVERCURRENT PROTECTION

- A. Molded-Case Circuit Breaker: MCCB, handle lockable as mentioned and specified in main distribution board.

3.5 MCC CIRCUIT BREAKERS:

MCCB below 800 Amperes and Air Circuit Breaker above 800 Amperes, both with utilization category "B" and electronic trip unit as indicated in section 16440 (Main Distribution Boards).

3.6 ACCESSORIES

- A. Devices are factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations (when mentioned on the drawings), Pilot Lights, and Selector Switches: heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break push-button station with a factory applied hasp arranged so a padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Elapsed Time Meters: Heavy duty with digital readout in hours.
- F. Meters: Power meter as indicated in section 16115 (main Distribution Boards).

- G. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.
- H. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay.
- I. Transient Voltage Surge Suppressors: IEC 60364, IEC 61643-11, IEC 664-1 and IEC 1643-1, selected to meet requirements for a high-exposure category.
- J. Impulse sparkover voltage coordinated with system circuit voltage.
- K. Factory mounted with a Recognized Testing Laboratory listed and labeled mounting device.

4. EXECUTION

4.1 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 (when mentioned on the drawings): 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.

4.2 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.

4.3 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs according to Division 16 Section "Basic Electrical Materials and Methods."
- B. Identify field-installed wiring and components and provide warning.

- C. Operating Instructions: Frame printed operating instructions for motor-control centers, including control sequences, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

4.4 CONTROL WIRING INSTALLATION

- A. Install wiring between motor-control devices according to Division 16 Section "Wires and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic control devices according to an indicated wiring diagram or one that is manufacturer approved, where available.
 - 1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.
 - 2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high temperature cutouts, and motor-overload protectors.

4.5 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 to IEC EN60439-1.

4.6 FIELD QUALITY CONTROL

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

4.7 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.

4.8 DEMONSTRATION

- A. Training: Engage a factory-authorized service representative to demonstrate solid-state and variable-speed controllers and motor-control centers, and train Owner's maintenance personnel.
 - 1. Conduct a minimum of 4 hours of training in operation and maintenance. Include training relating to equipment operation and maintenance procedures.
 - 2. Schedule training with at least 7 days' advance notice.

SECTION 8

MOTORS & STARTERS

1. GENERAL

The Contractor shall supply and install the motors and the starters under other sections when so mentioned, as shown on the Drawings and as herein specified. Motor starting method and corresponding furnished starter shall be concordant.

2. RATING OF MOTORS

Motors shall be suitable for operation on 220/230 volt single phase or 380/400 volt 3-phase, 3-wire, 50 Hz system and shall be dripproof fan cooled to IEC 34-6 induction motor type unless otherwise indicated or specified. All motors shall have a service factor of 1.15, and a power factor of 0.85 as a minimum. Motors of ratings smaller than 1 HP shall be single phase and those of ratings 1 HP and larger shall be three phase, unless otherwise indicated or approved. Motors of rating larger than seven horsepower shall be star-delta closed transition starting type, unless otherwise specified or required by the Local Authorities. Unless otherwise specified or mentioned on the drawings, motors of rating seven horsepower and smaller shall be direct on line starting type. Every motor shall be of sufficient capacity to operate the driven equipment under all load and operating conditions without exceeding its rated name-plate current or power or its specified temperature limit. The horsepower ratings for motors shown on the Drawings must be considered as an indication only. For the use of motors other than that specified, the Contractor shall assume the cost of, and responsibility for satisfactory accomplishing all changes (including engineering costs of redesign by the Engineer) in the work as indicated and specified. All derating resulting from site conditions shall be allowed for in the design. Motor performances shall comply with the requirements of IEC 34-1.

3. TYPES OF MOTORS

All motors shall be of a type approved for starting characteristics and ruggedness as may be required under the actual conditions of operation. All motors shall have class F insulation as a minimum requirement. The motors shall be designed so that the maximum temperature rise at continuous run under fullload and operation conditions shall be in accordance with IEC Standards for Motors and Generators and based on the local ambient temperature.

4. GENERAL DESIGN OF MOTORS

Motor windings shall be braced to withstand successfully the stresses resulting from the method of starting. The windings shall be treated thoroughly with approved insulating compound suitable for protection against moisture and slightly acid or alkaline conditions. Bearings shall be of the self-lubricating type, designed to ensure proper alignment of rotor and shaft, and to prevent leakage of lubricant. Bearings for open motors shall be of the sleeve or ball type, as specified under respective items of mechanical equipment.

Indoor motors located in relatively clean surrounding, free from any abrasive or conducting dust or chemical fumes, shall be enclosed ventilated dripproof type. Otherwise motors shall be totally enclosed fan cooled type. Vertical motors if any shall be provided with thrust bearings adequate for all thrusts to which they can be subjected in operation. Vertical motors of open type shall be provided with drip hoods of approved shape and construction. When the drip hood is too heavy to be easily removed, provision shall be made for access for testing.

5. MOTOR TERMINAL BOXES AND LEADS

Motors shall be furnished with oversized conduit terminal boxes to provide for making and housing the connections and with flexible leads of sufficient length to extend for a distance of not less than 10 cm beyond the face of the box. The size of cable terminals and conduit terminal box holes shall be as approved by the Engineer. An approved type of solderless lug shall be supplied. Totally enclosed motors shall have cast iron terminal boxes.

6. MOTOR SHOP TESTS

Motor shop tests shall be made in accordance with IEC Test Code or approved equal. Complete tests of each motor supplied shall be made and certified shop test data sheets shall be submitted, unless witness shop tests are required by the Detail Specifications pertaining to the equipment. Each motor shall be tested for efficiency and power factor at 50, 75 and 100 percent of its rated horsepower, for temperature rise, torque, starting current and dielectric strength; and for compliance with all specified performance requirements.

7. MOTOR STARTERS

Motor Starters shall be built and sized in accordance with IEC Standard 158-1 and IEC 947-4-

1 coordination type 2, BS 775 and IEC 292-1&2, or approved equal. Starters shall be non-reversing, magnetic type unless otherwise indicated or specified.

All starters shall be provided with thermal devices in each phase calibrated for close protection of the motors against overloads. These devices shall trip the starters in case of overload and shall not

allow it to be reset except manually. The thermal overload relays shall be adjustable from 90 to 110 percent of nominal rating. A single calibration adjusts all three legs. The overload relay shall be ambient compensated.

The starter shall be provided with auxiliary contacts for the connection of signaling, interlocking and other circuits as required for the controls.

Unless otherwise indicated, all starters shall be provided with START-STOP pushbuttons, and RED and GREEN LED pilot lights, all located on the starter front cover. An overload reset button shall be provided inside the cover, Pushbuttons shall be momentary contact or maintained type as

applicable to the function of control. Starters shall have horsepower ratings at least equal to ratings of motors they serve following IEC

947-4-1 coordination type 2. Voltage of control circuit shall not exceed 240 volts for starters in motor control centers or panels. Individually mounted starters or combination starters may have their control voltage on 380 volts provided local regulations or local inspectors do not forbid the use of same. The Contractor when utilising such voltage for control shall provide the use of same. The contractor when utilising such voltage for control shall provide a clear warning of existence of such voltage within the station. If 220 volts are required by the local regulations or local inspectors, a neutral conductor shall be brought within the feeder of the starter of approved cross section, at no extra charge. Starters shall be electrically held in,

providing inherent under voltage release. Starters when not part of a motor control center and are located indoors shall be encased in an IP 42 dust-proof enclosure, unless otherwise indicated. "Star-delta" starters, if any, shall have additional "Star" and "Delta" contractors which shall be electrically and mechanically interlocked to close the motor in "Delta" connection with the supply after the "Star" contractor has opened. A timing device shall be fitted to provide and adjust time in "Star" before changing over to the Delta connection. The protective and control device for motor protection, have to be type-2 co-ordinated to IEC 947-4.1. "Star-Delta" Starters shall provide closed transition. Schematic wiring diagram of all starters shall be provided on the interior of starter front over.

8. VARIABLE SPEED PUMPING SET

- A. The variable speed pumping set control system shall include as, a minimum:
 - 1. The programmable logic pump controller.
 - 2. Adjustable frequency drive(s).
 - 3. Automatic bypass.
 - 4. Additional equipment as specified or as required to properly execute the sequence of operation including remote sensor/transmitters.
- B. Pump Logic Controller:
 - 1. The controller shall be specifically designed for variable speed pumping applications.
 - 2. The controller shall function to a proven program that safeguards against damaging hydraulic conditions including motor overload, pump flow surges, hunting, end of curve.
 - 3. The pump logic controller shall capable of accepting up to 4 analog inputs from zone sensor/transmitters indicated on the plans. The controller shall scan each analog input a minimum of once every 500 milliseconds. It will then select the analog signal that has deviated the greatest amount from its setpoint. This selected signal will be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value.
 - 4. The pump controller shall be capable of controlling 6 pumps in parallel.
 - 5. The controller shall be field expandable to control up to 6 pumps in parallel and accept up to 16 analog inputs. This modification shall consist of nothing more than the addition of analog input modules and shall not require the use of special tools or factory reprogramming.
 - 6. The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral and derivative values shall be user adjustable over an infinite range.
 - 7. The pump logic controller shall be self prompting. All messages shall be displayed in plain English. The operator interface shall have the following features:
 - a. Multi-fault memory and recall
 - b. On-screen help functions
 - c. LED pilot lights and switches
 - d. Soft-touch membrane keypad switches.
 - 8. The readout shall be two lines of forty 0.50" brightly lit fluorescent characters capable of displaying the following values:

- a. Differential pressure in PSIG
- b. Pressure in PSIG
- c. Flow in GPM
- d. Kilowatt consumption
- e. Wire to water efficiency calculation
- 9. The following communication features shall be provided to the BMS:
 - a. Remote system start / stop
 - b. Failure of any system component
 - c. Process variable
 - d. AFD speed

C. Adjustable Frequency Drive (AFD)

- 1. The adjustable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
- 2. Enclosure shall be IP55 ventilated for installation as a wall mounted or free-standing unit, depending on the amp rating. A hand-off-automatic switch and speed potentiometer shall be mounted on the front of the enclosure.
- 3. AFD shall utilize a diode bridge rectifier to convert three phase AC to a fixed DC voltage. Power factor shall remain above 0.95 regardless of speed or load. AFDs employing power factor correction capacitors shall not be acceptable.
- 4. Insulated gate bipolar transistors shall be used in the inverter section to convert the fixed DC voltage to a three phase, adjustable frequency, AC output. A DC line reactor shall be provided to minimize harmonic and current distortion of the input power line.
- 5. The following customer modifiable adjustments shall be provided:
 - a. Accel time: 0.1 to 1800 seconds
 - b. Decel time: 0.1 to 1800 seconds
 - c. Minimum frequency: 0.5 HZ
 - d. Maximum frequency: 320 HZ
 - e. Analog input filter: 0.1 to 10 seconds
 - f. Analog outputs: 10 to 1 gain
 - g. Volts / Hertz ratio
- 6. Speed reference signal shall be customer selectable for 0-10 VDC or 4-20 mA.
- 7. The AFD shall be suitable for elevations to 3300 feet above sea level without derating.
Maximum operating ambient temperature shall not be less than 104 degrees F. AFD shall be suitable for operation in environments up to 95% non-condensing humidity.
- 8. The AFD shall be capable of displaying the following information in plain English via a 40 character alphanumeric display:
 - a. Frequency
 - b. Voltage
 - c. Current
 - d. Kilowatts per hour
 - e. Fault identification
 - f. Percent torque
 - g. Percent power

14. When in the "AUTOMATIC" mode, the pump(s) shall operate through the AFD(s) being controlled by a signal generated by the pump logic controller.
15. In the event of a system differential pressure failure, due to a pump, AFD, overload fault, the pump logic controller shall automatically initiate a timed sequence of events to start the remaining pump/AFD set(s) in the variable speed mode. A message on the display shall indicate the fault, pump/motor, or AFD. Subsequent failures shall initiate a timed sequence of events to the variable speed mode as available.
16. In the event of all AFD faults, all pumps shall be automatically started across the line.
17. When in the "BYPASS" mode, the selected pump(s) shall be able to be operated across the line at constant speed with motor overload protection. A solid red light shall signal this condition. All pumps shall be locked out of the variable speed mode.
18. In the event of an overload fault while in the "BYPASS" mode, the selected pump shall be locked out.
19. In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan/compare program. Alternative zone sensor/transmitters, if available, shall remain in the scan/compare program for control.
20. The zone number corresponding to the failed sensor/transmitter shall be displayed on the operator interface of the pump logic controller.
21. In the event of failure to receive all zone process variable signals, the AFD shall maintain 100% speed, reset shall be automatic upon correction of the zone failure.
22. PUMP, AFD, OVERLOAD fault shall be continuously scrolled through the display on the operator interface of pump logic controller until the fault has been corrected and the controller has been manually reset.

SECTION 9

**ANALOGUE ADDRESSABLE FIRE DETECTION & ALARM SYSTEM WITH
VOICE EVACUATION AND EMERGENCY VOICE/ALARM COMMUNICATIONS
SYSTEMS**

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes intelligent, interactive, analogue, addressable fire alarm systems with manual stations, detectors, signal equipment, controls, voice evacuation (VE), emergency voice/alarm communication systems and related devices.

1.2 DEFINITIONS

- A. Definitions in NFPA 72 apply to fire alarm terms used in this Section.

1.3 SYSTEM DESCRIPTION

- A. General: Non-coded, Interactive / Intelligent, addressable-analog system with manual and automatic alarm initiation; automatic sensitivity control of detectors; and multiplexed signal transmission dedicated to fire alarm service, voice evacuation (VE), emergency voice/alarm communication systems and extinguishing agent release. The system shall also include interfaces with the security systems and input-output points (or interface) to/from the BMS.

1.4 SUBMITTALS

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

- B. Shop Drawings:

Wiring Diagrams: Detail wiring and differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.

Battery: Sizing calculations.

Floor Plans: Indicate final outlet locations and routings of raceway connections.

Device Address List: Coordinate with final system programming.

System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.

Monitored input/output points schedule & sequence of operation.

Details of graphics display panel

- C. Coordination Drawings: Plans, sections, and elevations drawn to scale and coordinating installation of smoke detectors in ducts and access to them. Show the following near each duct smoke provision of detector installation:
 - 1. Size and location of ducts, including lining.
 - 2. Size and location of piping.
 - 3. Size and arrangement of structural elements.
 - 4. Size and location of duct smoke detector, including air-sampling elements.
 - 5. Size and location of speakers and all audio equipment.
- D. Operating Instructions: For mounting at the FACP and main audio rack.

- E. Product Certificates: Signed by manufacturers of system components certifying that products furnished comply with requirements.
- F. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.
- G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Comply with BS 5839.
- H. Maintenance Data: For fire alarm systems to include in maintenance manuals specified in Division 1. Comply with NFPA 72 or BS 5839 and EN 54.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of the FACP manufacturer, ISO 9002 certified for both installation and maintenance of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing systems similar to those indicated for this Project and with a record of successful in-service performance. UL listing for NFPA compliant products or LPS 1014 acknowledgment by the LPCB for BS 5839 / EN 54; is a requirement.
- C. Source Limitations: Obtain fire alarm system components through one source from a single manufacturer. Equipment must either be UL listed to NFPA requirements or be certified compliant to BS 5839 / EN 54. Mixing UL listed equipment and BS / EN certified products shall not be allowed.
- D. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.
- E. Comply with NFPA 72 for installation requirements and NFPA 72 & UL or BS 5839 / EN 54 for equipment.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but not less than one unit.
 - 2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but not less than one unit.
 - 3. Optical Smoke Detectors, Heat Detectors, combined optical smoke and rate of rise detector (with or without built-in sounder) and Flame Detectors: Quantity equal to 5 percent of amount of each type installed, but not less than one unit of each type.
 - 4. Detector Bases: Quantity equal to 2 percent of amount of each type installed (including bases with built-in sounder), but not less than one unit of each type.

5. Speakers and horns: Quantity equal to 10 percent of amount of each type installed, but not less than one unit of each type.
6. Voice Evacuation Amplifiers & Fire Fighters Telephones: Quantity equal to 5 percent of amount of each type installed, but not less than one unit of each type.
7. Keys and Tools: One extra set for access to locked and tamper proofed components.

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 that do not meet requirements or that fail within the specified warranty period.
 1. Warranty Period: 5 years from date of Substantial Completion for any component of the system.

2. PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. General: The fire detection with integrated voice evacuation and emergency voice/alarm communication systems shall comprise of main fire alarm control panels, optical smoke/heat sensor, heat sensor, optical smoke/heat sensor with integral sounder units, manual call points, electronic sounders, repeat panels, interface units, fire fighters phones, amplifiers and audio control units, each with its own short circuit built-in isolators. Please refer the relevant fire detection and voice alarm drawings and schematics. The repeat panels, master panel and the graphics terminal shall be sited as shown on the drawings. All loop cabling and any other components and accessories deemed necessary for a safe, reliable and satisfactory system shall conform to the relevant and applicable requirements and recommendations of **NFPA 72**,
- B. Control of System: By the FACP.
- C. System Supervision: Automatically detect and report open circuits, shorts, and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
- D. Priority of Signals: Automatic alarm response functions resulting from an alarm signal from one zone or device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.
- E. Noninterference: A signal on one zone shall not prevent the receipt of signals from other zones.

- F. **System Reset:** All zones are manually reset-able from the FACP after initiating devices are restored to normal.
- G. **Flexibility:** The system shall be fully programmed to accommodate fire alarm and voice communication zones as indicated on the drawings and schematics. The system shall be configured to allow on site modifications with the minimum of disruption using the PC based software and built-in features to facilitate future changes or alterations to the buildings.
- H. **Transmission to Remote Alarm Receiving Stations:** Automatically route alarm, supervisory, and trouble signals to a remote alarm station by means of a digital alarm communicator transmitter.
- I. **System Alarm Capability during Circuit Fault Conditions:** System wiring and circuit arrangement prevent alarm capability reduction when an open circuit, ground or wire-to-wire short occurs, or an open circuit and a ground occur at the same time in an initiating device circuit, signal line circuit, or notification- appliance circuit.
- J. **Loss of primary power at the FACP** initiates a trouble signal at the FACP and the remote annunciators. An emergency power light is illuminated at both locations when the system is operating on the secondary power supply.
- K. **The system shall be of safe soft addressable type i.e. all the devices on the loops of the FACP shall be:**
 - 1. Allocated addresses automatically from the panel at the time of system power up on a numerically lowest unused value basis (algorithms)
 - 2. Given an address during commissioning, the value of which shall be stored in non-volatile memory, within the electronics module of the outstation. This value shall be read during loop allocation and provided it is valid shall be used to setup the outstations primary address.
 - 3. If the devices are inserted or removed all the existing devices shall keep the same address.
- L. **The panel shall allocate the address in strict sequential order when the loop is powered up to speed up commissioning and ensure that it is impossible for two devices to have the same address.**
- M. **All devices shall be assigned up to 32 character alphanumeric label. In case of fire, fault or warning, the label of device sensing threshold shall appear on visual display unit of the panel.**
- N. **Any correction in label shall be able to be carried out from the built-in keyboard of FACP.**
- O. **Fire Detection and Alarm Systems, which rely on hard addressing techniques, are not acceptable.**
- P. **Basic Alarm Performance Requirements:** Unless otherwise indicated by the project's security department or local regulations, operation of an automatic alarm operation of one detector:
 - 1. Notification-appliance operation.

2. Identification at the FACP and graphics monitor of the zone originating the alarm. With a graphical display of the zone.
3. Identification at the FACP and graphics monitor of the device originating the alarm.
4. Recording of the event in the system memory.
5. Recording of the event by the computer of the graphics monitor which shall also print the event log (provide serial or Ethernet interface with software).
6. Delayed transmission of an audible (sounders, speakers) & visual (strobes) alarm in that zone **if the alarm has not been acknowledged as cleared** at the fire alarm panel, **within a programmable time delay in accordance with local codes.**

- Q. Basic Alarm Performance Requirements: Unless otherwise indicated by the project's security department or local regulations, operation of one manual station, automatic alarm operation of two detectors, un-cleared or unacknowledged alarm of one detector, or operation of a manual agent release station initiates the following:
1. Notification-appliance operation.
 2. Identification at the FACP and graphics monitor (of the separate computer) of the zone originating the alarm with a graphical display of the zone.
 3. Identification at the FACP and graphics monitor of the device originating the alarm.
 4. Transmission of an alarm signal to the remote alarm receiving stations.
 5. Unlocking of electric door locks (if any).
 6. Release of fire and smoke doors held open by magnetic door holders.
 7. Transmission of an audible (sounders, speakers) & visual (strobes) alarm in all zones.
 8. Actuating the operating status of fans and other air-handling equipment serving the zone where the alarm was initiated (refer to emergency sequence of operation).
 9. Actuating the position of smoke dampers in air ducts of system serving the zone where the alarm was initiated (refer to emergency sequence of operation).
 10. Recording of the event in the system memory.
 11. Recording of the event by a separate computer which shall print the event log. (provide serial or Ethernet interface with software).
 12. Activate auto dialer to notify fire brigade.
- R. Alarm Silencing, System Reset and Indication: Controlled by switches in the FACP and the remote annunciator.
1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
 2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
 3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.
- S. Remote Detector Sensitivity Adjustment: Manipulation of controls at the FACP causes the selection of specific addressable smoke detectors for adjustment, display of their current status, reading and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory and are printed out by the system

printer.

- T. Removal of an alarm-initiating device or a notification appliance initiates the following:
 - 1. A "trouble" signal indication at the FACP and the annunciator for the device or zone involved.
 - 2. Recording of the event by the system printer.
 - 3. Transmission of trouble signal to remote alarm receiving stations.
- U. Printout of Events: On receipt of the signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including the same information for device, location, date, and time. Commands initiate the printout of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- V. FACP Alphanumeric Display: Plain-English-language descriptions of alarm, supervisory, and trouble events; and addresses and locations of alarm-initiating or supervisory devices originating the report. Display monitoring actions, system and component status, system commands, programming information, and data from the system's historical memory.
- W. Topology: All system components and devices shall be connected to two-wire loop circuits (as shown in the typical schematics) with each component having its own individual built-in isolator. Removal or disconnection of any component from the loop shall not affect the functioning and performance of other components and the system. Please note that group isolators which are used to isolate a section of a loop in case of fault are not acceptable.
- X. Voice Evacuation System (VE):
 - 1. There shall be a seamless software interface between the fire alarm interface between the fire detection and voice alarm system.
 - 2. The amplifier units (AUs) shall be rated and the speaker circuits shall be wired as shown in the schematics. AUs shall house the power supply, battery backup and full monitoring facilities. The amplifiers and audio units shall be modular in construction allowing for a high degree of flexibility so that the performance can be closely matched to the requirements of the NFPA standards of the Voice Alarms.
 - 3. The Audio Control Unit (ACU) shall be designed to complement the fire alarm control panel, providing manual access to the voice alarm section of the system. Controls on the ACU shall be available for up to 64 broadcast zones of the voice alarm. Standard configurations shall allow for recorded Alert and Evacuate messages as well as an emergency microphone to be operated in each area. In addition up to four other recorded messages shall be stored in the ACU.
 - 4. The site shall be provided with a dedicated voice alarm system. The amplifier units shall be networked and reported back to the central stations at the BMS Room.
 - 5. The VE system shall be properly integrated with the fire alarm system for the

whole site.

6. The integrated VE system shall cover all normally accessible areas with the exception of areas where a high level of background noise is present or areas where general public is restricted. In these areas sounders connected to the fire alarm system shall be used.
7. The amplifiers units (cabinets, enclosure...etc) shall include amplifiers for local areas. The AUs shall be capable of complete standalone operation for the areas it is assigned should the network/interface connections fail.
8. In the event of a catastrophic failure occurring on any individual component within the AUs, pre- recorded emergency alarm message shall still be available at the ACU.
9. Initiation of voice alarm shall take immediate priority and shall cancel all other PA operations..
10. The voice alarm system shall be capable of broadcasting pre-recorded emergency alarm messages and live speech in the event of fire detection system activating.
11. The systems shall be capable of broadcasting up to 4 different pre-recorded messages to different zones or group of zones simultaneously.
12. Evacuate signal relates to a general evacuation message and alert message corresponds to standby instructions.
13. In addition a FIRE DRILL and an ALL CLEAR message shall be incorporated into the operation.
14. A fire alarm broadcast signal shall cancel any public address operation and shall override it.
15. Fireman's microphones shall be fitted to the Audio Control Units. These shall allow direct voice instructions to be transmitted to a single zone, selected zones or all zones. At least two microphone units shall be provided, at the front desk and the security room.
16. When a fireman's microphone is operated, this shall override any automatic voice alarm signal being transmitted to the zone selected. The Alert and Evacuate pre-recorded messages will be maintained in other zones while live voice fire announcements are being broadcast to selected loudspeaker zones.
17. Automatic gain control shall be provided for areas likely to have high background noise levels.

Y. Fire Fighters' Telephone System

- a. The Fire Alarm / Life Safety System Shall provide a fully integrated Fire Fighters' Emergency Telephone and Communications System. A Master Telephone handset shall be provided which will provide a totally independent 2-way communication between the Fire Alarm Control Panel and any of the Fire Fighters' Telephone Stations or Portable Telephone jacks located as indicated on

the plans for the building.

- Z. The system shall include an interface to the security system which shall be coordinated with the manufacturer/supplier of that system. The aim of this integration is to unlock relevant access control doors in the areas affected by the fire event.
- AA. The system shall include an interface (or input/output points) to the BMS system which shall be coordinated with the manufacturer/supplier of that system.

2.2 MANUAL PULL STATIONS (Break glass)

- A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
 - 1. Manufactured as per BS 5839 Pt.2, Pt.3 and Pt.4. or NFPA requirements, UL listed.
 - 2. Double-action mechanism requires two actions, such as a push and a pull after breaking the glass, to initiate an alarm.
 - 3. Station Reset: Key or wrench operated; double pole, double throw; switch rated for the voltage and current at which it operates.
 - 4. Integral Addressable Module: Arranged to communicate manual-station status (normal, alarm, trouble) to the FACP.
 - 5. Built-in isolator.

2.3 COMBINED OPTICAL SMOKE AND RATE OF RISE DETECTORS (SENSORS)

- A. General: Include the following features:
 - 1. Manufactured as per BS 5445 Pt.7, Pt.5 and Pt.8, BS5839 Pt.4. or NFPA requirements, UL listed.
 - 2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 3. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
 - 4. Addressing is automatic (dip switches and similar shall not be accepted).
 - 5. Integral Visual-Indicating Light: LED type. Indicates detector has operated.
 - 6. Sensitivity: Can be tested and adjusted in-place after installation from control panel.
 - 7. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
 - 8. Remote Controllability: detectors are intelligent and interactive analog-addressable type, individually monitored at the FACP for calibration, sensitivity, analogue reading and alarm condition, and individually adjustable for sensitivity from the FACP.
 - 9. Automatic drift compensation and control.
 - 10. In base isolator.
 - 11. EMI Protection 50V/m.
 - 12. Response time less than 7 seconds.

2.4 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door plate.
 - 1. Electromagnet: Requires no more than 3 W to develop 111 N holding force.
 - 2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.
 - 3. Rating: 24-V dc.
- B. Material and Finish: Match door hardware.
- C. CENTRAL FACP
- D. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.
 - A. Identify each enclosure with an engraved, red, laminated, phenol-resin nameplate with lettering not less than 25 mm high. Identify individual components and modules within cabinets with permanent labels.
 - B. Mounting: Surface.
- E. Alarm and Supervisory Systems: Separate and independent in the FACP. Alarm-initiating zone boards consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.
- F. Control Modules: Include types and capacities required to perform all functions of fire alarm systems.
- G. Indications: Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.
- H. Indicating Lights and System Controls: Individual LED devices identify zones transmitting signals. Zone lights distinguish between alarm and trouble signals, and indicate the type of device originating the signal. Manual switches and push-to-test buttons do not require a key to operate. Controls include the following:
 - A. Alarm acknowledge switch.
 - B. Alarm silence switch.
 - C. System reset switch.
 - D. LED test switch.
- I. Resetting Controls: Prevent the resetting of alarm, supervisory, or trouble signals while the alarm or trouble condition still exists.
- J. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACP and addressable system components, including annunciation, supervision, and control.
 - A. Visual display unit capable of displaying at least 4 lines 40 characters backlit display.
 - B. Built-in 40 character thermal printer operating when the access door is open. There shall also be an option to enable the printer when the door is closed.

- C. Built-in keyboard.
- K. Simple menu driven function keys with password protection shall allow users to an extensive range of software based features such as:
 - A. Last 100 fire events.
 - B. Last 255 system events.
 - C. Current fault and warning logs.
 - D. Analysis of analogue sensor information.
 - E. Interrogation of sensor cleanliness.
 - F. Loop map connections.
 - G. Enable/ disable sensors, zones, sounders, interface unit channels.
 - H. Fire plan configuration menus.
 - I. Outstation label changes.
 - J. Address allocation.
 - K. Status of outstation.
 - L. Status of all cards.
 - M. Printer on, off, line feed and test facilities.
 - N. Address allocation including soft addressing.
- L. Graphics display capability by connection to a computer system by a serial or Ethernet connection (provide software and programming).
- M. Instructions: Printed or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.
- N. VOLTAGE AND POWER SUPPLY: Main FACP is to provide 24 V d.c. to all zone alarm initiating and alarm signaling devices and is to be designed to operate from 220/230 V A.C., 50 Hz 2-wire, earthed power supply. Power supply is to be an integral part of the main fire alarm panel, switch mode solid state design, with built in transient protection (up to 6 kV), including UL recognized EMI filter, spark gaps and varistors. Additional power supply units are to be provided for the amplifiers. The power supply is to provide diagnostic LEDs to notify operator upon AC power and/or the control unit CPU failure.
- O. Monitored output relays for emergency MDBs and panels, HVAC, lifts, fire fighting panels, BMS, secondary fire alarm panels, fire doors, motorized dampers, motorized fuel valves, fuel pumps ...etc as required by the standard (B5 5839 or NFPA requirements) and to the satisfaction of the projet's security department and local regulations. Outputs shall allow for segregated selective control per floor and/or area application.
- P. Monitored input relays from fire pumps, fire fighting panels, secondary fire alarm panels, emergency MDBs and panels, synchronizing panel, smoke pressurization & extraction fans, fire dampers, BMS etc.
- Q. Interface to voice evacuation system. Hardwired schemes shall not be accepted, only a communication bus providing full integration of the voice system providing multiple addressing zones and staged evacuation shall be accepted. The operation of the alarm

sounders and the voice evacuation speakers shall be coordinated such that voice messages are not blurred by alarm tones emanating from sounders.

- R. RS 232/ RS 485 computer communication.
- S. Inputs to BMS (which are monitored by the fire alarm also) shall include but not limited to:
 - 1. Failure or disconnection of power supply.
 - 2. Failure of protective device.
 - 3. Valve tamper at fire pumps (refer to IN/OUT points schedule of fire alarm system).
 - 4. Flow switches at fire pumps (refer to IN/OUT points schedule of fire alarm system).
 - 5. Fire pumps power loss or phase reversal.
 - 6. Emergency Generator start failure.
 - 7. Emergency Generator low fuel.
 - 8. Emergency Generator low oil pressure.
 - 9. Each stairwell pressurization fan that is running (refer to IN/OUT points schedule of fire alarm system).
 - 10. Each smoke removal fan that is running or high speed (refer to IN/OUT points schedule of fire alarm system).
- T. In addition to the above, all other necessary controls, elements and accessories shall be included to provide a complete and efficient panel conforming to the requirements of BS 5839: part 4: 1988 and EN 54 or NFPA standards.

2.5 EMERGENCY POWER SUPPLY

- A. General: Components include stand-by sealed lead-acid battery, charger, and an automatic transfer switch.
 - 1. Battery Nominal Life Expectancy: 10 years, minimum.
- B. Battery Capacity: 24 hours: including supply of sounders, electronic bells, warning signs, strobe lights, control signals, full alarm load for 30 minutes.
 - 1. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails.
- C. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.
- D. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.6 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module listed for use in providing a multiplex system address for listed fire and sprinkler alarm-initiating devices with normally open contacts.
- B. Integral Relay: Capable of providing a direct signal to the elevator controller to initiate elevator recall or to a circuit-breaker shunt trip for power shutdown.
- C. The terminal shall assign a number of different graphic pages to each fire event – from a site overview of building layout, through a floor layout, breaking the site down into increasing levels of detail. Number of graphic pages required shall be finally determined by the client/consultant. For tender assume 10 pages per floor, based on the drawings produced on AutoCAD by the Contractor.
- D. The system shall operate on the Windows environment. The platform specification required is a desktop PC (COMPAQ, DELL, IBM or HEWLET PACKARD) compatible with the following minimum specifications:
 - 1. Pentium IV processor with hyper threading (HT) technology, 3.8 GHz speed, 2MB L2 cache.
 - 2. 1GB RAM.
 - 3. 120 GB hard disk (SATA).
 - 4. Display Adapter, 2048x1536 at 75 Hz maximum resolution, dedicated 128 MB video memory.
 - 5. 19-inch TFT-LCD monitor delivering a 600:1 contrast ratio, 0.294mm pixel pitch, 1280 x 1024 maximum resolution, scanning frequency of 30-81 kHz horizontal and 56-75 Hz vertical, and horizontal/vertical viewing angle of 160°/150°.
 - 6. Two serial ports, two parallel ports and six USB 2.0 ports.
 - 7. 1.44 MB floppy disk drive.
 - 8. DVD+/-R/W (5x) dual layer drive.
 - 9. Modem: autodial, internal, minimum 56 K Band.
 - 10. Operating System: Microsoft Windows XP professional SP2 or later edition.
 - 11. Fast Ethernet network interface card.
 - 12. Microsoft optical mouse with rotating wheel.
 - 13. Microsoft Keyboard.

N.B: The mentioned above computer systems hardware specifications are adequate for 8 months. The contractor shall submit equivalent time-upgraded specifications at the fire alarm system commissioning time.

- 14. Ink Jet Printer: (Hewlett Packard, Canon or equivalent): A3, 1200 DPI, color, 8 ppm in black & white and 4 ppm in color minimum. It shall include two automatic sheet feeders for A4 & A3 paper sizes. The combined text and graphics package shall be provided on the same supervisor.

2.7 AUDIO CONTROL UNIT (ACU)

- A. The Audio Control Unit (ACU) shall be a mains and battery backed unit and shall be installed next to (or into) the Fire Alarm Control Panel (please refer the schematic for the locations). These units shall be connected to the loops of the FACPs and the voice system audio loop. These units shall initiate the broadcast of live speech in the designated public areas using manual controls. The use of these units shall be primarily for broadcast of fire messages and other optional auxiliary messages which are site and application specific.
- B. The Audio Control Units shall be to BS5839 Part 1 and BS7443 or NFPA standards & UL listed.
- C. There shall be an audible indication by an integral buzzer to announce a local ACU fault.
- D. The user controls on the unit shall be key switch enabled to allow authorized use of system controls.
- E. The Audio loop shall connect the ACUs to all the amplifiers units (DAs) as shown on the schematics. The audio loop shall carry the messages and data from the master ACU to the distributed amplifier units in the system. The messages it carries shall be from the microphone or from the auxiliary message stores.
- F. The integral microphone with Press to talk button shall be located behind the enable controls door. It shall be possible to loop connect 10 external all call microphones for fire announcements.
- G. The ACUs shall be capable of storing 4 auxiliary messages (as mentioned below) that can be initiated at the ACU for broadcast on the secure fire alarm network with each message of 45 second duration.

2.8 DISTRIBUTED AMPLIFIERS UNITS (DA)

- A. The Distributed Amplifier unit shall be mains powered and battery backed unit and shall be normally installed near its loudspeaker circuit area. They shall amplify audio signal for broadcast to its zones of loudspeakers. The audio signal shall be either live or pre-recorded messages. The live speech shall be from the microphone and the prerecorded messages from the digital stores, which shall be local on the Alert and Evacuate Store Modules in the DA.
- B. Each DA zone shall consist of up to 8 loudspeaker circuits with each channel powered from separate amplifier module, to secure the broadcast of messages.
- C. The amplification of audio shall be by means of amplifier modules installed in the DAs. There shall be a number of modules available with various power ratings to meet the loudspeaker requirements. Their frequency bandwidth shall be in the range of 150Hz to 20Khz.
- D. The DA shall meet the requirements of BS5839 Part 1, 4 and 8 or relevant NFPA standards and be UL listed. Each of the DAs shall be given a label by the Fire Alarm

Control Panel to identify its location in the system. The label shall be automatically displayed along with the DA events.

- E. The DA shall facilitate optional local live speech. The global speech shall be broadcasted from the ACU microphones via the Audio loop to all the DA and its loudspeaker circuits in the system.
- F. The DA shall be IP 40 rated.
- G. The DAs shall be connected to the Audio System Rack to allow broadcast of the background music as a low priority task. This shall be done via the background music card installed in the DAs which shall have as many inputs & outputs (for background music) as the number of zones served by the DA.

2.9 SPEAKERS

A. Ceiling Mounted Speakers:

- 1. The speakers shall be either suitable for flush mounting to a false ceiling of any configuration or for surface mounting if there is no false ceiling. It shall be equipped with a multiple tapping matching transformer to provide easy control of speaker sound volume. Supporting brackets to mount the speaker onto false ceilings of different configurations shall be provided. The speaker shall not have any screw fixing arrangement on its grill.
- 2. The loudspeaker shall be a 12cm dynamic cone type, rated 6 Watts @ 100V line and 3 Watts @ 70V line.
- 3. It shall have the following transformer taps: 1,7k (6W) / 3,3k (3W) / 6,7k (1,5W) / 13k (0,8W) for 100V line.
- 4. The loudspeaker shall meet the following criteria:
 - Frequency response: 100 Hz - 16 kHz.
 - Sound Pressure Levels: 90dB (1W/1m), 98dB @ rated input.
 - Dispersion Angle: 150° Conical.
 - The loudspeaker should be designed for simple installation like using the spring catch method.
 - The body shall be of aluminum together with grill.
 - The speakers shall be complete with fire dome and thermal fusible link.

B. Cabinet Loudspeakers:

- 1. The speakers shall be either suitable for areas where there is a risk of tampering or vandalism. The speakers shall have a steel case suitable for wall flush mounting in dedicated metallic epoxy coated back box. It shall be equipped with a multiple tapping matching transformer to provide easy control of speaker sound volume.
- 2. The loudspeaker shall be a dynamic cone type, rated 4 Watts @ 100V line.
- 3. It shall have the following transformer taps: 4W / 2W / 1W / 0,5W for 100V line.
- 4. The loudspeaker shall meet the following criteria:
 - Frequency response: 120 Hz - 10 kHz.
 - Sound Pressure Level: 87dB (1W/1m), Q factor: 0.224.
 - Dispersion Angle: 120° conical.
 - The body shall be of epoxy coated mild steel.

C. **Re-entrant Speakers:**

1. The horn speaker shall be designed for outdoor-use and provide background music or paging announcements for high quality sound.
2. The horn shall employ a constant directivity horns (110° conical) for control sound directivity.
3. It shall be also designed to stand up to weather conditions when installed outdoors using epoxy coated aluminum enclosure.
4. The speakers shall comply with IP65 standard for dust proof and waterproof capabilities.
5. Stainless-steel brackets and screws shall be provided.
6. Speaker impedance shall be easily changed externally with a rotary switch.
7. The horn speakers shall meet the following criteria:
 - 15 Watts rated @ 100 V line.
 - Transformer taps: 15W / 10W / 7.5W / 5W / 2.5W for 100V line.
 - Sound Pressure levels: 103dB (1W/1 m).
 - Frequency response: 275 – 14 kHz.

2.10 WIRES AND CABLES FOR SOUNDERS, SPEAKERS, BELLS, and CONTROL SIGNALS (including detectors and addressable devices)

- A. Certified to have passed IEC 331 and 332 flame resistance and fire retardant tests or BS 7629: 1993 and BS 6387 or NEC 760 and UL 2464. The wiring is to be true class “A”. Conductors are to be copper of minimum size 1.5 mm² and/or larger such that voltage drop at full load is below 5%. The wiring is to be true class “A”.

2.11 CONDUITS AND RACEWAYS

- A. Flame retardant rigid PVC heavy gauge concrete embedded or steel conduits for surface mounted for Pirelli FP100. MICC or FP200 GOLD cables do not need PVC conduits. However, all connection blocks shall be fire resistant similar to “WAGO” pressure terminals or special MICC connectors, installed in metallic red painted boxes.

3. EXECUTION

1.1. EQUIPMENT INSTALLATION

- A. Connect the FACP with a disconnect switch with lockable handle or cover.
- B. Manual Pull Stations: Mount semi flush in recessed back boxes.
- C. Ceiling-Mounted Smoke Detectors: Not less than 10 cm and not more than 5 meters from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 10 meters apart in any direction.
- D. Wall-Mounted Smoke Detectors: At least 10 cm, but not more than 30 cm, below the ceiling.
- E. Smoke Detectors near Air Registers: Install no closer than 150 cm.

- F. Audible Alarm-Indicating Devices: Install not less than 25 cm below the ceiling (or false ceiling). Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.
- G. Visible Warning signs: Install above exit doors at least 15 cm above top of door frame.
- H. FACP: Surface mount with tops of cabinets not more than 1830 mm above the finished floor.

1.2. WIRING INSTALLATION

- A. Wiring Method: Install wiring in rigid PVC heavy gauge conduits except for fire resistant cables when unconcealed. Conceal raceway except in unfinished spaces and as indicated.
- B. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by the manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- C. Cable Taps: Use numbered terminal strips in junction, pull and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- D. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- E. Risers: Install vertical cable risers to serve the fire alarm system (sounders bells and control devices) as indicated on riser diagram.

1.3. IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Basic Electrical Materials and Methods."
- B. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."
- C. Install instructions frame in a location visible from the FACP.
- D. Paint power-supply disconnect switch red and label "FIRE ALARM."

1.4. GROUNDING

- A. Ground cable shields and equipment according to system manufacturer's written instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.

1.5. FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field- assembled components and connections and to supervise pre-testing, testing, and adjustment of the system. Report results in writing.
- B. Pre-testing: After installation, align, adjust, and balance the system and perform complete pre-testing. Determine, through pre-testing, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. Report of Pre-testing: After pre-testing is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.
- D. Final Test Notice: Provide a minimum of 10 days' notice in writing when the system is ready for final acceptance testing.
- E. Minimum System Tests: Test the system according to procedures outlined in BS 5839. Minimum required tests are as follows:
 - 1. Verify the absence of unwanted voltages between circuit conductors and ground.
 - 2. Test all conductors for short circuits using an insulation-testing device.
 - 3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawings.
 - 4. Verify that the control units are in the normal condition as detailed in the manufacturer's operation and maintenance manual.
 - 5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
 - 6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.

7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, graphics (on separate computer), signal tones, and annunciator indications.
8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.
- F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.
- H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

1.6. CLEANING AND ADJUSTING

- A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

1.7. DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 12 hours' training.
 2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
 3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

1.8. ON-SITE ASSISTANCE

- A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

SECTION 10

TESTS & CERTIFICATES

1.1 GENERAL

After completion of the Electrical Work, the complete systems shall be tested thoroughly before commissioning. Any modifications or repairs necessary on completion of the tests shall be done at the Contractor's expense.

The tests outlined herein shall be in addition to, and not substitution for, the tests of the individual items at the manufacturer's plant. Insulation and grounding resistance test shall be made before operating tests. Proper rotation shall be determined before permanent connections are made.

The Contractor shall provide all testing equipment on Site.

The Contractor shall make the necessary openings in the circuits, for the testing instruments and shall place and connect all instruments, equipment, and devices necessary for the tests. Upon completion of the tests, these shall be removed and all circuits connected to their permanent condition.

The tests shall be conducted in the presence of the Engineer and local power authorities representative. The Engineer shall be notified seven calendar days or more in advance when any test is to take place, and it shall not be started without his permission.

Certificates when so required shall be submitted for any equipment installed under this contract originating by an authorized inspecting body in the country of the manufacturer.

Unless otherwise specified, the Contractor shall supply the electric current necessary for the tests.

The Contractor shall state and guarantee the particulars as specified in his tender documents. The Engineer shall not depart from, such guarantees without written permission. If such guarantees are not respected, the Engineer has the right to reject the faulty equipment.

The Contractor shall submit four copies of all test results.

Test shall include the following:

- Insulation megger tests on wires.
- Continuity and resistance tests.
- Receptacles proper wiring tests.
- Operational tests on all electrical equipment.

1.2 INSULATION MEGGER TESTS

Tests for insulation level shall be a 500-volt Megger. A minimum of one megohm (1,000,000 ohms) applying to the complete installation shall be obtained. This means that when all the phase wires at the panelboard are connected together and to the testing instrument, all switches closed, all appliances inserted in the circuit, all neutral wires left in the air, and the other end of the Megger is connected to the grounding, then there shall be a minimum of 1 megohm between the whole of the installation taken together and the grounding.

1.3 CONTINUITY & RESISTANCE TESTS

A continuity test to ensure that all connections have been made properly shall be made. This can be done by the use of a bell set. Test shall also include ensuring all switches and other interrupting devices breaking the phase wire and not the neutral wire.

Test shall include, in addition to checking continuity of current carrying wires and cables, continuity of grounding conductors. This shall be done through a Megger which shall produce an alternating current of a magnitude equal to one and a half times the rating of the circuit under test with a maximum of 25 amps.

1.4 SOCKET OUTLETS (RECEPTACLES) PROPER WIRING TEST

All socket outlets (receptacles) shall be connected properly such that looking at the face of the receptacles; the live connection shall be on the right, the neutral on the left and the grounding at the top.

1.5 OPERATIONAL TESTS

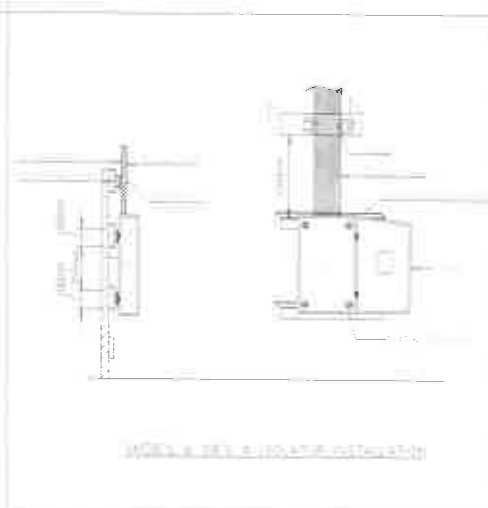
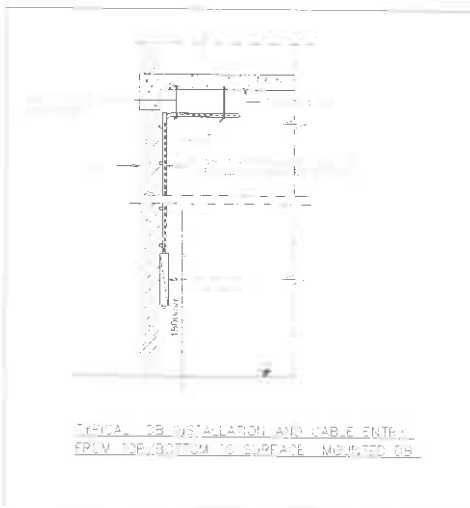
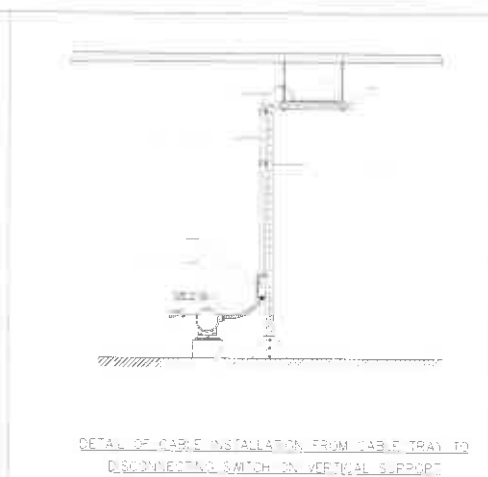
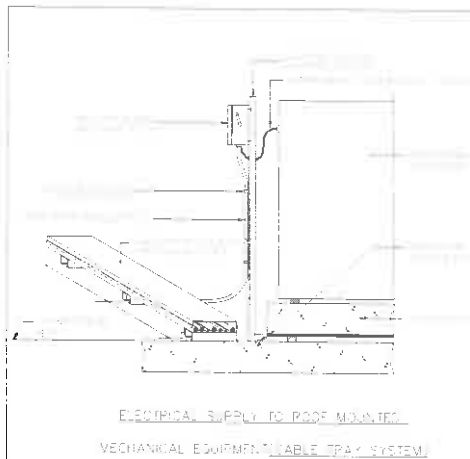
The Contractor shall demonstrate the proper operation of circuit breakers, switches and any other equipment as requested by the Engineer, or as specified elsewhere in these Specifications.

Each motor and associated equipment shall be run as nearly as possible under normal operating conditions for as long a time as is necessary to demonstrate correct alignment, wiring capacity, speed, and satisfactory operation. The motor shall be loaded to full capacity, or as near there to as possible.

1.6 INSULATION RESISTANCE TESTS OF MOTORS

All motors shall be tested for insulation in accordance with the requirement of IEC Standard Two copies of the test data shall be submitted.

CDR- ROOF PLANT HEAT EXTRACTION
ELECTRICAL DRAWINGS



DETAILED DESIGN			
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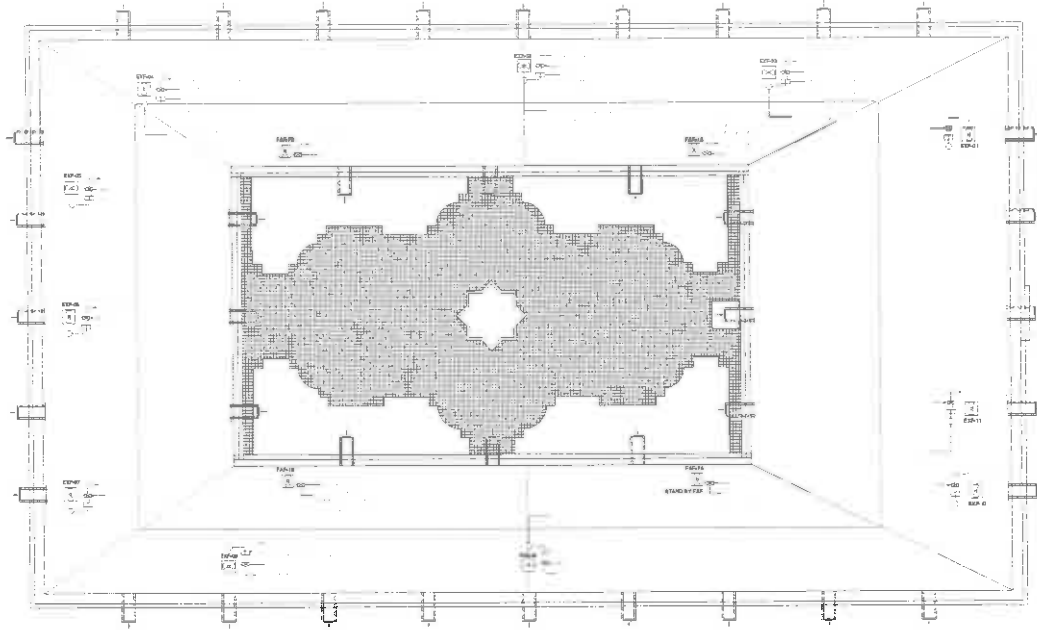
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NOTES:

- Each Exhaust Fan shall be controlled by a local digital temperature controller. The fan shall start when the sensed temperature exceeds the adjustable high setpoint and stop when the temperature falls below the adjustable low setpoint.
- Fans shall be supplied from the existing feeder, where available and suitable. Otherwise, a new feeder shall be installed from the corresponding existing fan distribution panel. The contractor shall verify the feeder arrangement, cable routing, fan locations, as-built conditions, and site conditions prior to installation.



CDR- ROOF PLANT HEAT EXTRACTION
MECHANICAL DRAWINGS

List of Drawings		
Sheet Number	Sheet Name	Scale
M-V-000	Mechanical List of Drawings	NTS
M-V-001	Typical Details	NTS
M-V-101	Roof Floor Ventilation System Layout	1:500

DETAILED DESIGN

Notes

1. All dimensions are in millimeters (mm) unless otherwise specified.
2. All dimensions are to the centerline of the pipe or duct unless otherwise specified.
3. All dimensions are to the finished surface of the material unless otherwise specified.
4. All dimensions are to the centerline of the pipe or duct unless otherwise specified.
5. All dimensions are to the finished surface of the material unless otherwise specified.
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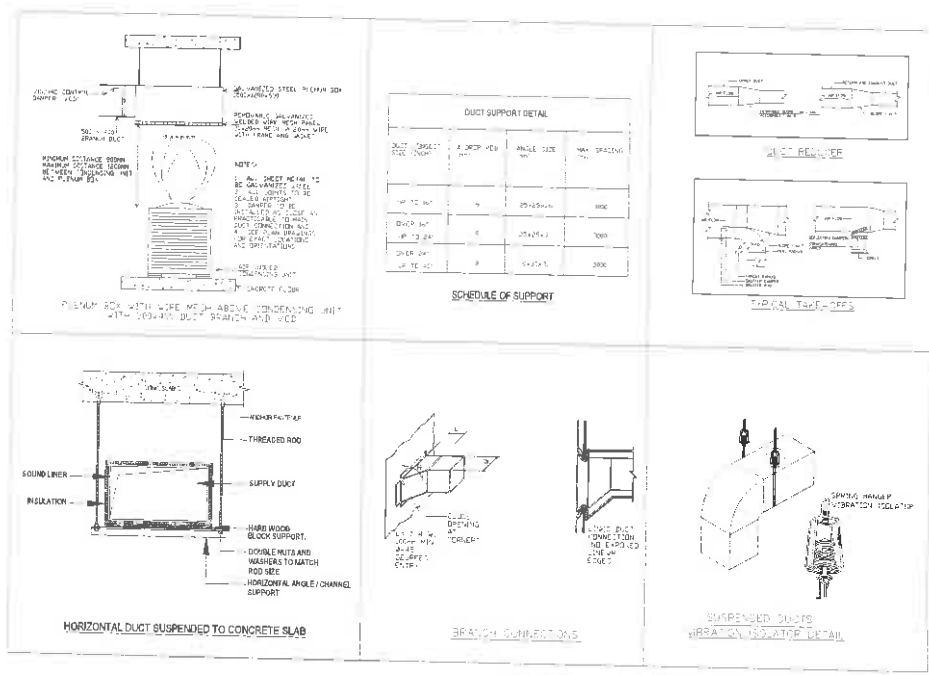
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REVISIONS

NO.	DESCRIPTION	DATE
1	Issue for construction	10/10/2011

APPROVED

 PROJECT MANAGER

PROJECT INFORMATION

Project Name: _____
 Client: _____
 Location: _____
 Date: 10/10/2011

DETAILED DESIGN

1. A_0 is a $n \times n$ matrix and $\mathbf{u}$ is a $n \times 1$ vector.
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