المؤسسة العامة القطرية للكهرباء والماء
Qatar General Electricity & Water Corporation

CONTRACT No GTC 626/2014A

CONSTRUCTION OF MEGA RESERVOIR PRPSs
(PACKAGE A - UMM BIRKA)

CONTRACT DOCUMENTS
(VOLUME 5 OF 19)

CONSOLIDATED CONTRACTORS GROUP S.A.L. (OFFSHORE) (CCC) &
TEYSEER CONTRACTING COMPANY W.L.L.
JOINT VENTURE

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Packaged side stream bag filter complete with skid mounted assembly and pump set with factory wired PLC controller.

- Construction
  1. Carbon Steel; epoxy coated interior and exterior
  2. Lid: quick opening, swing bolt design
  3. Pressure Gauge and Differential Pressure Taps on vessel inlet and outlet
  4. Vent on vessel lid
  5. Drain on vessel bottom
- Efficiency

  Filter to effectively capture contaminants to 40 micron
- Controls
  1. All filtration operations shall be controlled by the dedicated unit controller supplied as part of the side stream disk filter system, factory wired, tested and commissioned.
  2. The controller is to be integrated into the building BMS such that the current set point is adjustable from the building head end and all system faults and statuses are available via the BMS
  3. Bad change requirement to be based on differential pressure sensors and annunciated at the BMS head end
  4. Manual over ride of backflushing to be provided

EXECUTION

1.18 Selection

- All water ancillaries are to be selected by the contractor with duties calculated based on project shop drawings. The selections given in the design drawings give indicative selections only

1.19 INSTALLATION

- Install specialties in strict accordance with manufacturer's instructions.

7.3.22 23 2123 - Hydronic Pumps

GENERAL

1.1 SUMMARY

- This Section includes the following:
  1. Horizontal Split Case Double Suction Pumps
  2. Long Coupled End Suction Pumps
- Related Sections
  1. 23 0513 - Common Motor Requirements for HVAC Equipment
  2. 23 0800 - Commissioning of HVAC
  3. 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment

1.2 References

- BS 21 Specification for pipe threads for tubes and fittings where pressure – tight joints are made on the threads (metric dimensions)

- BS EN 1092 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated.
- BS 3790 Specification for endless wedge belt drives and endless V-belt drives
- BS 4814 Specification for expansion vessels using internal diaphragm, sealed hot water systems
- ISO 5199 Technical specifications for centrifugal pumps
- EN 733 standards for centrifugal pump dimensioning
- IEC 60034 – standards for AC motors
- BS EN ISO 5198 Centrifugal, mixed flow and axial pumps. Code for hydraulic performance tests. Precision class.
- BS 5257 Specification for horizontal end-suction centrifugal pumps (16 bar)
- PD 5304 Safe use of machinery
- BS 7074 Application, selection and installation of expansion vessels and ancillary equipment for sealed water systems. Code of practice for domestic heating and hot water supply.
- BS EN ISO 9906 Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1 and 2.
- BS EN 60335-2-51 Specification for safety of household and similar electrical appliances. Particular requirements. Stationary circulation pumps for heating and service water installations.
- BS EN 10226 Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation
- BS EN 1151-1&2-2006: Pumps, Totodynamic pumps, circulation pumps not exceeding 200W for heating installations and hot water domestic water installations.
- BS 4082-1&2: Specification for external dimensions for vertical in-line centrifugal pumps.
- BS 5257: Specification for horizontal end-suction centrifugal pumps (16 bar).

1.3 GENERAL REQUIREMENTS

- The installer shall recalculate the total system resistance based upon the final plant selection and installed drawings and revise the pump duty as necessary to achieve the design flow rate.
- The installer shall similarly reselect the necessary electrical requirements or any other variation in associated equipment caused by a change in system pressure drop.
- Pumps shall be specifically manufactured for intended classes of service, with non-overloading characteristics throughout the operating curve (motors shall be adequately sized for the entire performance of the curve). Impeller shall be statically and dynamically balanced. Impeller size shall be sized to suite the next motor size, thus allowing an impeller change without the need to change the pump or motor

- All pumps shall have the motor, motor frame, impeller casing and drives of sufficient size to allow the capability of a 10% minimum increase in head generated at the stated flow rate by increasing the impeller size only.
- Pumps shall be 'type' tested in accordance with BS EN ISO 5198 and BS EN ISO 9906.
- Pumps shall be selected to ensure that they are not operating at the extremes of their range by basing the selection on a mid range impeller. Where pumps are operated under variable speed control then they shall be selected to the right hand side of the best efficiency point (BEP). A constant speed pump shall be selected within +/-20% of the BEP. For constant flow pumps the contractor shall allow for trimming of the impellor at commissioning.
- Minimum pumping efficiency shall be 70% at the stated duty unless stated otherwise.
- Pumps on closed circuit systems shall be selected with a maximum operating speed of 1450 rpm unless otherwise stated or agreed with the Engineer.

1.4 Submittals

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:
  1. Full Resistance Calculations for each hydraulic system
  2. Certified pump curves showing performance characteristics with pump and system operating point plotted including NPSH. Pump test data shall comply with BS EN ISO 9906 and BS EN ISO 5198. Data shall be related to pump speed to allow the effect of speed changes to be assessed.
  3. Electrical Characteristics and connection requirements
  4. Manufacturer model number
  5. Materials
  6. Testing certificates
  7. Detailed assembly drawings
  8. Dimensions
  9. Weights
  10. Required clearances
  11. Method of field assembly
  12. Components
  13. Wiring Diagrams (Power, Signal & Control)
- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

GENERAL REQUIREMENTS

1.5 Centrifugal Pumps

- Pumps shall be provided with cast iron casings unless otherwise stated.
- Shafts shall be stainless steel and impellers shall be manufactured as specified below. Shafts shall be corrosion resistant.
- Shaft seals shall be the drip-less mechanical type suitable for the operating conditions.
- Direct drive pumps and their drive motors shall be mounted on a common bed-plate.

- Unit-constructed close-coupled pumps shall be of the back pull-out type, enabling the motor, drive and impeller to be withdrawn from service without disturbing the volute casing, casing, connections etc.
- Close-coupled pumps shall be arranged such that the failure of a pump seal shall not result in damage to the drive motor.
- Belt driven pumps shall be of the overhead compact type, comprising vertical split case design pump pedestal, driven, via 'vee' belts, by a motor mounted vertically above the pump.
- Belt driven pumps shall incorporate an isolation pad within the motor mounting arrangement to minimize the transmission of vibration to the pump casing.
- Pumps shall be suitable for mounting on a prepared base, being either concrete or inertia type where indicated.
- All pumps shall be suitable for the service pumped and the operating temperatures and pressures stated elsewhere.
- Pumps shall be capable of providing the duties required at the design operating conditions.
- Connecting pipework shall be arranged to ensure that no stresses are transmitted to the pump casings.
- Unless otherwise stated pumps shall have a maximum sound pressure level of 75 dBA at a distance of 1 metre

1.6 In Line Centrifugal Pumps

- Pump construction

1. Pumps shall be top pull out design suitable for vertical mounting.
2. Pump body shall be of Cast iron as per EN-GJL-250 standards to suite maximum working pressure.
3. Impeller shall be Bronze as per EN-JL1030 standards, enclosed type, dynamically balanced, keyed to shaft and secured by a locking nut.
4. Mechanically seal pump liquid cavity at motor shaft with Silicon Carbide seal seat and Carbon seal ring suitable for continuous operation at 140 Deg.C.
5. Pumps should have a solid Stainless Steel shaft compliant to EN 1.4057, 1.4305 or 1.4436 depending on the size of the pump and working pressure.
6. The coupling shall be motor-pump shaft with sleeve type of stainless steel construction and should offer stable and quite operation.
7. Provide casing drains and vents ports.
8. Prior to shipment the complete pump with it's respective driver (Motor) shall be factory tested at the operating conditions required, thoroughly cleaned and painted with an epoxy based coating made in a cathodic electro deposition (CED) process which has been approved by the Water Regulations Advisory Scheme (WRAS) to BS 6920 standards.
9. Motor: The motor shall be sized to operate continuously without exceeding the horsepower rating regardless of the flow and head throughout the entire range of operation. The motors shall be 4-pole TEFC operating at a speed of 1450RPM. Windings shall have Class 'F' insulation and shall be mounted on a common base plate and be connected to its motor via a shrouded flexible coupling.

    a. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

b. When used in a variable speed pumping system the motor shall be suitable for use with the selected VSD or VFD etc.

10. Efficiency: Minimum 85%

1.7 Horizontal split case centrifugal double suction pumps

- Pump Construction:

1. Casing: Ductile iron casing as per ASTM A 536 standards or Cast iron casing as per EN-GJL-250 standards to suite maximum working pressure, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection. Drain port connection, flanged suction and discharge ports, supported on base frame.
2. Impeller: Double suction type high-grade gun metal (Bronze) to BS1400 Grade LG2-C; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Stainless steel to BS970 Grade 431S29
4. Mechanical Seal: The seals shall be flexible bellows type having a carbon face running against a stationary ceramic seat. The liquid cavity shall be sealed off at the pump shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring
5. Pump Bearings: Permanently lubricated ball bearings with 0.05mm limit of deflection
6. Base Coupling and Guards: The pumps shall be mounted on a heavy-duty mild steel channel and directly connected though a heavy-duty flexible coupling to a horizontal motor. The base shall be provided with a drip rim. The pump manufacturer shall provide coupling guard, which shall be mounted between the pump and motor and attached firmly to the base. The pump and motor assembled set shall be supplied factory mounted on heavy-duty mild steel channel frame. The pump set assembly shall be fully treated and painted with anti-corrosive epoxy paint system prior to dispatch from the factory
7. Prior to shipment the complete pump with it's respective driver (Motor) shall be factory tested at the operating conditions required, thoroughly cleaned and painted with an epoxy based coating made in a cathodic electro deposition (CED) process which has been approved by the Water Regulations Advisory Scheme (WRAS) to BS 6920 standards.
8. Motor: The motor shall be sized to operate continuously without exceeding the horsepower rating regardless of the flow and head throughout the entire range of operation. The motors shall be 4-pole TEFC operating at a speed of 1450RPM. Windings shall have Class 'F' insulation and shall be mounted on a common base plate and be connected to its motor via a shrouded flexible coupling.

   c. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   d. When used in a variable speed pumping system the motor shall be suitable for use with the selected VSD or VFD etc.

9. Efficiency: Minimum 85%

1.8 Base Mounted Pumps Pumps

- Pump Construction:

1. Casing: End suction type back pull out design, horizontal shaft, single stage, flexible or close coupled as indicated for maximum working pressure. Cast iron casing as per EN-GJL-250 standards to suite maximum working pressure, with suction and discharge gauge ports, renewable bronze casing wearing rings, drain plug, flanged suction and discharge ports, supported on base frame.

2. Impeller: Double suction type high-grade gun metal (Bronze) to BS1400 Grade LG2-C; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Stainless steel to BS970 Grade 431S29
4. Mechanical Seal: The seals shall be flexible bellows type having a carbon face running against a stationary ceramic seat. The liquid cavity shall be sealed off at the pump shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring
5. Pump Bearings: Permanently lubricated ball bearings with 0.05mm limit of deflection
6. Base Coupling and Guards: The pumps shall be mounted on a heavy-duty mild steel channel and directly connected though a heavy-duty flexible coupling to a horizontal motor. The base shall be provided with a drip rim. The pump manufacturer shall provide coupling guard, which shall be mounted between the pump and motor and attached firmly to the base. The pump and motor assembled set shall be supplied factory mounted on heavy-duty mild steel channel frame. The pump set assembly shall be fully treated and painted with anti-corrosive epoxy paint system prior to dispatch from the factory
7. Prior to shipment the complete pump with it's respective driver (Motor) shall be factory tested at the operating conditions required, thoroughly cleaned and painted with an epoxy based coating made in a cathodic electro deposition (CED) process which has been approved by the Water Regulations Advisory Scheme (WRAS) to BS 6920 standards.
8. Motor: The motor shall be sized to operate continuously without exceeding the horsepower rating regardless of the flow and head throughout the entire range of operation. The motors shall be 4-pole TEFC operating at a speed of 1450RPM. Windings shall have Class 'F' insulation and shall be mounted on a common base plate and be connected to its motor via a shrouded flexible coupling. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   e. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   f. When used in a variable speed pumping system the motor shall be suitable for use with the selected VSD or VFD etc.
9. Efficiency: Minimum 85%

1.9 PUMP SPECIALTY FITTINGS

- Suction Diffuser: Angle pattern, 2060kPa pressure rating, ductile-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.
- Triple-Duty Valve: Angle or straight pattern, 2060-kPa pressure rating, ductile-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

EXECUTION

1.10 PUMP INSTALLATION

- Prior to shipment the complete pump with its respective driver (Motor) shall be factory tested at the operating conditions required, thoroughly cleaned and painted with an epoxy based coating made in a cathodic electro deposition (CED) process which has been approved by the Water Regulations Advisory Scheme (WRAS) to BS 6920 standards

- Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- Pumps shall be provided with anti-vibration mountings and flexible connections. The installer shall ensure that the complete unit is effectively balanced to eliminate noise and vibration.
- Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
    1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 19 to 38mm between pump base and foundation for grouting.
    2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- Where stand-by pumps are installed, one pair of gauges shall be so connected with isolating cocks that the pressure head of each pump can be read.

1.11 ALIGNMENT

- Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
- Comply with pump and coupling manufacturers' written instructions.
- Before attempting to start the pumps the contractor shall ensure the manufacturer has checked the alignment of the pumps and their motors and other drivers shall be carefully checked. Alignment shall be checked for both offset and angularity. Alignment shall be by means of an Ames dial or laser equivalent
- After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

1.12 CONNECTIONS

- Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- Each pump shall be fitted with an isolating valve on the inlet and outlet connections. Valves and strainers shall be pipeline size, not connection size and shall be in accordance with the relevant sections of this specification.
- Non-return check valves, selected to have low resistance flow, shall be incorporated in each discharge line.
- Each pump shall be provided with two pressure gauges, one connected to the suction side and one to the discharge side.
- Pumps shall be complete with a drain plug and, except where the pump is inherently self-venting, a manual air vent.
- Pump connections shall be provided with flanges or unions, as appropriate, to permit the pipework to be removed for casing and impeller inspection and cleaning without draining the system or major dismantling of pipework.
- Pump connections shall be screwed to BS 21 and BS EN 10226 for sizes up to 50 mm diameter and flanged to BS EN 1092 to suit the system maximum pressure on sizes 65 mm and above.
- Bedplates, incorporating drain pans shall have a piped drain arranged to discharge over a protected tundish.
- Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

7.3.23 23 2300 - Refrigerant Piping

GENERAL

1.1 SUMMARY

- This Section includes refrigerant piping used for air-conditioning refrigerant applications.
- related sections
  1. 23 8126 - Split System Cooling
  2. 23 6200 - Packaged Compressor and Condenser Unit

1.2 References

- BS EN 12735-1 Copper and copper alloys. Seamless, round copper tubes for air conditioning and refrigeration. Tubes for piping systems
- BS EN 378 Specification for refrigerating systems and heat pumps. Safety and environmental requirements.
- BS EN 14324 - Brazing. Guidance on the application of brazed joints
- BS EN 1254 - Copper and copper alloys. Plumbing fittings. Fittings with ends for capillary soldering or capillary brazing to copper tubes

- ASTM B88 and ANSI/NSF 61: Streamline Copper Water Tube (Types K.L.M).
- ASTM B280: Streamline Copper Refrigeration Service Coils.
- ASTM B280: Streamline Nitrogenized ACR Hard Drawn Copper Tube.
- ASTM B306: Streamline Copper Drainage Tube (DWV).

1.3 General requirements

- n/a

1.4 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:
  1. Product Data: For each type of valve and refrigerant piping specialty indicated.
  2. Include pressure drop, based on manufacturer's test data, for thermostatic expansion valves, solenoid valves, and pressure-regulating valves.
  3. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and equipment.
  4. Refrigerant piping indicated is schematic only. Size piping and design the actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes, to ensure proper operation and compliance with warranties of connected equipment.
  5. Welding Certificates: Copies of certificates for welding procedures and personnel.
  6. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
  7. Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.
- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

1.5 DELIVERY, STORAGE, AND HANDLING

- Deliver and store piping and specialties in shipping containers with labeling in place.
- Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

1.6 MAINTENANCE PRODUCTS

- See Section 01 - Product Requirements, for additional provisions.
- Provide two refrigeration oil test kits each containing everything required to conduct one test.
- Provide two filter-dryer cartridges of each type.

PRODUCTS

1.7 COPPER TUBE AND FITTINGS

- Copper tubes for refrigerant pipework shall comply with BS EN 12735-1 and shall be suitable for the refrigerant and oil used.
- Where the refrigerant pressure is above the limits for copper pipe then heavy grade mild steel tube shall be used instead.

1.8 Components

- Expansion Valves

  1. Expansion valves shall be thermostatic and be situated as near as possible to the liquid distributor on the evaporator.
  2. The following components shall be fitted upstream in the liquid line shut-off valve, capped refrigerant charging valve, a refrigerant drier, refrigerant strainer, a liquid sight glass and moisture indicator and solenoid valve.
  3. Expansion valves shall be selected for external equaliser operation. Connections shall be compatible to standard refrigeration fittings.

- Liquid Line Solenoid Valve

  Solenoid valves shall be direct acting or pilot operated type and shall be suitable for the refrigerant medium being used.

- Liquid Line Drier

  In systems over 35 kW, refrigeration replaceable core type driers shall be used, mounted horizontally or vertically with the flange at the bottom to prevent foreign matter entering the system during core changes.

- Liquid/Moisture Indicators

  1. Sight glasses shall be liquid line size. In very large liquid lines the glass may be installed in a bypass arrangement.
  2. Sight glasses shall be installed in the main liquid line or liquid feeds to the evaporator, and in the condenser or receiver outlet. Sufficient distance downstream of any valve shall be provided to avoid turbulence in the liquid line being detected.

- Liquid Suction Heat Interchangers

  These shall be installed in the refrigeration circuit where it is considered necessary to sub-cool the liquid refrigerant to prevent flash gas occurring at the expansion valve.

- Oil Separators

  These shall be installed where it is necessary to prevent substantial absorption of refrigerant in the crankcase oil during shut down periods or where, because of multi-coil installation, it is difficult to ensure return of the oil to the compressor crankcase.

- Hand Valves

  Shut-off valves shall be incorporated in the refrigeration circuits where required for serviceability. They shall be suitable for solder type connection compatible with refrigerant fittings.

- Vibration Eliminators

Vibration eliminators shall be incorporated in the lines as determined by system requirements. Vibration eliminators shall be installed to allow for horizontal and vertical movement and must not be subjected to longitudinal forces. They shall be manufactured in copper, bronze or stainless steel with connections suitable for standard refrigeration fittings.

- Fittings

  Fittings and joints shall be kept to the absolute minimum with pulled bends being used wherever possible.

EXECUTION

1.9 PIPING INSTALLATION

- Pipework shall be dry, completely free from scale and internally degreased prior to installation
- All refrigerant pipework and ancillaries to be installed in strict accordance to the manufacturers recommendations
- Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- Refrigeration pipework joints shall be brazed or silver soldered. Joints shall be kept to the absolute minimum. Formed bends shall be used in preference to fittings.
- Brazing shall be carried out in accordance with BS EN 14324 by operatives having approved qualifications in accordance with the necessary standards.
- Dry nitrogen shall be passed continuously through the pipework at minimal pressure and at an adequate velocity during brazing or soldering to eliminate internal oxidation. All excess solder and flux shall be removed on completion of joints.
- Fittings shall be integral ring solder type complying with BS EN 1254 -1.
- Connections shall be provided in the high and low pressure sides of each system to facilitate evacuating and charging.
- Piping and other components which have been prepared and are not to be used immediately shall be capped and sealed. During installation no component or length of tubing shall be left un-blanked longer than necessary for installation.
- Suction lines shall be sized to provide a minimum practical pressure drop commensurate with sufficient velocity for oil entrainment.
- The suction lines shall be designed to slope back to the compressor to avoid oil logging around the system.
- Where the vertical rise exceeds 3 metres, an oil trap shall be formed in the suction line at the base of the riser and at 3 metre intervals throughout the length of the riser, or at such intervals as are recommended by the refrigerant equipment manufacturer.

- Where compressors unload, provisions shall be made where necessary to ensure adequate oil return at all stages of unloading without causing an excessive pressure drop.
- Include expansion joints if required to accommodate expansion and contraction. Cold bridging is to be prevented.

1.10 HANGERS AND SUPPORTS

- Piping hangers and supports must accommodate expansion and contraction, vibration, dead load of piping and its contents, and seismic-bracing requirements.
- Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- Install the following pipe attachments:
  1. Adjustable steel clevis hangers for individual horizontal runs less than 6m long.
  2. Roller hangers and spring hangers for individual horizontal runs 6m or longer.
  3. Pipe Roller: multiple horizontal piping 6m or longer, supported on a trapeze.
  4. Spring hangers to support vertical runs.
  5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
  1. Verify actual supported loads for hanger sizes and spacing and issue to structural engineer for approval.
  2. DN 15: Maximum span, 1500mm; minimum rod size, 6.4mm.
  3. DN 18: Maximum span, 1500 mm; minimum rod size, 6.4mm.
  4. DN 25: Maximum span, 1800mm; minimum rod size, 6.4mm.
  5. DN 32: Maximum span, 2400mm; minimum rod size, 9.5mm.
  6. DN 40: Maximum span, 2400mm; minimum rod size, 9.5mm.
  7. DN 50: Maximum span, 2400mm; minimum rod size, 9.5 mm.
  8. DN 65: Maximum span, 2700mm; minimum rod size, 9.5mm.
  9. DN 80: Maximum span, 3m; minimum rod size, 9.5mm.
  10. DN 100: Maximum span, 3.7m; minimum rod size, 13mm.
- Support multi-floor vertical runs at least at each floor.

1.11 SYSTEM CHARGING

- Charge system using the following procedures:
  1. Install core in filter dryers after leak test but before evacuation.
  2. Evacuate entire refrigerant system with a vacuum pump to 67Pa. If vacuum holds for 12 hours, system is ready for charging.
  3. Break vacuum with refrigerant gas, allowing pressure to build up to 14kPa.
  4. Charge system with a new filter-dryer core in charging line.

7.3.24 23 2500 - HVAC Water Treatment

GENERAL

1.1 Summary

- Section Includes:
  1. Cleaning of piping systems.

2. Chemical feeder equipment.
3. Chemical treatment.
4. Water Treatment

- Related Sections:

1. Section 23 2113 - Hydronic Piping.
2. Section 23 2114 - Hydronic Specialties.
3. Section 23 0913 - Instrumentation and Control Devices for HVAC.

1.2 References

- BS 6700 Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages
- BSRIA AG 2/93 Water treatment for building services systems
- BSRIA AG 1/2001.1 Pre-commission cleaning of pipework systems (2nd edition)

1.3 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

5. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
6. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.
7. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.
8. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
9. Certificate: Submit certificate of compliance from authority having jurisdiction indicating approval of chemicals and their proposed disposal.
10. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.
11. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.
12. Provide on site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

1.4 General Requirements

- This section covers the water treatment of heating, chilled water, hot and cold water pipework systems.
- Use a water treatment specialist, as agreed with the Engineer, for the analysis, design, supply, installation and operation of any system cleaning and chemical treatment process.
- Ensure the water treatment and pipe cleaning processes comply with statutory authority, COSHH Regulations and health and safety requirements.

1.5 MAINTENANCE MATERIALS

- Supply sufficient chemicals for treatment and testing during five years warranty period.

PRODUCTS

1.6 Chemicals

- Cleaning Chemicals: Chem 2005 Alkaline based cleaning chemical or equal approved
- Passivator / Iron Stabilizer & Sequesting agent: Chem PC 10 or equal approved
- Corrosion Inhibitors: Chem 2903 Proprietary Molybdate based corrosion inhibitors consists of an aqueous solution of Molybdate, a pH buffer, possibly a dispersing agent, and an azole. Or equal approved.
- Microbiocide: Chem 651 is isothiazolone based and Chem 608 is Glutaraldehyde based wide spectrum board range Non – Oxidising biocide suitable for close loop system or equal approved

1.7 Manual Dosing System

- A manual chemical feeder dosing pot of 68 litre minimum capacity dosing pot shall be installed as shown on drawings.
- The Feeder shall be of mild steel welded construction suitable for 16 bar maximum working pressure. It shall be supplied complete with filling valve and tundish to facilitate charging, and all control valves. A non-return valve shall be fitted between the tundish and top filling valve to prevent possible blow-back during filling. The capacity of the feeder shall be a minimum of 68 litres.

1.8 Automatic Dosing System for Chilled Water Systems

- Fully Automatic dosing systems for corrosion / scale inhibitor & biocide dosing shall be provided for chilled water closed system as follows.
- Positive Displacement Diaphragm pumps: Duplex (duty/standby), self priming, rated for intended chemical with 25 % percent safety factory for design pressure and temperature.
  1. Adjustable flow rate
  2. Thermoplastic construction
  3. Fully enclosed, continuous duty, 230 V, 50 Hz single phase motor
  4. Built – in relief valve.
- Chemical solution Tanks: Chemical – resistant reservoirs fabricated from high density opaque polyethylene with graduated markings.
- Moulded fibreglass cover with recess for mounting pump, agitator and liquid –level switch

  Capacity – 230 litres

1.9 Agitator

- Direct drive, 1360 rpm, mounted on tank with angle adjustment. Fully enclosed, continuous duty. Stainless steel clamp and motor mount, with stainless-steel shaft and propeller.
- SOLUTION METERING PUMP
- Positive displacement, diaphragm pump with adjustable flow rate, thermoplastic construction, continuous-duty fully enclosed electric motor and drive, and built-in relief valve.

1.10 LIQUID LEVEL SWITCH

- Polypropylene housing with integrally mounted PVC air trap, receptacles for connection to metering pump, and low level alarm.

1.11 CONDUCTIVITY CONTROLLER

- Packaged monitor controller with solid state circuiting, five percent accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control function light, output to control circuit and recorder.

1.12 WATER METER

- Displacement type cold water meter with sealed, tamper-proof magnetic drive, impulse contact register, single pole, double throw dry contact switch.

1.13 SOLENOID VALVES

- Forged brass body globe pattern, normally open or closed as required, explosion- proof and watertight solenoid enclosure, and continuous duty coil.

1.14 TIMERS

- Electronic timers, infinitely adjustable over full range, 150 second and five minute range, mounted together in cabinet with hands-off-automatic switches and status lights.

1.15 TEST EQUIPMENT

- Manufacturers:
- Provide white enamel test cabinet with local and fluorescent light, capable of accommodating 4 - 10 ml zeroing titrating burettes and associated reagents.
- Provide the following test kits:

1. Alkalinity titration test kit.
2. Chloride titration test kit.
3. Sulphite titration test kit.
4. Total hardness titration test kit.
5. Low phosphate test kit.
6. Conductivity bridge, range 0 - 10,000 micro-ohms.
7. Creosol red pH slide complete with reagent.
8. Portable electronic conductivity meter.
9. High nitrite test kit.

1.16 CHLORINATION EQUIPMENT

- Final disinfection shall be effected by chlorination of the filtered water. Chlorination shall be provided by a modular sodium hypochlorite injection unit. The chlorine solution shall be produced using granular sodium hypochlorite batched in a mixing tank. Dosing shall be carried out by pumping from the dosing tank into the filter outlet pressure line prior to discharge into clear water tank.
- The chlorination system shall be design to provide a residual free chlorine level of 0.2-0.3 mg/L at all times. mg/l is expected to be required with a maximum rate of 1.0 mg/l. The dosing rates of the pumps as well as the dosing tank size are given on the Contract Drawings.
- In case the proposed residual concentration of free chlorine is not high enough to prevent re-growth of bacteria in the most distant parts of the distribution system, the proposed equipment shall be able to increase it up to approximately 1 mg/l without causing any taste or health problems for the consumers located close to the clear water tank.
- Chlorination units shall be sized for an average chlorine dosage rate of 0.5 mg/l and maximum dosage rate of 1.0 mg/l.

- The right residual chlorine concentration after disinfection at the Water Treatment Plant Chlorine dosing unit shall be set and later evaluated by increasing the concentration step-wise and checking the last service point within the distribution network for residual chlorine. If trace amounts of free chlorine are detectable in the most distant supply point, safe operation of the whole distribution network is ensured.
- The modular sodium hypochloride injection dosing equipment is to be installed as a complete unit consisting of the following components:
  1. Dosing pumps (1 duty + 1 stand-by).
  2. Dosing Controller
  3. Dosing tank
  4. Electrical agitator
  5. Suction line with foot valve, filter, PVC tube etc
  6. Level switch controller for dry run protection with cable for empty signal Pulsation damper
  7. Pressure retention valve
  8. Injection unit
  9. Accessories (overflow, drain, inlet valves, pipework etc)

EXECUTION

1.17 General requirements

- Pre-commission cleaning of heating and cooling pipework systems shall be carried out in accordance with BSRIA Application Guide AG 1/2001.1 Pre-commission cleaning of pipework systems.
- The recommendations of BSRIA Application Guide AG 2/93 shall be consulted in the selection of chemicals for corrosion control.
- The installer shall before commencement of the works:
  1. Provide a detailed method statement within the operating and maintenance manual for the chemical cleaning and ongoing water quality treatment for the water systems provided under the contract. The method statement shall include the maximum agreed Pseudomonas (cfu/l) and TVC (cfu/l) levels. These levels shall be agreed with the CA prior to addition of any water filling of the systems
  2. Prepare drawings that show the detailed provisions for incorporating the cleaning facilities. The drawings should show the details of all temporary facilities required
  3. Determine the potential for partial or phased cleaning of a system and locate suitable isolating valves to prevent cross contamination
  4. Provide details of the method by which flushing velocities are to be achieved, i.e. pumping requirements and motor power requirement for temporary pumping facilities
  5. Agree witnessing and reporting stages for confirmation that system cleaning is being conducted in accordance with the agreed procedure, and that the results are acceptable
  6. Obtain approval from the local Water Authority for the disposal of contaminated flushing water, and in particular, for the disposal of cleaning chemicals. If approval cannot be obtained make preparations for removal of the waste by other means.
  7. During the fabrication and installation of pipework systems, the installer shall comply with the recommended Codes of Practice and take sufficient care to prevent the ingress of extraneous matter.
  8. Ensure that the flushing and chemical cleaning procedures are planned so that the whole operation is carried out as a continuous process, i.e. there are no delays

during the flushing stage, or between the flushing and chemical cleaning stages. Chemical cleaning must be carried out immediately after the pre-flush.

9. Chemical cleaning shall not be undertaken unless the system has been thoroughly clean-water flushed to the satisfaction of the cleaning specialist.
10. Notify manufacturers and suppliers of equipment of proposed system cleaning and chemical treatment processes. Establish for all equipment requirements of any particular cleaning and chemical treatment process due to size of waterways or materials used.

- All chemicals for system cleaning, corrosion inhibition and bacteria control must be selected by a water treatment and chemical cleaning specialist and agreed with the CA prior to commencement of the works.
- Maintain progressive records of a staged cleaning process.
- If existing systems are modified or extended, the water quality in the existing system shall be checked by the water treatment specialist and the results submitted to the Engineer. Any necessary remedial measures, as advised by the water treatment and chemical cleaning specialist and agreed with the Engineer, shall be undertaken before connecting to new plant or equipment.
- Cleaning and treatment of existing systems (or new systems incorporating old pipework) shall be advised by the water treatment and chemical cleaning specialist and agreed with the Engineer prior to the commencement of the Works.
- If a system has been previously dosed with chemicals establish the type and for what purpose. Ensure that new chemicals are compatible and there is no interference or reaction between chemicals or system materials.
- Maintain progressive records of a staged cleaning process.
- It is the responsibility of the installer to advise the water treatment specialist of the materials used in the construction of the plant and systems.
- Comply with the Local Authority requirements in undertaking cleaning / flushing activities and disposal of used water and chemicals.

1.18 Technical Services

- Technical services and monitoring shall be an integral part of the Treatment Program. As part of the total package, the water treatment specialist employed by the contractor and shall provide on site service for the up to and for the first year following practical completion with the following.

  1. Check and inspect each plant being treated.
  2. Discuss with the operating personnel the performance of the program.
  3. Review logged and analyzed system parameters.
  4. Take samples and analyses on site.
  5. Prepare on each visit a detailed handwritten report & discuss the findings with the plant management.
  6. The frequency of service by the specialist supplier will be every 15 days.
  7. Provide the above up to provisional handover & 12 months thereafter.

- The contractor shall employ the water treatment company to provide a Specialist Field Service Engineer. The Engineer must:

  1. Supervise and report on the entire process of flushing, pre-cleaning and passivation as well as commissioning of the complete control equipment

2. Provide regular site visits (a minimum of 24 per year). A service plan must be submitted for a one year contract at time of equipment approval. The service contract upto and 12 months after preliminary handover shall form part of the specialist scope of supply. This shall start from date of condenser water / chilled water handover.
3. During site visits provide the following analyses and report in writing:
   a. pH
   b. Electrical Conductivity at 25 Deg C
   c. Corrosion Inhibitor Level
   d. Total Iron as Fe++
   e. Total suspended solids

- The water treatment specialist employed by the contractor shall provide comprehensive test kits for use by the client. The client's personnel are to be trained in their use.
- 2 times yearly test for legionella using a certified Third Party Laboratory

1.19 Pipework Inspection

- At a suitable period before any water system is finally filled and connected to a permanent water supply, the Sub-Contractor shall cut two 500mm long pipe samples from each section of each water service. The cost of obtaining these samples, testing the same and making good shall be included by the Contractor.
- The Engineer will arrange to have the pipe samples examined for signs of corrosion or deterioration at the Contractors expense. Immediately prior to commissioning, all steel pipework water services shall then be chemically cleaned by a specialist company.
- The specialist's method statement shall be agreed by the Engineer prior to the chemical cleaning work proceeding.
- The results of the internal pipe inspection shall be taken into account in the cleaning work to be undertaken. Water analysis shall be provided after flushing to show that the cleaning has been successful.
- Domestic water services may need cleaning as above dependant upon results of the pipe analysis. Costs shall be included by the Contractor

1.20 FLUSHING OUT AND CLEANING OF ALL WATER SYSTEMS

- All pre-commissioning cleaning activities are to be in accordance with BSRIA Application Guide AG1/2001
- Immediately after the satisfactory completion of the sectional first fix and the whole system final fix hydraulic pressure tests, all foreign matter shall be removed and the systems shall be flushed out.
- Water systems shall be flushed out with clean water. Steam and gas installations shall be scavenged with steam or compressed air.
- Whenever possible the flushing medium shall be fed into the system at high points and flushed out at low points on the system via suitably sized valved or plugged washout points. In general, 15mm drain valves or cocks are not considered suitable as washout points.
- The flushing and cleaning medium shall be fed into the system at the highest pressure that the system will safely withstand and be carried out for a sufficient period of time to ensure that all foreign matter is removed.

- The flushing shall be witnessed by the Engineer and the duration of the flushing of each service shall be recorded by the Contractor and certified by the Engineer
- The flushing shall be carried out by a qualified 3 rd party who will provide externally diesel driven temporary pumps for the flushing procedure.
- Provide adequate venting of lines to prevent air binding or restriction of flow in any portion of the system.
- For the flushing stage, a sump or other means shall be arranged for collection of foreign materials.
- Systems shall be circulated using temporary pumps of required duty to achieve > 3.0 m/second pipe velocity based on the largest pipe size and complete with external temporary bag filters of at least 450m3/hr to remove particles from the piping systems. As a minimum the velocities set out in BSRIA Application Guide AG1/2001. The contractor shall allow for the provision of these temporary pumps and bag filters for the duration of flushing. The contractor shall also allow for the removal from site by tanker of the contaminated flushing water including chemicals as required by the local authority.
- All plant, equipment and pumps shall be bypassed during the entire flushing operation before adding final chemical addition.
- Supervision of the entire operation will be by the water treatment specialist supplier.
- Immediately following the final flushing of each service the Contractor shall employ a specialist water treatment company to take three samples of water from each service and provide an analysis of the same to indicate whether flushing has proved successful. Samples are to be taken in positions agreed with the Engineer.
- Further flushing shall be undertaken until agreeable analyses are obtained indicating that all impurities and suspended solids have been removed.
- Any filters, meters, circulating pumps, traps, valves, controllers, non-return valves and items of equipment which may be damaged or prevent adequate flushing shall be removed during the flushing process.
- On completion of the flushing, all strainer cages shall be removed and cleaned, all dirt pockets shall be opened up and cleaned. Immediately following each flushing procedure the pipework service, including all hot and cold domestic water services, heating services and chilled water services shall be carefully and completely drained of all possible water.
- The system is then to be refilled with clean, potable water. For Chilled Water, Chem 2005 or equal approved shall be added at a rate of 1 kgs/m3 of the system volume.
- The system should be circulated for up to 48 hours and then drained with clean water.
- Samples should be taken from each loop by witnessed by the Engineer. These shall be marked with the system identifications, date and the word "Clean".
- If required the system shall then be passivated to ensure no fresh corrosion occurs on the cleaned and flushed pipework.
- Passivator Chem PC 10 (or equal approved) is added 1.0 kgs/m3 based on hold up volume in chilled water during the Initial stage and circulated for 24 hrs for preventing fresh corrosion during this period and stabilizing iron values.

- For Chilled Water, to the clean water add at the end of the cleaning process Chem 2903 (or equal approved) at the rate of 1.5 kgs/m3 of system capacity. (The contractor shall submit calculations for the system volume.)
- For Chilled Water, after circulating for 24 hrs add Chem 651 or equal approved (50 mg/l) and again circulate for 24 hrs.
- Witnessed samples shall be taken for each loop for the Engineer. These shall be marked with the system identification, date and the word "Final".
- Independent third party analysis shall be provided for Engineer's approval for the final connection.
- The final water quality parameters shall meet the following requirements:

  For Chilled Water:

  a. Total Iron as Fe++: < 1 ppm
  b. Total Dissolved Solids: < 500 ppm
  c. pH: 8.5 ~ 10.5
  d. Molybdate as MoO4: 80 ~ 100 ppm
  e. Suspended Solids: < 20 ppm
  f. Chloride as Cl-: < 100 ppm

- Installation Contractor shall provide certification showing the areas/sections treated, the levels of chorine solution used and the results of the subsequent microbiological tests.
- The method of obtaining samples, sampling points, etc., shall be recorded by the Contractor and witnessed and certified by the Engineer. The Contractor shall allow for the samples to have tests carried out by DEWA, to confirm that the water from the installation is suitable for human consumption and free from harmful bacteria/chemicals. The original copy plus two additional copies of the test reports shall be forwarded to the Engineer. The methods used to test the samples shall be in accordance with those laid down in 'Analysis of Raw, Potable and Waste. Tests shall also include a legionella test and analysis
- All costs shall be allowed as necessary and the time for the full and correct execution of these clauses shall be allowed for within the Contract Period.
- In the event of chlorination tests not receiving the approval, the Contractor shall flush out, re-chlorinate and test as previously specified and allowance shall be made in the Tender for this and any further re-tests which may be necessary.
- Immediately following sterilisation and when a permanent water supply is available to each service and drainage is available, all possible air shall be removed from the systems and the systems shall thereafter be maintained full at all times.

7.3.25 23 3113 - Metal Ducts

GENERAL

1.1 SUMMARY

- Section includes:

  1. General duct work
  2. Fire protected ductwork
  3. Kitchen ductwork

4. Rectangular ducts and fittings.
5. Circular ducts and fittings.
6. Round oval ducts and fittings
7. Flexible ductwork
8. Flexible connectors
9. Duct liner.
10. Sealants
11. Gaskets
12. Tapes

- Related Sections:

1. 23 0130 - HVAC Air Duct Cleaning
2. 23 0500 - Common Work Results for HVAC
3. 23 0713 - Ductwork Insulation
4. 23 3116 - Non Metallic Ducts
5. 23 3300 - Air Duct Accessories
6. 23 3319 - Duct Silencers
7. 23 3700 - Air Outlets and Inlets
8. 23 4000 - HVAC Air Cleaning Devices
9. 23 4100 - Particulate Air Filtration

1.2 REFERENCES

- BS EN 13180 Ventilation for buildings. Ductwork. Dimensions and mechanical requirements for flexible ducts
- CIBSE Code A Commissioning Code A – Air distribution systems
- BSRIA AG 3 / 89.3 Commissioning air systems
- HVCA DW 144 Specification for sheet metal ductwork
- HVCA DW 143 A practical guide to ductwork leakage testing
- HVCA DW 151 Specification for plastic ductwork
- HVCA DW 191 Guide to good practice: Glass fibre ductwork
- HVCA DW 171 Specification for kitchen ventilation systems
- HVCA DW/TM 3 Guide to good practice for the design for the installation of fire and smoke dampers
- HVCA TR/19 Internal cleanliness of ventilation systems
- BS CP 352 Mechanical ventilation and air conditioning in buildings
- BS 476 Fire tests on building materials and structures
- BS 5588 Fire precautions in the design, construction and use of buildings
- BS IS0 10294 Fire resistance tests. Fire dampers for air distribution systems
- EN 1366-2 Fire resistance tests on service installations in buildings
- ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials
- ASTM E 2231 Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics

- NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems; National Fire Protection Association
- NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association

1.3 General Requirements

- All fire rated duct works are to be in compliance with the Qatar Civil Defence Fire Life Safety Code of Practice. The requirements of this document supersede all over information
- The contractor is responsible for the design of the duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports in compliance with the HVCA DW series documentation and performance requirements
- The Contract shall have sufficient expertise, organisational ability, drawing office production capacity and site erection capability to deal with a development of this size within the proposed construction programme.
- Ensure that selection of the equipment which has the effect of changing ductwork connection sizes from those shown on the tender drawings, is fully conveyed to the working drawings.
- Ductwork dimensions are internal. Where applicable, make allowance for any internal lining.
- Ensure that ductwork installation complies with the requirement for thermal and acoustic insulation specification.
- Ensure that ductwork, gasket, flexible joints, acoustics linings and sealants do not support bacterial growth and do not product fire or smoke hazards.

1.4 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

  1. Product Data: Provide data for duct materials.
  2. Samples: Submit two samples of typical shop fabricated duct fittings.
  3. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate. Pressure test all supply and return ductwork as required by DW/143 as appropriate for pressure classification for the ductwork.
  4. Manufacturer's Installation Instructions: Indicate special procedures for glass fiber ducts.
  5. Manufacturer's Certificate: Certify that installation of glass fiber ductwork meet or exceed specified requirements.
  6. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.
  7. Shop Drawings:

     a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
     b. Factory- and shop-fabricated ducts and fittings.
     c. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
     d. Elevation of top of ducts.
     e. Dimensions of main duct runs from building grid lines.
     f. Fittings.

g. Reinforcement and spacing.
h. Seam and joint construction.
i. Penetrations through fire-rated and other partitions.
j. Equipment installation based on equipment being used on Project.
k. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
l. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

8. Contractor-Design Submittal:

a. Sheet metal thicknesses.
b. Joint and seam construction and sealing.
c. Reinforcement details and spacing.
d. Materials, fabrication, assembly, and spacing of hangers and supports.
e. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

9. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
b. Suspended ceiling components.
c. Structural members to which duct will be attached.
d. Size and location of initial access modules for acoustical tile.
e. Penetrations of smoke barriers and fire-rated construction.

10. Items penetrating finished ceiling including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

11. Welding certificates.

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

1.5 General DuctWork

- Zinc Coated Steel Ductwork shall be manufactured from strip mill, cold reduce sheet, continuously hot dip galvanized in accordance with BS EN 10142 Grade DX51D+Z coating type Z275. Unless specified otherwise herein.
- Mild Steel Ductwork shall be cold reduced steel to BS EN 10130 Grade FEP 01A
- Stainless steel ductwork shall meet BS EN ISO 9445 1&2 -2010: continuously cold rolled stainless steel (grade 1.4301, x5CrNil8-10).

1.6 Fire Rated Ductwork

- Minimum 2mm Galvanized sheet metal with 90mm combustion resistant mineral wool insulation material with appropriate thermal properties and with 105 kg / m3 density, selected to meet the 2 Hr at 400 deg C fire rating criteria (for DW 144 Type A & B)
- Insulation must be held in place using steel insulation pins, tack welded to the surface of the duct. Stainless steel straps (19mmx0.5mm) shall be provided at 600 mm interval. Calcium silicate board shall be used between duct and support.
- The ductwork system shall be type tested in accordance with BS 476 Part 24 and shall meet the requirements for stability, integrity and insulation applicable otherwise the air temperature applicable to the BS 476 Part 24 test shall be to the ISO 834 fire curve. The temperature at which the fan will operate will not vary the BS 476 part 24 test temperature mentioned previously.
- Ductwork shall also be required to meet the requirements of BS 5588 Part 9. External insulation where exposed to view within an area if the building shall be further protected with a sheet steel.
- Where ductwork passes between fire compartments and cannot be protected by the use of fire dampers then the ductwork shall be constructed to meet the fire resistance value of the highest value structure through which is passes. Compliances with the standards shall be applicable to ductwork system as a whole including brackets, supports, jointing and sealing with structures.
- The fire rated duct support system shall be located at a maximum of 1500mm centres, the size of the hangers and bearers upgraded to account for reduction in tensile strength of steel, due to a two hour fire from 430 Newton/mm^2 to 10 Newton/mm^2. Proof that suitable size hangers and bearers are being used shall be submitted to the Engineer for approval. All gaskets and sealants shall be non-combustible, grease resistant, 2 Hr fire rated, with maximum temperature rating up to 400 deg C and installed as fire tested.
- Alternatively a proprietary coating may be proposed by the contractor to provide the required 2 Hour Fire Rating. The entire duct system including the hangers shall be applied and certified by the coating manufacturer and also shall bear the approval of UL and the Local Civil Defence. A relaxation of the duct wall thickness may be considered, at the Engineers discretion, if the proprietary protective system will provide the required protection.
- Where the duct passes through compartment walls the space between the duct and the wall shall be reinforced and packed with proprietary fire stopping material to maintain the stability and integrity of the system for the required period.
- Fire rated ductwork to have passed impact test to BS5669 and Appendix A of BS 5588 Part 5. In addition to the above, all fire rated ductwork shall be subject to approval by the local Civil Defence Department. Upon part or complete installation of the Fire Rated Duct the local licensed supplier of the fire resistant ductwork and, if appropriate, coating shall issue a Certificate of Conformance after satisfactory installation.

1.7 RECTANGULAR DUCTS AND FITTINGS

- Fabricate ductwork in accordance with HVCA DW 144 Part 3
- Hangers and supports as per HVCA DW 144 Part 6 and section 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment of this specification

- Ductwork supports shall be arranged so that minimum stress is imposed upon the ductwork and additional supports shall be provided either side of equipment such as attenuators, coils, etc.
- Where the duct is large enough to allow human access for cleaning, the duct and its supports shall withstand the additional load and the type and access components should allow the cleaning person to enter and exit the duct in a safe manner.
- Ensure that all materials used are compatible.

1.8 Flat oval DUCTS AND FITTINGS

- Fabricate and support in accordance with HVCA DW 144 Part 5
- Hangers and supports as per HVCA DW 144 Part 6 and section 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment of this specification
- Ductwork supports shall be arranged so that minimum stress is imposed upon the ductwork and additional supports shall be provided either side of equipment such as attenuators, coils, etc.
- Where the duct is large enough to allow human access for cleaning, the duct and its supports shall withstand the additional load and the type and access components should allow the cleaning person to enter and exit the duct in a safe manner.
- Ensure that all materials used are compatible.

1.9 Circular DUCTS AND FITTINGS

- Fabricate and support in accordance with HVCA DW 144 Part 4
- Hangers and supports as per HVCA DW 144 Part 6 and section 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment of this specification
- Ductwork supports shall be arranged so that minimum stress is imposed upon the ductwork and additional supports shall be provided either side of equipment such as attenuators, coils, etc.
- Ensure that all materials used are compatible.

1.10 CIRCULAR FLEXIBLE DUCTWORK

- Flexible ductwork shall only be used where indicated on the drawings for final connections to terminal devices. flexible ductwork turning through greater than 45 degrees shall not be acceptable, and an overall length exceeding 500mm shall not be permitted. The actual extended length of flexible ductwork shall not be greater than 25% of the connection distance between components.
- Material shall be suitable for working temperatures and pressures of the systems within which is installed and shall be tear resistant. The type of flexible ductwork shall be acceptable to the building control officers. the contractor shall obtain written acceptance to the type of flexible connection proposed. Flexible ductwork shall have a fabric skin between a plastic coated galvanised wire helix.
- Flexible ductwork conveying conditioned air shall be pre-insulated, and where indicated on the scheme drawings shall incorporate south attenuation.
- Flexible ductwork shall comply with the fire test requirements of BS 476 Part 6 for a fire propagation index of performance not exceeding 12 of which not more than 6 should derive from the initial period of the test, BS 476 Part 7 Class 1 spread of flame, BS 476

Part 8 fire resistance of 15 minutes minimum. Flexible ductwork shall not pass between fire zones.

- Flexible insulation ducts shall be UL 181 listed. Exterior jacket shall be metalized polyester vapour barrier with 2 ply black polyester core with aluminum foil exterior finish. Insulation shall be fibreglass, R 4.2. Core shall be double ply polyester laminated with carbon steel wire helix.

1.11 FLEXIBLE CONNECTIONS

- Flexible connections to DW 144 Part 7 section 26
- Flexible connection shall be fitted to fan inlet and discharge connects, all connections to air plant containing vibration generating equipment and all at all points where ducts structural expansion joints. Ductwork passing across building expansion joints shall be provided with flexible connections that shall allow an axial displacement in the horizontal plane to match the building movement tolerance and an associated displacement within the vertical plane.
- Flexible connections all be fitted in such a manner to maintain acceptable alignment. Flexible connections shall have a minimum effective length of 100mm and a maximum effective length of 200mm. Flexible connections shall be considered as part of the ductwork system when considering leakage rates, or fire protection integrity and stability.
- They shall be fabricated from a material that is non-combustible, rot proof and of a quality and grade to suite the temperature, velocities and pressures involved, they shall not permit perceptible air leakage or noise breakout. Flexible connections shall not pass between fire zones. All flexible connection joints shall have fire resistance properties of a least 20 minutes integrity to BS 476: part 8 and comply with BS 476 part 7, Class 1 surface of very low flame spread or the requirements of current local Civil Defence Requirements which ever is more onerous
- Canvas or asbestos material joints shall not be used.
- Flexible connections shall be fitted free from stress and shall not be required to support and weight. The material shall be securely fixed to a frame and not secured by straps. Where connections are identified as requiring an acoustic performance in respect of sound breakout the connection material and form of fixing shall be selected by the attenuator manufacturer.
- Flexible connection shall not impair the electrical bonding of any part of the ductwork system.

1.12 DUCT LINER

- Duct Liners to be as per DW 144 Part 7 Section 29, 23 0713 - Ductwork Insulation and 23 3319 - Duct Silencers
- All internal linings to be Class 0 fire characteristics or in line with, current, local Civil Defence requirements whichever is more onerous

1.13 SEALANTs

- Sealants to be provided to satisfy the pressure class of the duct work as defined by DW 144 or appropriate standard
- An approved liquid or mastic sealant shall be used on all longitudinal and cross joints at works. 'Socket and spigot' and 'cleated' joints made on site, joints shall be applied during or after assembly of the joints to suit.

- The use of self adhesive tape as a primary sealant over both longitudinal and cross joints on air supply and air extract ductwork is not permitted.

1.14 Gaskets

- Gaskets to be provided to satisfy the pressure class of the duct work as defined by DW 144 or appropriate standard
- Gasket strips to be to the manufacturers recommendations for the proposed duct system
- All proprietary gaskets to be Class 0 fire characteristics or in line with, current, local Civil Defence requirements whichever is more onerous

1.15 Tapes

- Tapes to be provided to satisfy the pressure class of the duct work as defined by DW 144 or appropriate standard
- Tapes to be to the manufacturers recommendations for the proposed duct system
- All tapes to be Class 0 fire characteristics or in line with, current, local Civil Defence requirements whichever is more onerous

EXECUTION

1.16 DUCT INSTALLATION

- Install ducts according to relevant HVCA DW standard for the material under consideration and in strict accordance with the manufacturer's recommendations unless otherwise indicated.
- Make all lips in the direction of airflow. Hammer down all edges and slips so as to leave smooth finished surface inside the ducts.
- Install round ducts in maximum practical lengths.
- Install ducts with fewest possible joints.
- Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- All ducts shall be braced and stiffened and shall be tight so that they will not breathe, rattle, vibrate or say. Cross-break or transverse bead all rectangular ducts with heights or widths of 300mm or larger.
- Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- Install ducts with a clearance of 25mm, plus allowance for insulation thickness.
- Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 38 mm.

- Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with the requirements of this specification and DW TR19 Guide to Good Practice: Internal Cleanliness of New Ductwork Installations
- Duct sealant shall be by an approved manufacturer. Brush joints with the compound before and again after assembly. Exposed ducts shall be sealed on the inner surface only.
- Flexible ducts shall not be installed inaccessible locations, such as above gypsum board ceiling unless specific agreement from the Consultant is obtained.
- Where ductwork passes through wall or floor, other than when fire damper is required, pack around the duct using a fire resistant material to ensure a sound and air-tight joint.
- Located all sheet metal ducts where shown and sizes as shown, if changes of size or location of ducts are found necessary because of building construction, make a specific proposal for review by the Consultant prior to proceeding with the change.
- Provided access ports at convenient location in all main ducts and main branch take-offs with airtight cover and extension sleeves through insulation to allow air meter readings.
- Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- Install and seal metal and flexible ducts in accordance with relevant HVCA DW standard locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- Use crimp joints with or without bead for joining round duct sizes 200 mm and smaller with crimp in direction of air flow.
- Use double nuts and lock washers on threaded rod supports.
- Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.
- Tape joints of PVC coated metal ductwork with PVC tape.
- Connect terminal units to supply ducts directly or with one 300 mm maximum length of flexible duct. Do not use flexible duct to change direction.
- Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for clean out.
- During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring
- Connect diffusers or light troffer boots to low pressure ducts directly or with 1.5 m maximum length of flexible duct held in place with strap or clamp.
- Connect flexible ducts to metal ducts with adhesive.

- Use stainless steel for ductwork exposed to view and stainless steel or carbon steel for ducts where concealed.
- During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- At exterior wall louvers, seal duct to louver frame and install blank-out panels.

1.17 INSTALLATION OF EXPOSED DUCTWORK

- Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- Repair or replace damaged sections and finished work that does not comply with these requirements.

1.18 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 6m in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 38mm from bottom of duct.
- Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

1.19 DUCT SEALING

- Seal ducts for duct static-pressure, seal classes, and leakage classes specified in accordance with relevant HVCA DW standard for the relevant material and pressure class

1.20 HANGER AND SUPPORT INSTALLATION

- Hangers and supports to be provided in accordance with relevant HVCA DW standard for the relevant material and pressure class
- Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  1. Where practical, install concrete inserts before placing concrete.
  2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 100mm thick.
  4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 100mm thick.
  5. Do not use powder-actuated concrete fasteners for seismic restraints.
- Hangers Exposed to View: Threaded rod and angle or channel supports.

- Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 5m.
- Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1.21 CONNECTIONS

- Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- Connections to be provided in accordance with relevant HVCA DW standard for the relevant material and pressure class

1.22 Duct Cleaning

- Comply with section 23 0130 - HVAC Air Duct Cleaning of this specification and the requirements of DW TR 19 Guide to Good Practice: Internal Cleanliness of New Ductwork Installations

1.23 Air Leakage Testing

- Undertake air leakage testing as defined in section 23 0593 - Testing, Adjusting and Balancing for HVAC of this specification

1.24 START UP

- Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

7.3.26 23 3300 - Air Duct Accessories

GENERAL

1.25 SUMMARY

- Section Includes:
  1. Air turning devices/extractors.
  2. Back draft dampers.
  3. Fire Dampers
  4. Smoke Dampers
  5. Combination fire and smoke dampers.
  6. Damper Operators
  7. Duct access doors.
  8. Duct test holes.
  9. Flexible Duct connections
  10. Volume Control Dampers
- Related Sections:
  1. Section 23 3100 - HVAC Ducts and Casings.
  2. Section 23 3600 - Air Terminal Units
  3. Section 26 2726 – Wiring devices
  4. Section 23 3319 - Duct Silencers

1.26 REFERENCES

- BS 476 Fire tests on building materials and structures

- BS 5588 Fire precautions in the design, construction and use of buildings
- BS IS0 10294 Fire resistance tests. Fire dampers for air distribution systems
- EN 1366-2 Fire resistance tests on service installations in buildings
- BS EN 13180 Ventilation for buildings. Ductwork. Dimensions and mechanical requirements for flexible ducts
- BSRIA AG 3 / 89.3 Commissioning air systems
- DW 144 Specification for sheet metal ductwork
- DW 143 A practical guide to ductwork leakage testing
- DW 145 Guide to Good Practice For the Installation of Fire and Smoke Dampers
- DW 151 Specification for plastic ductwork
- DW 191 Guide to good practice: Glass fiber ductwork
- DW 171 Specification for kitchen ventilation systems
- DW/TM 3 Guide to good practice for the design for the installation of fire and smoke dampers
- TR/19 Internal cleanliness of ventilation systems
- UL 555 - Standard for Fire Dampers; Underwriters Laboratories Inc.; 2006.

1.27 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:
  1. Product Data: Provide for shop fabricated assemblies including volume control dampers.
  2. Electrical characteristics and connection requirements.
  3. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers.
  4. Manufacturer's Installation Instructions: Provide instructions for fire dampers.
- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

1.28 TURNING VANES

- Air turning to be manufactured and provided in line with DW 144 Part 3 Section 11.4
- Air turning vanes shall be provided on all supply air 90° bends, branches, etc. on ductwork above 150mm wide
- Turning vanes to be purpose made from preformed double aerofoil section 0.8 mm thickness galvanised steel blades at 44 mm pitch of a maximum length of 1250 mm between fixings or division plates on ducts wider than 1250 mm.
- Fixing shall be by means of galvanised mounting plates spot welded to the blade and secured to the ends of the blades and the ductwork walls at 150 mm centres.

1.29 Splitters

- Air splitters to be manufactured and provided in line with DW 144 Part 3 Section 11.3

- Where indicated adjustable splitters shall be provided to regulate the volume of air passing through a branch 'take off'. They shall be of similar construction to turning vanes and shall have an adjustable bracket which shall be accessible from outside the duct to enable balancing of the airflow through the branch.

1.30 Dampers

- All dampers shall be in accordance with DW 144 or DW 154 as appropriate unless stated otherwise.
- Damper casings leakage performance to be calculated as described in DW 143 A practical guide to Ductwork Leakage Testing

1.31 Volume Control Dampers

- General

  The number and location of dampers shall be in accordance with the latest editions of CIBSE Commissioning Code Series A - Air Distribution and BSRIA AG3 Commissioning air systems to facilitate balancing and regulation of the complete and/or part of the system. Volume control dampers shall be installed in all locations necessary to adequately balance the system to the Engineer's satisfaction, whether or not these are indicated on the drawings.

  a. At terminal grilles, diffusers, outlets, etc.,
  b. Within sub-branch ducts which serve 3 or more terminal units, grilles, diffusers, etc
  c. Within branch or zone ducts
  d. Within the main supply, return or extract/exhaust duct which carries the total air flow, located in the plantroom near to the fan and on the plant side of any silencer, to regulate the total air volume
  e. On fresh air inlets, exhausts and return air arrangements to regulate the volume
  f. As noted on the Air system schematic drawing

- Single Blade Damper shall only not be used without specific agreement from the Engineer. Where provided:

  1. Single pivoted blade contained within a casing or section of ductwork
  2. Blade to be adjustable through a nominal 90° angle by means of quadrant mechanism
  3. Where automatic control is specified the spindle shall be extended to enable a powered actuator to be mounted
  4. Up to 300mm maximum duct width (rectangular) single skin dampers to be provided
  5. Up to 315mm maximum duct diameter (circular) single skin dampers to be provided
  6. Above 1250mm maximum duct width and maximum duct height of 300mm (rectangular) double skin dampers to be provided

- Multi Blade Dampers

  1. Shall be multi-leaf opposed blade type with the damper blade traversing the narrower dimension of the ductwork.
  2. Where dampers are required for ductwork in excess of 1250mm the blades shall be suitably reinfore=ced or supported
  3. No individual damper blade should exceed 200mm in width

4. Casing frames shall be constructed from 1.2 mm mild steel galvanised channel outer frame and 1.0 mm galvanised steel inner frame to give a double skin construction.
5. Frames shall have all welded corner integral flanges for duct connections and the frame shall contain die cast zinc alloy gears, out of the air stream, operating the blades from either an externally mounted low torque hand wheel and spring loaded locking gear with pointer indicator, or a motor driven unit.
6. Where automatic operation is required a geared drive spindle shall be provided, in lieu of the control box and hand-wheel, to suit the motor driven link or spring assembly control unit.

- Iris Dampers

1. Shall be of the multi-plate circular shutter type dampers constructed in galvanised sheet steel with a lockable controller lever, control scale and pressure differential measuring connections located either side of the shutter blades.
2. Dampers shall be sized and selected to limit the velocity to a maximum of 5 m/s and shall have a freearea not less than 95% of the ductwork area when fully open unless stated otherwise.
3. On circular ductwork above 800 mm diameter dampers shall be of the multi-leaf opposed blade type as specified elsewhere with circular spigot flange connections to suit the size of adjoining ductwork.

- Air Tight Dampers

1. Where dampers are required for automatic control or a tight shut off is necessary then a fixed compressible neoprene or rubber gasket shall be provided along the entire length of the tips of the blades to ensure an air tight seal between blades and the frame.
2. Air tight dampers shall be provided on all fresh air inlet and exhaust dampers in addition to any other locations specified.
3. On all rooms provided with gaseous fire suppression systems automatic dampers shall be air tight

- Non return dampers

1. Shall be the 'off centre pivot' weighted multi-leaf parallel blade type damper
2. Construction to be galvanised sheet steel contained in a galvanised sheet steel frame with flanges to suit the ductwork connections
3. Neoprene strips to be provided at the ends of the blades to provide an air tight shut off against air flow in the opposing direction to the normal air flow.
4. Dampers shall have a minimum free area of 90% and a pressure drop not in excess of 30 kPa when fully open under fan pressure unless stated otherwise.

1.32 Fire dampers

- Fire dampers shall be provided in strict accordance with local Civil Defence authority requirements
- Fire Damper testing to be to BS EN 1366-2
- Installation of fire dampers to be as per DW 145
- Installation of Fire Dampers to result in no reduction of duct work free area
- Fire damper frame shall be constructed from 18 gauge galvanized steel with 'Hat Channel' shape.

- Frame shall be 140mm wide including 25mm flanges. The frame sections shall be secured together in corners with continuous seam welds. The blade shall be manufactured from 20 gauge galvanized steel.
- Fire dampers blades shall be of the quick release folding curtain type and shall provide positive closure to maintain integrity and not permit the passage of flame.
- All fire dampers shall have at least two stainless steel constant force springs. The coil of the spring shall retain on spring spot and the free end of spring shall be secured to the bottom blade.
- Fusible links shall be rated for a temperature of 74 deg. C unless otherwise specified. Fire damper with any dimension more than 900mm shall be manufactured from multiple sections. The bottom blade of the folding shutter shall be fitted with a manual release device to facilitate the opening of the damper from either side of the damper.
- Fire damper performance to be as per UAE Fire Life Safety Code of Practice
- An external visual indication of the open / closed status of the damper and the direction of air flow shall be fitted. An adequate sized facility for periodic manual release and resetting of any mechanism for test purposes shall be provided. Resetting shall be capable of being a single handed operation via local access doors.

1.33 Smoke Dampers

- Smoke dampers shall be provided in strict accordance with local Civil Defence authority requirements
- Smoke Damper performance to be as per 200 m3/(h.m2) BS EN 1366-10
- Smoke dampers shall restrict the spread of smoke and products of combustion.
- Installation of Smoke Dampers to result in no reduction of duct work free area
- Where specified a device shall be fitted to allow damper open/closed status to be monitoried by a building management system or dedicated monitoring system.
- Blade configuration to be multiple blade type with overlaping blades and suitable edge seals to maintain smoke tight seal
- Construction to be 0.5mm thick stainless steel aerodynamic interlocking blades incorporating synthetic seal, with steel blade end bearings and peripheral gasketting.
- Housed in a galvanised steel fully welded 1.2mm spigotted casing suitable for square, rectangular, circular or flat oval connections.
- Blades to be mechanically connected to an actuator (electrical or pneumatic) to maintain the blades in the normally open or closed position (as specified)
- Both the damper and actuator shall be factory assembled and tested as one assembly and shall be furnished to the job site as a complete assembly.

1.34 Combination fire Smoke Dampers

- Combination Fire & Smoke dampers shall be provided in strict accordance with local Civil Defence authority requirements
- Combination Fire & Smoke damper performance to be as per 200 m3/(h.m2) BS EN 1366-10

- Combination Fire & Smoke dampers shall restrict the spread of smoke and products of combustion.
- Installation of Combination Fire & Smoke dampers to result in no reduction of duct work free area
- Automatic smoke and fire dampers shall be of double skin spigot case having continuously welded corners and spigot connections.
- Stainless steel aerofoil blades of double skin construction, interlocking within twin trailing edges, the interlocking providing a double metal seal.
- Incorporated within the blade profile is a synthetic seal to ensure low closed blade smoke leakage at ambient temperature.
- Automatic smoke and fire dampers shall be tested to and comply with European Standard EN1366-2.
- Automatic smoke and fire dampers shall be fitted with a snaplock interface and the relevant control mode specified on the drawings
- Where specified a device shall be fitted to allow damper open/closed status to be monitoried by a building management system or dedicated monitoring system.
- The snaplock interface and control mode to provide closure with proportional torque control and give visual indication of damper status.
- Dampers will be fail-safe by means of electrical thermal release which operates at 74°C, by loss of power, to the actuator or by depression of the test switch
- Both the damper and actuator shall be factory assembled and tested as one assembly and shall be furnished to the job site as a complete assembly.

1.35 DAMPERS OPERATORS

- Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
- Provide sufficient number of operators to achieve unrestricted movement throughout damper range.
- Provide one operator for maximum 2 sq m damper section.
- Pilot Positioners: Starting point adjustable from 15 to 83 kPa and operating span adjustable from 35 to 90 kPa.
- Electric Operators:
    1. Spring return, adjustable stroke motor having oil immersed gear train, with auxiliary end switch.
    2. Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
    3. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.
    4. Provide one operator for maximum 3.34 sq m (36 sq ft) damper section.

- Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. All actuators shall be manufactured so as to function without failure in a continuous 50 deg. C ambient condition.
- Where necessary, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
- All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.
- Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.
- All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 W for DC applications. Actuators operating on 120 VAC or 230 VAC shall not required more than 11 VA.
- All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
- All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation
- Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
- Actuators shall have built-in switches to provide positional feedback to the BMS system.
- Actuators shall be Underwriters Laboratories Standard 873 listed.
- Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
- Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.
- All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 W for DC applications. Actuators operating on 120 VAC or 230 VAC shall not required more than 11 VA.
- All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
- All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation
- Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
- Actuators shall have built-in switches to provide positional feedback to the BMS system.

- Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.

1.36 DUCT ACCESS DOORS

- Fabricate in accordance with DW 144 Part 7, and as indicated.
- Access doors with sheet metal screw fasteners are not acceptable.
- Provided access panel as shown on drawings and at all fire dampers, gravity dampers, motorized dampers, coil, heaters, humidifiiers, fan bearing or simiar equipment requiring occosuiional maintenance or inspection. Panels shall be of double wall construction and shall be internally insulated on insulated ducts. Frame shall be structural angle with welded corners, gasketted to recieve the panel. Panel shall be held in place with 4 window sash locks. All access doors for fire dampers shall be labeled "Fire Damper", and the location shall be indficated as "as-built drawings. Provide hinged insulated access doors as shown on drawings.
- Access floors shall be located to provide access for inspection, adjustment, calibration and maintenance of equipment, controls and other components mounted within the duckwork system or other enclosures conveying air.
- Access door shall be at least 450 x 300mm clear opening or as large as possible where the duct side is less than 300mm. Where necessary and where the duct size is 150mm x 150mm or less access panels shall be fitted both sides of the ducts or flanged section of renoveable ductwork of a minimum length of 300mm shall be provided.
- Provided access panels where shown, required and directed and in the following locations:
  1. Bottom of all duct risers
  2. Next to outside intakes and outlets
  3. At each fire dampers
  4. Into apparatus casings to facilitate maintenance and cleaning of all components.
- Access doors shall be located as close as possible to the components to be inspected, adjusted, calibrated and maintained. They shall be fitted before and after "in-line" plants items, such as air heater batteries, air coolers, humidifiers, attenuators, filters, fans, fire dampers, control sensors, control dampers and turning vanes. Panels shall be provided to permit jointing of ductwork section in critical locations.
- Access doors shall be pirpose manufactured items being grease proof, pre-insulated and fitted with neoprene seals and quick release / cam type locks. Panels ahall be air made air tight with a continuous neoprene rubber gasket. Covered shall be attached to the frame by means of hinges or wire cable. Door frames shall be capabble of extending the access door to remain flush with the external finish of the insulation. The door frame shall fully envelope cut edges of the insulation.

1.37 DUCT TEST HOLES

- Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

1.38 FLEXIBLE DUCT CONNECTIONS

- Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- Flexible Duct Connections: Fabric crimped into metal edging strip.

1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 1.0 kg/sq. m.

   g. Net Fabric Width: Approximately 50 mm wide.

2. Metal: 75 mm wide, 0.6 mm thick galvanized steel.

- Leaded Vinyl Sheet: Minimum 14 mm thick, 4.2 kg/sq.m, 10 dB attenuation in 10 to 10,000 Hz range.

EXECUTION

1.39 PREPARATION

- Verify that electric power is available and of the correct characteristics.

1.40 Duct work INSTALLATION

- Install accessories in accordance with manufacturer's instructions and relevant HVCA DW Standard. Refer to Section 23 3100 for duct construction and pressure class.
- Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with DW 172. Provide minimum 200 x 200 mm size for hand access, 450 x 450 mm size for shoulder access, and as indicated. Provide 100 x 100 mm for balancing dampers only. Review locations prior to fabrication.
- Provide duct test holes where indicated and required for testing and balancing purposes.
- Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- Install fire dampers, smoke dampers and combination smoke and fire dampers in accordance with DW 145
- Demonstrate re-setting of fire dampers to Client's representative.
- For fans developing static pressures of 1250 Pa and over, cover flexible connections with leaded vinyl sheet, held in place with metal straps.
- Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.
- Use splitter dampers only where indicated.
- Provide balancing dampers on high velocity systems where indicated. Refer to Section 23 3600 - Air Terminal Units.
- Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
- Provide double thickness turning vanes at a; 90° bends.

1.41 DELIVERY, STORAGE, AND HANDLING

- Protect dampers from damage to operating linkages and blades.

1.42 EXTRA MATERIALS

- See Section 01 - Product Requirements, for additional provisions.
- Provide two of each size and type of fusible link.

1.43 WARRANTY

- See Section 01 - Closeout Submittals, for additional warranty requirements.
- Provide five year manufacturer warranty for air terminal units and integral controls.

7.3.27 23 3319 - Duct Silencers

GENERAL

1.1 SUMMARY

- Section Includes:
  1. Duct Silencers.
  2. Cross-Talk Silencers.
  3. Acoustic Housings.
  4. Ductwork Lagging.
  5. Acoustic Louvers.
- Related Sections:
  1. Section 07 9005 - Joint Sealers.
  2. Section 23 3100 - HVAC Ducts and Casings: Connections to silencers.
  3. Section 23 3300 - Air Duct Accessories: Flexible duct connections.

1.2 REFERENCES

- BS 476: Part 7 Fire tests on building materials and structures. Part 7 Method of test to determine the classification of the surface spread of flame of products
- BS 5422 Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within a temperature -40° C to + 700° C
- BS EN 1092 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated.
- BS EN ISO 354 Acoustics. Measurement of sound absorption in a reverberation room
- BS EN 61672 Electro-acoustics.
- BS EN ISO 11820 Acoustics. Measurements on silencers in situ
- BS EN ISO 7235 Acoustics. Laboratory measurement procedures for ducted silencers and air terminal units. Insertion loss, flow noise and total pressure loss
- DW144 HVCA Specification for sheet metal ductwork
- DW151 Specification for plastic ductwork
- BS 4142 Method for rating industrial noise affecting mixed residential and industrial areas internal

1.3 General REQUIREMENTS

- Use acoustical devices to maintain sound level of spaces at levels not to exceed those as defined in the Acousticians report
- Maintain rooms at following maximum sound levels as stated in the scope of works document
- Noise from mechanical services plant, service yards and other areas also needs to be adequately controlled to prevent the potential for complaints from residents as part of the proposed development and also in existing residential areas.
- Furthermore, it is recommended that in order to limit the potential for complaints that noise from mechanical services plant is limited to 60 dBA, Leq 5 minutes at 10m from the building's facade.

1.4 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:
  1. Product Data: Provide catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance.
  2. Shop Drawings: Indicate assembly, materials, thicknesses, dimensional data, pressure losses, acoustical performance, layout, and connection details.
  3. Samples: Submit two cross-talk silencers 24 x 24 inch (600 x 600 mm) in size.
  4. Design Data: Provide engineering calculations, referenced to specifications and AMCA 301 standards indicating that maximum room sound levels are not exceeded.
  5. Test Reports: Indicate dynamic insertion loss and noise generation values of silencers and acoustic housings meet or exceed specified sound transmission loss values.
  6. Manufacturer's Installation Instructions: Indicate installation procedures necessary to maintain integrity of sound isolation.
  7. Manufacturer's Field Reports: Indicate installation is complete and in accordance with instructions.
  8. Project Record Documents: Record actual locations of acoustic devices
- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats.

PRODUCTS

1.5 GENERAL

- Attenuators and other noise control equipment shall be installed to achieve the stated noise levels with minimum resistance to air flow.
- The installer shall be take due consideration of the planning restrictions relating to the acoustic requirements of the project and ensure compliance with the plant operating at all design configurations.
- Noise level data for all items of plant, based on octave band analysis data, shall be submitted to the Engineer prior to ordering.
- The Contractor shall undertake the final selection of sound attenuation equipment to satisfy the particular performance requirements of the specification and the spatial allowances based on final plant/equipment selection and final co-ordinated installation drawings

- The installer shall undertake the redesign of the final acoustic requirements associated with approved alternative equipment or materials which subsequently varies the Works in any way whatsoever.
- All attenuating materials shall be inherently non-combustible and limit the surface spread of flame to Class 1 when tested in accordance with BS 476: Part 7 and shall not emit toxic or hazardous fumes if ignited. Non-flammable adhesives shall not be used.
- All acoustic components shall be made from materials with zero ozone depletion potential (CFC and HCFC free). Submit to the Engineer, prior to ordering, written confirmation from the manufacturer(s) that the products to be installed are CFC and HCFC free.
- For all acoustic infill material test evidence must be available and submitted to the CA showing that the fibres from which the products are made are not classified as a possible carcinogen as detailed by European Directive 97/69/EC. Fibres shall also comply with the requirements as stated elsewhere and with HSE guidelines.
- Ensure that isolation mounts are not bridged by rigid connections such as electrical conduits or obstructions underneath the floating equipment.
- Provide acoustic seals around all pipework and ductwork penetrations through plantroom enclosures and other enclosures where acoustic separation is required and indicated.
- Attenuators shall be installed in accordance with manufacturer's recommendations.
- Attenuators shall be delivered to site and stored with ends sealed to prevent contamination or damage.
- The direction of airflow through the attenuator shall be clearly marked on the external casing.
- Attenuator ratings shall be determined in accordance with BS EN ISO 7235.
- Static pressure loss of attenuators shall not exceed those specified at the required airflow. Attenuators shall be selected such that the following pressure drops are not exceeded for the various background noise levels:
- The dynamic insertion loss of attenuators shall include the effect of any facing materials. Facing materials shall be provided for contaminated air streams such as Kitchen exhaust.
- Casings shall be manufactured from galvanised mild steel sheet of not less than 0.8mm thickness with continuously lock-formed joints and constructed to minimise air leakage. The casing construction shall be in accordance with the ductwork specification for the connecting ductwork as stated elsewhere.
- The acoustic infill material shall be inorganic mineral or glass fibre of a density sufficient to obtain the specified acoustic performance and packed to eliminate voids due to vibration and settling. The infill materials shall be non-combustible, inert, non-hygroscopic, rot and vermin proof. All internal surfaces shall be sealed against fibre release.
- The infill material shall be guaranteed against erosion and to enable airway velocities of up to 25 m/s.
- Infill materials shall be inherently non-combustible and limit the surface spread of flame to Class 1 when tested in accordance with BS 476: Part 7 and shall not emit toxic or hazardous fumes if ignited.
- Vapour barriers which are not an inherent part of the acoustic material, shall be of minimum thickness not exceeding 0.07mm and shall be installed unstressed. The material

shall be inherently non-combustible and limit the surface spread of flame to Class 1 when tested in accordance with BS 476: Part 7 and shall not emit toxic or hazardous fumes if ignited. Membranes used shall be suitably supported and fixed. Any loss of acoustic performance due to this treatment will be deemed to be accommodated in the overall performance of the noise control equipment.

- Splitters shall have aerodynamic leading and trailing fairings. Square ends will not be acceptable unless approved by the Engineer.
- Side attenuator elements shall be fitted as standard to reduce noise breakout and assist in smooth airflow.
- Splitter elements in straight rectangular attenuators shall stand vertically, and shall be a tight-fit within the casing.
- L-section and T-section splitter attenuators shall be designed for smooth air flow. Splitters in bend attenuators shall be fitted perpendicular to the plane of the bend.
- Horizontal splitter elements shall be stiffened to prevent flexing or airway restriction and provide retention of acoustic infill.
- Splitters shall preferably be in a vertical orientation and shall be a tight-fit within the casing. The configuration shall have a regular splitter/airway dimension across the full width of the unit.
- Where required intermediate stiffeners shall be fitted for rigidity.
- In plantrooms it is preferred that attenuators be located immediately before penetration of the plantroom enclosure but where this is not possible external acoustic lagging shall be installed on the ductwork between the attenuator outlet and the plantroom enclosure to prevent noise break in to the distribution ductwork.
- Attenuators located in kitchen extract systems shall have an approved protective coating to permit cleaning and grease removal.

1.6 ABSORBATIVE DUCT SILENCERS

- Aerodynamic and Acoustic Performance Verification

  1. Silencers shall maintain octave band centre frequency insertion losses under design operating conditions of not less than those specified on the applicable acoustic hardware schedules or specifications. Product manufacturers shall specify insertion losses from their selected silencers under the operational design conditions. This information shall be derived from measurements undertaken in accordance with British Standard 4718:1971 "Methods of test for silencers for air distribution systems".
  2. Silencers shall exhibit pressure losses at design flows and temperatures no greater than those specified on the applicable acoustic hardware schedules or specifications. Product manufacturer's published pressure losses shall be derived from measurements undertaken in accordance with BS 4718. Where the intended position of a silencer is known, suppliers shall confirm the likely pressure losses due to turbulence effects from adjoining duct elements.
  3. In addition to certified insertion loss data, silencer suppliers shall confirm the 125 Hz to 8 kHz octave band sound power levels generated by their proposed silencers at the quoted operating conditions.

- Construction Requirements

1. The outer casing of all duct or duct mounted silencers shall be constructed in accordance with the current relevant ductwork specifications in terms of material thicknesses and seam constructions.
2. Silencer connections shall be drilled angle flanges, unless alternative connections are specified in the schedule or by the Mechanical Services Consultant or Contractor. Flanges shall also conform to the relevant construction code or its equivalent.
3. Acoustic (splitter) elements in rectangular silencers 900 mm or more in length shall include faired leading and trailing edges (square ends will not be acceptable unless confirmed otherwise by the Acoustic Consultant). Silencers less than 900mm in length shall have a faired leading edge only, unless specified otherwise.
4. The acoustic medium within the splitters shall comprise inert, non-hygroscopic, rot and vermin proof and non-combustible mineral wool or glass fibre. The medium shall be packed to a minimum density 48kg/m3. Splitters shall incorporate a glass fibre tissue facing, which will be retained by a perforated galvanised sheet steel facing or other approved protection membrane. Splitters shall be constructed so that no egress of acoustic medium will occur into the gas stream under operational design conditions.
5. Particular requirements for special materials, paint finishes etc., if indicated on the drawings or schedules, shall be noted by the manufacturer.
6. The silencer construction shall include, as a minimum, a half-width splitter fixed to each side wall of the silencer casing. Splitters shall preferably be in a vertical orientation and the configuration shall have a regular splitter/airway dimension across the full width of the unit. It is, however, the responsibility of the supplier to ensure that the parallel splitter elements in the silencer are correctly oriented for the adjoining duct geometry, particularly where silencers are located close to bends, bifurcations, etc.
7. Horizontal splitters will normally be limited to silencers having a module width less than or equal to 900mm and should be stiffened to prevent flexing or airway restriction.
8. For circular silencers, internal acoustic elements shall comprise an acoustic medium of mineral wool or glass fibre, as specified above for rectangular silencers. The medium will be retained by perforated galvanised metal facing, or other approved infill protection membrane. Splitters shall be constructed so that no egress of acoustic medium will occur into the gas stream under operational design conditions.
9. For silencers manufactured in modules, the complete unit shall be shop assembled (unless instructed otherwise by the Mechanical Services Contractor). This specification, together with the manufacturer's confirmed guarantee and acoustic and aerodynamic performance ratings, shall apply to the unit as a fully assembled product.
10. Silencers shall be delivered to site with ends sealed to prevent contamination or damage by dust, rubble, etc. whilst on site. The direction of airflow through the silencer shall be clearly marked on the external duct casing (unless otherwise specified).
11. High temperature silencers (e.g. for diesel exhausts, boiler flues, etc.) shall have casings manufactured from suitable gauge steel. Precautions shall be

taken to cater for expansion and thermal shock. The internal elements shall be packed with an inert, non-hygroscopic, rot and vermin proof non-combustible mineral or glass fibre acoustic medium of at least 96kg/m3 density, and faced with a layer of glass fibre cloth behind a perforated metal facing. For very high temperatures, steel wool or equivalent materials may be used for the acoustic medium. Such requirements will be noted on the relevant acoustic hardware schedules as necessary.

12. The cross sectional dimensions detailed in the schedules are to be followed exactly. However, the supplier may propose alternative dimensions in line with his own standard sizes, provided the minimum acoustic and aerodynamic performance requirements are achieved and agreement is confirmed with the Mechanical Services Consultant or Contractor.
13. Melinex or other thin films between the perforated facing and the infill medium may be required for some applications. Such materials may reduce the acoustic performance of the silencer significantly, and this must be taken into account when interpreting the relevant acoustic hardware schedules. Film thicknesses of greater than 0.05mm will not be permitted, and the use of very thin films (0.008-0.010mm) is preferred.
14. Special constructions and materials may be specified where corrosive, toxic gases or similar substances are present. Such constructions will be detailed as an addendum to this specification.
15. Silencers shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

1.7 Reactive Silencers

- Aerodynamic and Acoustic Performance Verification

  1. Silencers shall provide octave band centre frequency insertion losses under design operating conditions of no less than those indicated on the applicable acoustic hardware schedules or specifications.
  2. Silencers shall have a static pressure loss, under maximum operating conditions, of no greater than those shown in the relevant schedules.

- Construction Requirements

  1. The outer cases of all silencers shall be constructed from appropriate heavy gauge steel with all seams and joints continuously welded. Elements within the silencer shall be designed and constructed to allowance for differential expansion and thermal shock.
  2. Silencers shall be delivered to site with ends sealed to prevent contamination or damage by dust, rubble, etc. whilst on site. The direction of airflow through the silencer shall be clearly marked on the external duct casing (unless otherwise specified).
  3. The reactive silencer sizes if shown in the schedules and specifications are indicative only. The supplier may modify these in line with his own standard sizes, provided the acoustic and aerodynamic requirements are achieved. It is the suppliers responsibility to ensure the Client is advised of the actual sizes being offered, where these differ from the schedules and specifications.
  4. The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

1.8 Kitchen exhaust SILENCERS

- Where in-line attenuators are used they must be constructed so that there is no grease impregnation into the acoustic media and a protective membrane, which does not reduce the acoustic performance, should be specified for this purpose.

1.9 ACOUSTIC LOUVERS

- Performance Requirements
  1. Acoustic weather louvres shall provide insertion losses under operating conditions of not less than those indicated in the relevant acoustic hardware schedules. In addition, static pressure losses, under maximum operating duties, shall not exceed those shown in the schedules.
  2. The louvre shall be designed to prevent the penetration of rain, snow, hail etc. under normally encountered meteorological conditions.
- Constructional Requirements
  1. Louvre framework shall be formed from suitable gauge galvanised mild steel or aluminium, supporting louvre blades of like material. The acoustic medium within each blade shall have a density of 60 - 100kg/m3 and comprise inert, rot and vermin proof, non-hygroscopic and incombustible mineral fibre, faced with glass fibre tissue and retained on the lower blade face by perforated, galvanised mild steel or aluminium.
  2. Louvres manufactured in sections shall be shop assembled (unless the Mechanical Services Contractor instructs to the contrary) and this specification, together with the manufacturer's own guarantee and performance ratings, shall apply to the unit as a fully assembled product.
  3. Acoustic louvres shall be supplied with integral bird screens of galvanised mild steel or aluminium mesh, fixed to the internal face. The mesh pitch shall be a maximum of 25mm.
  4. The louvres shall be supplied complete with all necessary flanges and fixings, etc., for fitting into the builderswork opening as required by the Mechanical Services Contractor.
  5. All gaps between the outside of the louvre frame and the builderswork opening or duct shall be made good and sealed to full depth with dense grout and/or non-hardening mastic sealant.
  6. The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres notsealed or otherwise stabilised to ensure that fibre migration is prevented.

1.10 DUCTWORK LAGGING

1. Where ducting is lined, the lining should have a minimum thickness of 25 mm thickness with the following absorption coefficients:

Absorption Coefficient @ Octave Band Centre Frequency (Hz)					
125	250	500	1000	2000	4000
0.05	0.15	0.1	0.45	0.6	0.5

2. The acoustic media should not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure fibre migration is prevented.

EXECUTION

1.11 INSTALLATION

- Install in accordance with manufacturer's instructions and the Acousticians typical details
- Support duct silencers independent of ducts with flexible duct connections, lagged with leaded vinyl sheet on inlet and outlet. Refer to Section 23 3100 and Section 23 3300.
- Install cross-talk silencers in wall. Seal wall penetrations; refer to Section 07 9005.
- Where indicated, lag ductwork by wrapping with insulation and covering. Apply covering to be air-tight. Do not attach covering rigidly to ductwork.
- Attach ductwork to acoustic louvers with flexible duct connections. Refer to Section 23 3300.

1.12 FIELD QUALITY CONTROL

- Provide services of an independent testing agency to take noise measurements in accordance with provisions of NEBB (STDS). Use meters meeting requirements of ANSI S1.4.
- After start-up, final corrections and balancing of systems take octave band sound measurements over full audio frequency range in areas adjacent to mechanical equipment rooms, duct and pipe shafts, and other critical locations, as directed.
- Provide one-third octave band measurements of artificial sound sources in areas indicated as having critical requirements.
- Submit complete report of test results including sound curves.
- Unless otherwise stated, sound pressure levels shall be measured in all spaces containing supply or extract terminals, all plantrooms, all rooms immediately adjacent to plantrooms and all rooms located above or below plantrooms.
- Noise readings shall be taken at the site boundaries and adjacent facades to demonstrate the acoustic performance of the systems complies with the noise levels stated elsewhere.
- Locations for noise readings shall be agreed with the Engineer prior to measurements being undertaken.
- Measuring of environmental noise shall be in accordance with BS 4142 and the local authority guidelines.
- All measurements undertaken to demonstrate compliance with the specification shall be performed using sound measuring equipment conforming to BS EN 61672 and other relevant standards. Calibration certification for all measuring equipment shall be submitted to the CA prior to measurements being undertaken.
- Duplicate records of all such shall be provided to the Engineer within 3 days of testing and copies included in the operating and maintenance documentation. All records shall be signed by a competent person and witnessed. Results shall be submitted to the Engineer for examination before any system is offered for final acceptance.

- Any witnessing or independent checking by the Engineer shall be carried out solely at the discretion of the Engineer as considered necessary.
- All necessary apparatus, measuring equipment, instruments, and meters required for acoustic testing of the Works shall be provided by the installer at no additional cost.

7.3.28 23 3413 - Axial HVAC Fans

GENERAL

1.1 SUMMARY

- Section Includes:
  1. Axial fans.
  2. Aero-foil bifurcated fans
  3. Axial smoke exhaust fans
  4. Motors and drives.
  5. Accessories.
- Related Sections:
  1. Section 22 0513 - Common Motor Requirements for Plumbing Equipment.
  2. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
  3. Section 23 3300 - Air Duct Accessories: Back-draft dampers.
  4. Section 23 0913 - Instrumentation and Control Devices for HVAC.
  5. Section 26 2726 – Wiring devices

1.2 REFERENCES

- BS 7854 - Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts.
- BS 848-1 - Fans for general purposes. Performance testing using standardized airways
- BS EN ISO 5136 (BS 848-2.5) - Acoustics. Determination of sound power radiated into a duct by fans and other air-moving devices. In-duct method.
- BS ISO 13347 – Industrial fans. Determination of fan sound power levels under standardized laboratory conditions.
- BS 14695 (BS 848-6) - Fans for general purposes. Method of measurement of fan vibration.
- BS 4999 - Specification for general requirements for rotating electrical machines.
- BS 5000 - Rotating electrical machines of particular types or for particular applications.
- BS EN 60034 - Rotating electrical machines.
- BS 3790 - Specification for endless wedge belt drives and endless V-belt drives.
- BS EN 60079 - Electrical apparatus for explosive gas atmospheres. General requirements
- BS EN 12101-3 - Smoke and heat control systems. Specification for powered smoke and heat exhaust ventilators
- PD 5304 Guidance on safe use of machinery

- SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.3 General Requirements

- All fan resistances stated have been calculated based on design drawings. The installer shall recalculate the total system resistances based on the final selection of plant and installation drawings and revise the fan resistance as necessary to achieve the design air volume flow.
- Similarly, if the fan power requirements and sound power level changes, the installer shall reselect the necessary motor size, wiring and suitable attenuation to achieve the noise levels stated elsewhere at no additional cost.
- The installer shall ensure that the fan is capable of generating sufficient pressure to meet the required volume flow in the ductwork system as installed including any effect on fan performance from suction and discharge connections.
- Fan resistances shall take account of pressure drop across filters in dirty conditions.
- Individual components shall, in addition to the requirements of this section, comply with other relevant sections of this specification.
- All fans shall be tested in accordance with BS 848 - 1 and BS ISO 13347. Fan impellers shall be statically and dynamically balanced at the works of the manufacturer and test certificates issued to the Engineer.
- Fans shall be constructed to proven design standards and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty, during starting, during stopping and during speed and duty changes. Fan casings shall be of substantial construction, adequately stiffened and braced to prevent vibration and drumming. Bolted inspection covers shall be provided to allow easy access to internal working parts. Lubrication points shall be extended to accessible positions external to the casings.
- Galvanizing of casing shall be in compliance with BS EN ISO 1461, but shall not be less than 0.61 kg/m2.

1.4 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:
  1. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
  2. Product Data: Including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
  3. Shop Drawings: Indicate assembly of axial fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
  4. Test Reports: Indicate performance data for adjustable axial fan blades for at least five blade settings, including maximum.
  5. Manufacturer's Instructions: Indicate installation instructions.

6. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

1.5 GENERAL

- Fans shall have the performance and duty as stated elsewhere.
- Fans shall be selected to deliver the required air volume flow rate and meet the noise levels indicated.
- Any allowances required to meet manufacturing tolerances shall be included.
- Manufacturing drawings shall be submitted to the Engineer of all fans for approval prior to manufacture.
- Fans shall be installed in a manner strictly in accordance with the manufacturer's recommendations.
- Manufacturer's test certificates, acoustic data and fan curves shall be submitted to the Engineer. Fan curves shall indicate performance under all likely operating conditions.
- Externally mounted fans and internal exposed surfaces on fans handling outside air shall be protected against corrosion.
- Fans and drives shall be resiliently mounted. Mountings and supports shall be arranged to prevent undue movement of fans relative to adjacent ductwork systems or building structure.
- Fans and drives shall be mounted on rigid base-frames or support structures to ensure that proper alignment is maintained.
- Belt driven fans shall be fitted with pulleys suitable for V-belts. The pulleys shall be fixed by taper lock type bushes and shall be secured to the fan and motor shaft by keys fitted into machined keyways.
- Belt-driven fans shall be capable of running continuously at 10% in excess of the selected duty speed and shall have a minimum of two belts. A set of replacement belts and pulleys shall be provided and fitted where required.
- Duplicate extract fans for toilet extract systems should have automatic change-over.
- All fans shall be capable of operating at ambient temperatures of 50 degree Celsius and the casing material shall be able to withstand sun radiation temperature up to 85 degree Celsius.
- All fans used for life safety operations or hazardous operations shall be subject to Civil Defence Department approval. Fan used in engineering smoke control application shall be capable of operation for at least 400 degree Celsius for a minimum of 2hours.
- The fan motors shall be insulated to a minimum of a Class 'B' insulation.
- Where required flexible connections shall be installed at both the inlet and outlet of each fan.

1.6 AXIAL FANS

- Product Requirements:
  1. Performance Base: Sea level conditions.
  2. Temperature Limit: Maximum 315 degrees C.
- Hub and Impeller:
  1. Airfoil Impeller Blades: Adjustable high density PVC, reinforced glass fibre, or die-cast aluminium alloy
  2. Hub: Die cast aluminum alloy or cast iron hub or with belt drive of spun, welded steel, bored and keyed to shaft; to facilitate indexing of blade angle with manual adjustment stops.
  3. Controllable Pitch Assemblies: Incorporate ball bearing counterbalanced blade and variable pitch assembly into hub with mechanical link to casing exterior mounted actuator, or pneumatic or electric actuator incorporated within hub.
  4. Cast Components: X-ray components after fabrication and statically and dynamically balance assembly before attachment to motor or shaft.
- Casing:
  1. Fabricate casing of 6 mm steel for fans 1000 mm in diameter and smaller and 10 mm steel for larger fans.
  2. Continuously weld, with inlet and outlet flange connections, and motor or shaft supports. Incorporate flow straightening guide vanes for fans specified for static pressures greater than 250 Pa.
  3. Finish with one coat enamel applied to interior and exterior.
- Bearings and Drives:
  1. Bearings: Heavy duty pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9 L-10 life at 50,000 hours.
  2. Shafts: Hot rolled steel, ground and polished, with keyway; protectively coated with lubricating oil.
  3. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 10kW and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 15kW and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
  4. Belt Guard: Fabricate to SMACNA Duct Construction Standards - Metal and Flexible; 2.6 mm thick, 19 mm diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
  5. Lubrication: Extend lubrication fittings to outside of casing.
- Accessories:
  1. Guide Vanes: Welded steel construction with airfoil vanes and casing flanges, finished to match casing.
  2. Adjustable Inlet Vanes: Steel construction with blades supported at both ends with two permanently lubricated bearings, variable mechanism out of air stream terminating in single control lever with control shaft for double width fans and locking quadrant.
  3. Inlet Bell: Bell mouth inlet fabricated of steel with flange.
  4. Outlet Cones: Fabricated of steel with flanges, outlet area/inlet area ratio of 1.5/1.0, with center pod as recommended by manufacturer.
  5. Inlet Screens: Galvanized steel welded grid to fit inlet bell.

6. Dampers: Welded steel construction, consisting of two semi-circular vanes pivoted on oil-retaining bearings in short casing section, finished with one coat enamel. Provide air stream operation closing blades by reverse air flow and gravity.
7. Access Doors: Shaped to conform to casing with quick opening latches and gaskets.
8. Blade Pitch Actuator: Factory mounted and calibrated, electric actuator requiring single phase power and accepting electric input.
9. Stall Alarm Probe: Factory installed sensing probe to detect fan operation in stall. Refer to Section 23 0913.
10. Vibration Detector: Factory installed vibration switch to stop fan with extra set of contacts. Refer to Section 23 0913.

1.7 Aerofoil Bifurcated Fans

- Fans and ancillaries shall be constructed to withstand the rated temperatures for the required duration as stated elsewhere.
- High temperature units shall be suitable for operation in air stream temperatures up to 400°C for 2 hours unless otherwise stated.
- Axial flow fans shall be long casing adjustable pitch aerofoil bladed type, which shall have non overloading characteristics.
- Casings shall be mild steel with continuously welded joints and be lined or finished as indicated.
- Casings shall be of the same thickness throughout unless otherwise indicated, and shall extend for the overall length of the impeller, hub, and motor protection tunnel where applicable, and have circular flanged ends.
- The impeller shaft shall have a seal at the tunnel wall to prevent leakage in either direction between the motor tunnel and the fan interior.
- Drive motors for axial flow fans of the bifurcated type shall be located out of the air-stream.
- All fans shall be single type and shall be completed with mounting feet, rubber type anti-vibration mountings to specification detailed elsewhere, mounting mild steel brackets and hangers.

1.8 Axial Smoke Exhaust Fans

- Smoke extract fans and dual purpose smoke extract fans shall comply with the requirements BS EN 12101-3.
- Fans and ancillaries shall be constructed to withstand the rated temperatures for the required duration as indicated. Motors and drives shall be similarly constructed or protected and ventilated to ensure that they are not subjected to fire conditions.
- Units shall be suitable for normal operation in ambient conditions up to 60°C and high temperature conditions up to 400°C for 2 hours as stated elsewhere.
- Motors shall be pre-wired with high temperature rated cable to an external terminal box through high temperature flexible conduits. All components shall be rated for the operating conditions.
- Fans shall be manufactured from galvanised steel. Run and standby fans shall incorporate inlet and outlet flanges with pre-drilled bolt holes, and an external terminal box

to IP55. The motor shall be foot mounted and protected to IP55 (shall be either 6 or 8 poles), class H insulated and shall have sealed for life bearings. Blades shall be manufactured from aluminium alloy. Day to day ambient operation up to an ambient temperature of 46 o C and fire operation at 400oC for 2 hour shall be possible.

- The secondary power supply to the duty/standby fan arrangement shall be capable of providing the power supply within 15 seconds of failure of the primary power.
- The primary and secondary power supply cables shall be fire rated MICC and shall terminate in the at the control panel. This panel shall include a changeover device to automatically effect the transition from primary to secondary power supply if the primary supply fails. Similarly changeover of fans shall be automatic upon failure of the duty fan

1.9 MOTORS AND DRIVES

- Centrifugal fans shall be belt-driven unless otherwise indicated. All other fans shall be direct coupled unless handling hazardous substances where they shall be driven as required by the application and provided with protection to the drive to ensure safe operation of the fan.
- Each motor shall comply with BS 4999, BS 5000, and BS EN 60034 and shall be of such a size and type to start and drive the equipment under normal conditions of service without overloading.
- Where mounted in external air, or highly moisture laden atmosphere, they shall be weatherproof or separately protected. Motors in hazardous atmospheres shall be flameproof, certified to BS EN 60079.
- Motors shall comply with other relevant sections of this specification.
- Nameplates shall be positioned so that they are readable from normal access positions.
- Motors arranged for automatic starting shall have a label of durable material, not less than 150mm x 100mm in size, permanently affixed in a prominent position and having, in clearly inscribed characters, the legend:

  Danger. This motor is automatically controlled and may start without warning. Isolate before inspection.

- Vee-belt drives shall comply with BS 3790. A minimum of two belts shall be provided and the drive sized so that the rated output of the motor can be transmitted with one belt removed. A complete set of spare belts shall be provided.
- All final motor selections shall be agreed with the Engineer prior to any equipment being ordered.

EXECUTION

1.10 INSTALLATION

- Install in accordance with manufacturer's instructions.
- Install with resilient mountings and with flexible electrical leads.
- Install flexible connections specified in Section 23 3300 between axial fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum 25 mm flex between ductwork and axial fan while running.
- Install fan restraining snubbers; Adjust snubbers to prevent tension in flexible connectors when fan is operating.

- Provide fixed sheaves required for final air balance.
- Provide safety screen where inlet or outlet is exposed.
- Provide back-draft dampers on discharge of exhaust fans and as indicated.
- Provide access to adjustable blade axial fan wheels for varying blade angle setting. Adjust blades for varying range of volume and pressure.
- Provide floor mounted axial fans with reinforced legs. Provide ceiling suspended units with support brackets bolted to casing flange.

1.11 QUALITY ASSURANCE

- Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.12 DELIVERY, STORAGE, AND PROTECTION

- Protect motors, shafts, and bearings from weather and construction dust.

1.13 ENVIRONMENTAL REQUIREMENTS

- Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

1.14 EXTRA MATERIALS

- See Section 01 - Product Requirements, for additional provisions.
- Supply two sets of belts for each fan.

1.15 WARRANTY

- See Section 01 - Closeout Submittals, for additional warranty requirements.
- Provide five year manufacturer warranty for air terminal units and integral controls.

7.3.29 23 3416 - Centrifugal HVAC Fans

GENERAL

1.1 SUMMARY

- Section Includes:
  1. Forward curved centrifugal fans.
  2. Airfoil centrifugal fans.
  3. Radial centrifugal fans.
  4. Tubular centrifugal fans.
  5. Inline centrifugal fans.
  6. Vent sets.
  7. Motors and drives.
  8. Fan accessories.
- Related Sections:

1. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
2. Section 23 0713 - Duct Insulation.
3. Section 23 3300 - Air Duct Accessories: Back-draft dampers.

1.2 REFERENCES

- BS 7854 - Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts.
- BS 848-1 - Fans for general purposes. Performance testing using standardized airways
- BS EN ISO 5136 (BS 848-2.5) - Acoustics. Determination of sound power radiated into a duct by fans and other air-moving devices. In-duct method.
- BS ISO 13347 - Industrial fans. Determination of fan sound power levels under standardized laboratory conditions.
- BS 14695 (BS 848-6) - Fans for general purposes. Method of measurement of fan vibration.
- BS 4999 - Specification for general requirements for rotating electrical machines.
- BS 5000 - Rotating electrical machines of particular types or for particular applications.
- BS EN 60034 - Rotating electrical machines.
- BS 3790 - Specification for endless wedge belt drives and endless V-belt drives.
- BS EN 60079 - Electrical apparatus for explosive gas atmospheres. General requirements
- BS EN 12101-3 - Smoke and heat control systems. Specification for powered smoke and heat exhaust ventilators
- PD 5304 Guidance on safe use of machinery
- SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.3 GENERAL REQUIREMENTS

- All fan resistances stated have been calculated based on a design drawings The installer shall recalculate the total system resistances based on the final selection of plant and installation drawings and revise the fan resistance as necessary to achieve the design air volume flow.
- Similarly, if the fan power requirements and sound power level changes, the installer shall reselect the necessary motor size, wiring and suitable attenuation to achieve the noise levels stated elsewhere at no additional cost.
- The installer shall ensure that the fan is capable of generating sufficient pressure to meet the required volume flow in the ductwork system as installed including any effect on fan performance from suction and discharge connections.
- Fan resistances shall take account of pressure drop across filters in dirty conditions.
- Individual components shall, in addition to the requirements of this section, comply with other relevant sections of this specification.
- All fans shall be tested in accordance with BS 848 - 1 and BS ISO 13347. Fan impellers shall be statically and dynamically balanced at the works of the manufacturer and test certificates issued to the Engineer.

- Fans shall be constructed to proven design standards and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty, during starting, during stopping and during speed and duty changes. Fan casings shall be of substantial construction, adequately stiffened and braced to prevent vibration and drumming. Bolted inspection covers shall be provided to allow easy access to internal working parts. Lubrication points shall be extended to accessible positions external to the casings.

1.4 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:
  1. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
  2. Product Data: Including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
  3. Shop Drawings: Indicate assembly of axial fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
  4. Test Reports: Indicate performance data for adjustable axial fan blades for at least five blade settings, including maximum.
  5. Manufacturer's Instructions: Indicate installation instructions.
  6. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

1.5 GENERAL

- Fans shall have the performance and duty as stated elsewhere.
- Fans shall be selected to deliver the required air volume flow rate and meet the noise levels indicated.
- Any allowances required to meet manufacturing tolerances shall be included.
- Manufacturing drawings shall be submitted to the Engineer of all fans for approval prior to manufacture.
- Fans shall be installed in a manner strictly in accordance with the manufacturer's recommendations.
- Manufacturer's test certificates, acoustic data and fan curves shall be submitted to the Engineer. Fan curves shall indicate performance under all likely operating conditions.
- Externally mounted fans and internal exposed surfaces on fans handling outside air shall be protected against corrosion.
- Fans and drives shall be resiliently mounted. Mountings and supports shall be arranged to prevent undue movement of fans relative to adjacent ductwork systems or building structure.

- Fans and drives shall be mounted on rigid base-frames or support structures to ensure that proper alignment is maintained.
- Belt driven fans shall be fitted with pulleys suitable for V-belts. The pulleys shall be fixed by taper lock type bushes and shall be secured to the fan and motor shaft by keys fitted into machined keyways.
- Belt-driven fans shall be capable of running continuously at 10% in excess of the selected duty speed and shall have a minimum of two belts. A set of replacement belts and pulleys shall be provided and fitted where required.
- Duplicate extract fans for toilet extract systems should have automatic change-over.
- All fans shall be capable of operating at ambient temperatures of 50 degree Celsius and the casing material shall be able to withstand sun radiation temperature up to 85 degree Celsius.
- All fans used for life safety operations or hazardous operations shall be subject to Civil Defence Department approval. Fan used in engineering smoke control application shall be capable of operation for at least 400 degree Celsius for a minimum of 2hours.
- The fan motors shall be insulated to a minimum of a Class 'B' insulation.
- Where required flexible connections shall be installed at both the inlet and outlet of each fan.

1.6 CENTRIFUGAL FANS

- WHEEL AND INLET
  1. Forward Curved: Black enamelled steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; steel hub swaged to back plate and keyed to shaft with set screw.
  2. Airfoil Wheel: Steel construction with smooth curved inlet flange, heavy back plate die formed hollow airfoil shaped blades continuously welded at tip flange, and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.
  3. Radial: Steel construction with inlet flange, heavy reinforced back plate, plate blades with reinforcing gussets welded or riveted to back plate and flange; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.
- HOUSING
  1. Fan casings shall be constructed from mild steel sheet, with welded or riveted joints and welded angle stiffeners, constructed to permit withdrawal of the fan impeller. Casings shall be rigid without deflection, drumming or excessive vibration.
  2. Factory finish before assembly to manufacturer's standard.
  3. For fans handling air downstream of humidifiers, provide two additional coats of paint.
  4. Provide bolted construction with horizontal flanged split housing, where indicated.
  5. Fabricate plug fans without volute housing, in lined steel cabinet.
- BEARINGS AND DRIVES
  1. Fan impeller shall be supported by an individual bearing system. Bearings shall be ball or roller type and shall be self aligning.

2. Indirectly driven fans shall be provided with pedestals incorporating two bearings. Bearings on the non-driven side of the fan shall be provided with a scroll stiffening framework supported from the fan base to maintain bearing position and alignment.
3. Shafts: Hot rolled steel, ground and polished, with keyway, protectively coated with lubricating oil, and shaft guard.
4. Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 11.2 kW and under, selected so required rpm is obtained with sheaves set at mid Fixed sheave for 15 kW and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
5. Belt Guard: Fan guards shall be purpose-made by the manufacturer or to the approval of the manufacturer and be constructed from galvanised or plastic coated steel wire. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

- ACCESSORIES

1. Fixed Inlet Vanes: Steel construction with fixed cantilevered inlet guide vanes welded to inlet bell.
2. Adjustable Inlet Vanes: Steel construction with blades supported at both ends with two permanently lubricated bearings, variable mechanism out of air stream terminating in single control lever with control shaft for double width fans and locking quadrant.
3. Discharge Dampers: Parallel blade heavy duty steel damper assembly with blades constructed of two plates formed around and welded to shaft, channel frame, sealed ball bearings, with blades linked out of air stream to single control lever.
4. Inlet/Outlet Screens: Galvanized steel welded grid.
5. Access Doors: Shaped to conform to scroll, with quick opening latches and gaskets.
6. Scroll Drain: 13 mm steel pipe coupling welded to low point of fan scroll.

1.7 WC's EXTRACT FANS

- WC's shall be ventilated using a twin centrifugal extract fan which shall be low profile acoustically treated double inlet, double width, belt driven type with backward curved aerofoil section blade efficiency of 75%.
- The WC's extract fan casing shall be manufactured in mill finish aluminium alloy and incorporate two full size access panels.
- The unit shall be situated within the roof level plantroom and shall be supplied with SELV twin fan control microsave interface panel, automatic duty sharing and automatic changeover mechanism.
- Each of the fan motors shall be of the variable speed type with a maximum motor speed of 1440rpm and each motor shall be suitable for 380volt, 3 phase, 50Hz electrical supply and shall incorporate a 3 phase isolator on the outside of the unit to feed both motors. A compatible speed controller shall be mounted on each fan for commissioning purposes.
- The unit shall be designed such that one motor is driven and the other motor is idling through its belt connection. The motor shall be sufficiently sized to cater for each additional drive losses of the idling motor.
- Reverse flow shut off dampers shall be fitted to the WC's extract fan where indicated.

- The WC extract fan(s) shall include suitable BMS connections for monitoring fault conditions.

EXECUTION

1.8 INSTALLATION

- Install in accordance with manufacturer's instructions.
- Install fans with resilient mountings and flexible electrical leads.
- Install flexible connections between fan inlet and discharge ductwork; refer to Section 23 3300. Ensure metal bands of connectors are parallel with minimum 25 mm flex between ductwork and fan while running.
- Install fan restraining snubbers; Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- Provide fixed sheaves required for final air balance.
- Provide safety screen where inlet or outlet is exposed.
- Pipe scroll drains to nearest floor drain.
- Provide back draft dampers on discharge of exhaust fans and as indicated; refer to Section 23 3300.

1.9 SCHEDULE

- Refer to drawing Schedule.

1.10 QUALITY ASSURANCE

- Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.11 DELIVERY, STORAGE, AND PROTECTION

- Protect motors, shafts, and bearings from weather and construction dust.

1.12 ENVIRONMENTAL REQUIREMENTS

- Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

1.13 EXTRA MATERIALS

- Supply two sets of belts for each fan.

1.14 WARRANTY

- See Section 01 - Closeout Submittals, for additional warranty requirements.
- Provide five year manufacturer warranty for air terminal units and integral controls.

7.3.30 23 3700 - Air Outlets and Inlets

GENERAL

1.15 SUMMARY

- Section Includes:
  1. Rectangular Ceiling Diffusers
  2. Perforated Face Ceiling Diffusers
  3. Ceiling Supply Registers/Grilles
  4. Ceiling Exhaust & Return Registers/Grilles
  5. Ceiling Slot Diffusers
  6. Wall Supply Registers/Grilles
  7. Wall Exhaust & Return Registers/Grilles
  8. Linear Wall Registers/Grilles
  9. Jet Diffuser
  10. Drum Diffuser
  11. Door Grilles
  12. louvers
  13. Sand Trap Louvers.
- Related sections
  1. 23 0130 - HVAC Air Duct Cleaning
  2. 23 0713 - Ductwork Insulation
  3. 23 0716 - HVAC Equipment Insulation
  4. 23 3113 - Metal Ducts

1.16 REFERENCES

- BS EN ISO 5135 Acoustics. Determination of sound power levels of noise from air-terminal devices, dampers and valves by measurement in a reverberation room
- BS EN 13030 Ventilation for buildings. Terminals. Performance testing of louvers subjected to simulated rain.

1.17 General Requirements

- Grilles, diffusers and louvers shall be provided to handle the required air quantities as stated elsewhere whilst meeting the specified design criteria in respect of noise and comfort.
- The acoustic performance of all diffusers, grilles and other terminal devices shall be in accordance with BS EN ISO 5135 or any other approved standard.
- Wherever indicated the room noise level rating shall not be exceeded with the system operating at its maximum duty and taking into account all accumulative effects of the diffusers, area served, and noise regenerated by regulating/balancing dampers immediately behind the diffuser or grille to provide the correct air volume flow rate
- In all instances the diffusers shall be provided supplied in any RAL colour to the Engineers specification as advised during the approvals process at no additional cost (Temperature resistant up to max. 50 °C),

1.18 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

1. Product Data: Provide data for equipment required for this project.
2. Review outlets and inlets as to size, finish, and type of mounting prior to submission.
3. Submit schedule of outlets and inlets showing type, size, location, application, and noise level
4. Samples: Submit two of each required air outlet and inlet type.

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

1.19 General Requirements

- Prior to the equipment being ordered, the installer shall verify the selection data.
- The final layout shall be subject to agreement with the Architect and Interior Designer. The installer shall allow for detailed locations being adjusted suiting final setting out of ceilings, floors and walls.
- The installer shall liaise with the manufacturer to ensure compatibility and coordination between the grille/diffuser and ceiling support system.
- The installer shall provide a method statement to the Engineer outlining the final fixing methods and details of all grilles, diffusers and louvres prior to installation.
- Diffusers shall be draught free, shall provide rapid mixing of primary and re-circulation air to ensure that the design air movement and room temperature gradient is not exceeded.
- In this respect the maximum velocity at 1.5 m height shall not exceed 0.26 m/s and the room temperature gradient shall not exceed 2 °C from floor to normal office ceiling height unless otherwise stated.
- Air diffuser pressure drops shall be selected at a minimum to ensure that the Noise Rating of the diffuser is achieved.
- Grilles, diffusers and louvres shall be provided to an approved finish and sample charts and samples shall be provided for approval.
- Duct mounted grilles and diffusers shall be fitted with volume control regulators, adjustable from the unit face unless otherwise indicated.
- Grilles and diffusers visible in rooms shall be secured by concealed fixings wherever possible.
- Mitres, end caps and corners shall be welded in such a manner as does not show on the surface. The diffuser or grille face shall have the joint filled and finished so that it does not shoe. The joint shall remain concealed after the finish has been applied at the manufacturer's works.
- Visible grilles and diffusers shall be secured by concealed fixings wherever exposed to view. Units shall be capable of being easily cleaned by having faces readily accessible or by removable centre cores as indicated.
- All grilles and diffusers shall be provided with a neoprene or other sealing strip to provide a permanent seal against the adjacent surface and as a means of absorbing variations in the surface.

1.20 RECTANGULAR CEILING DIFFUSERS

- Type: Square and rectangular, adjustable pattern, multi-louvered diffuser to discharge air in 360 degree pattern with sectorising baffles where indicated.
- Frame: Mount type to suite architectural provision. In plaster ceilings, provide plaster frame and ceiling frame.
- Fabrication: Steel with baked enamel finish; RAL color to be confirmed by the engineer
- Accessories: Radial opposed blade damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

1.21 PERFORATED FACE CEILING DIFFUSERS

- Type: Perforated face with fully adjustable pattern and removable face.
- Frame: Mount type to suite architectural provision. In plaster ceilings, provide plaster frame and ceiling frame.
- Fabrication: Steel with steel frame and baked enamel finish; RAL color to be selected
- Accessories: Radial opposed blade damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

1.22 CEILING SUPPLY REGISTERS/GRILLES

- Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, two-way deflection.
- Frame: 25 mm margin with countersunk screw mounting and gasket.
- Fabrication: Aluminum extrusions with factory enamel finish; RAL color to be selected
- Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

1.23 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- Type: To suite architectural provisions.
- Frame: 32 mm margin with countersunk screw mounting.
- Fabrication: Steel with 0.90 mm minimum frames and 0.80 mm minimum blades, steel and aluminum with 0.90 mm minimum frame, or aluminum extrusions, with factory off-white enamel finish, RAL color to be selected.
- Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

1.24 CEILING SLOT DIFFUSERS

- Type: Continuous 25 mm wide slot, 4 slots wide, with adjustable vanes for left, right, or vertical discharge; integral ceiling fire damper.
- Fabrication: Steel with factory clear lacquer finish, RAL color to be selected.
- Frame: 32 mm margin with countersunk screw mounting and gasket, mitered end border.
- Plenum: Integral, galvanized steel, insulated.

1.25 WALL SUPPLY REGISTERS/GRILLES

- Type: To suite architectural provisions.

- Frame: 32 mm margin with concealed mounting and gasket.
- Fabrication: Steel with 20 gauge (0.90 mm) minimum frames and 22 gauge (0.80 mm) minimum blades, steel and aluminum with 20 gauge (0.90 mm) minimum frame, or aluminum extrusions, with factory off-white enamel finish, RAL color to be selected.
- Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.

1.26 WALL EXHAUST AND RETURN REGISTERS/GRILLES

- Type: To suite architectural provisions.
- Frame: 32 mm margin with countersunk screw mounting.
- Fabrication: Steel frames and blades, with factory off-white enamel finish, RAL color to be selected.
- Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

1.27 LINEAR WALL REGISTERS/GRILLES

- Type: To suite architectural provisions.
- Frame: 32mm margin with countersunk screw mounting and gasket.
- Fabrication: Aluminum extrusions, RAL colour to be selected
- Damper: Integral gang-operated opposed blade damper with removable key operator, operable from face.

1.28 DOOR GRILLES

- Type: To suite architectural provisions.
- Frame: 0.90 mm steel with auxiliary frame to give finished appearance on both sides of door, with factory prime coat finish.

1.29 LOUVERS

- Type: To suite architectural provisions.
- Fabrication: 1.50mm thick galvanized steel welded assembly, with baked enamel finish, color to be selected.
- Mounting: Furnish with interior flat flange for installation.

1.30 LOUVER SCREENS

- General: Provide screen at each exterior louver.
- Screen Location for Fixed Louvers: Interior face.
- Screening Type: Insect screening.
- Secure screens to louver frames with stainless-steel machine screws, spaced a maximum of 150 mm from each corner and at 300 mm o.c.
- Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
    1. Metal: Same kind and form of metal as indicated for louver to which screens are attached.

2. Finish: Same finish as louver frames to which louver screens are attached.
3. Type: Re-wireable frames with a driven spline or insert for securing screen mesh. D. Louver Screening for Galvanized Steel Louvers:
4. Insect Screening: Stainless steel, 1.4-by-1.4-mmmesh, 0.23mm wire.

1.31 SAND TRAP LOUVERS

- High efficiency sand trap louvers shall be furnished and installed where shown on the plans with insect screen. Designed to remove the bulk of airborne sand and dust from inlet air in dry, dusty or sandy climates whilst maintaining the design air flow rate characteristics by means of a special double blade design. The finish custom color paint as scheduled by the Consultant.

1. Louver Depth: 100 mm.
2. Frame and Blade Material and Nominal Thickness: Galvanized steel sheet, of thickness required to comply with structural performance requirements, but not less than 1.3 mm for frames and for blades.
3. Mullion Type: Exposed.
4. Performance Requirements:
5. Structural: Capable of withstanding a wind load of 0.96 kPa, equivalent to wind of 145 kph.
6. Air Performance: Not more than 32-Pa static pressure drop at 3.8-m/s free-area velocity.
7. 27% free area (Based on a 1220-mm square unit).
8. Sand efficiency removal of approximately 90% measured during tests described in ASHRAE Standard 52-76 test method.

1.32 Plenum Boxes

- Plenum boxes shall be provided to all air outlets and inlets as indicated and shall be to the same ductwork specification as the connecting ductwork and fitted with round inlets with flexible connections and butterfly type balancing dampers unless otherwise stated.
- Where connected to insulated ductwork the plenum box shall be insulated to the same standard as the connecting ductwork.
- Outlets from plenum boxes shall be either circular or rectangular to suit the diffuser neck connection.
- The dimensions of the plenum box shall be as recommended by the diffuser manufacturers and shall be of adequate dimensions to ensure correct diffuser performance in terms of noise level, throw and pressure drop.
- Where appropriate plenum boxes shall be provided with galvanized steel perforated plates to achieve equal air distribution and pressure drop across the whole face of connecting grilles or diffusers. The details of all plenum boxes shall be submitted to the CA for approval prior to ordering
- Where plenum boxes are fitted with an opposed blade damper, dampers shall not be required on the neck of the diffuser being served.
- Plenum boxes shall be provided with acoustic lining (as specified elsewhere) to achieve room NC levels. All return air terminals, grilles and diffusers open to the ceiling void for free return air path shall be provided with acoustically lined plenum boxes to prevent noise transfer between the void and room. Acoustic lining shall be as provided to ensure noise levels of the space and any adjacent rooms are maintained.

EXECUTION

1.33 INSTALLATION

- Install in accordance with manufacturer's instructions.
- Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.
- Install diffusers to ductwork with air tight connection.
- Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weather tight connection. Form closely fitted joints with exposed connections accurately located and secured. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- Repair louvre finishes damaged by cutting, welding, soldering and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weather tight louver joints are required.

1.34 SCHEDULES

- Refer to schedule located on drawings

1.35 QUALITY ASSURANCE

- Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- Test and rate louver performance in accordance with AMCA 500-L.
- Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum five years of documented experience.

1.36 WARRANTY

- See Section 01 - Closeout Submittals, for additional warranty requirements.
- Provide five year manufacturer warranty for air terminal units and integral controls.

7.3.31 23 6423 – Scroll Water Chillers

GENERAL

1.37 SUMMARY

- Section Includes:

  Packaged, air-cooled scroll water chillers.
- Related Section:

1. 23 0516 - Expansion Fittings and Loops for HVAC Piping
2. 23 0523 - General-Duty Valves for HVAC Piping
3. 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment
4. 23 0593 - Testing, Adjusting and Balancing for HVAC
5. 23 0993 - BMS Sequence of Operation for HVAC Controls
6. 23 2113 - Hydronic Piping
7. 23 2123 - Hydronic Pumps

1.38 References

1. BS EN 14511-1:2004 Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling. Terms and definitions
2. ISO 9614 Acoustics. Determination of sound power levels of noise sources using sound intensity . Measurement at discrete points
3. ISO 3744 Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane.
4. 97/23/EC Pressure equipment and gas appliances: Pressure Equipment Directive
5. EN 60204-1 Safety of machinery. Electrical equipment of machines. General requirements
6. 2006/42/EC Machinery directive
7. 2006/95/EEC Low-voltage directive
8. ARI Standard 550/590-2003 code for rating and testing of water chillers.
9. UL 1995 for Safety for Heating and Cooling Equipment.
10. ARI 550/590 – Water Chilling Packages Using the Vapour Compression Cycle
11. ARI 370 – Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment
12. ANSI/ASHRAE Standard 15 – Safety Code for Mechanical Refrigeration
13. ASHRAE 34 – Number Designation and Safety Classification of Refrigerants
14. ASHRAE 90.1 – Energy Standard for Buildings except Low-Rise Residential Buildings
15. ANSI/NFPA 70 – National Electrical Code (N.E.C.)
16. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1
17. OSHA – Occupational Safety and Health Act
18. Manufactured in facility registered to ISO 9001

1.39 General Requirements

- General: Install and commission, as shown on the schedules and plans, factory assembled, charged, and tested air cooled scroll compressor chiller(s) as specified herin. Chiller shall be designed, selected, and constructed using a refrigerant with Flammability rating of "1", as defined by ANSI/ASHRAE STANDARD 34 Number Designation and Safety Classification of Refrigerants. Chiller shall include not less than two refrigerant circuits above 50 tons (200kW), scroll compressors, direct-expansion type evaporator, air-cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls including capacity controller, control center, motor starting components and special features as specified herin or required for safe, automatic operation.

  Cabinet: External structural members shall be constructed of heavy guage, galvanized steel coated with baked on powder paint which, when subject to ASTM B117, 1000 hour, 5% salt spray test, yields minimum ASTM 1654 rating of "6".

- Operating Characteristics: Provide low and high ambient temperature control options as required to ensure unit is capable of operation from 30°F to 115°F (-1°C to 46°C) ambient

temperature. [Optional: 0°F to 125°F (-18° Pressure Transducers and Readeout Capability

- Discharge Pressure Transducers: Permits unit to sense and display discharge pressure.
- Suction Pressure Transducers: Permits unit to sense and display suction pressure.
- High Ambient Control: Allows units to operate when the ambient temperature is above 115°F (46°C). Includes discharge pressure transducers
- C to 52°C) ambient.]
- The manufacturer and specific model offered shall be Eurovent Certified.
- Factory must be ISO-9001 certified.
- Packaged chillers shall be selected to achieve the cooling duty necessary to satisfy the design requirements when operating under the temperature conditions stated elsewhere.
- Refrigerants used shall be as stated elsewhere. No refrigerant comprising or containing CFC or HCFC's shall be used. All refrigerants used shall be approved by the Engineer
- The design maximum cooling rate shall be achieved at the maximum ambient conditions indicated. Each unit shall be capable of running continuously at the lowest step of cooling capacity without any adverse effect. The plant shall be charged with lubricant, and be provided with a holding charge of refrigerant or inert gas before dispatch from the Works where a full charge is impractical.
- Chillers shall be Eurovent class A certified for high efficiency and shall comply with EC requirements for machinery, electromagnetic and pressure equipment directives.
- Major components shall be readily accessible for safe maintenance and arranged to facilitate removal without disturbing other system components. Plant shall be arranged to ensure tube removal or maintenance is unobstructed.
- Venting of refrigerant to atmosphere will not be allowed during installation, commissioning and maintenance. Connections shall be provided to allow abstraction of the refrigerant charge into purpose gas bottles using refrigerant recovery equipment. Each machine shall be provided with a liquid receiver to hold the full refrigerant charge. In case the chiller design allows the refrigerant charge to be stored entirely in the condenser coil, refrigerant recovery unit is not required.
- The chiller manufacturer shall start-up, run, test and commission each chiller before dispatch from the factory and during the commissioning period. Factory testing shall include a demonstration that the chiller is capable of delivering the design duty with the required temperatures, flow rates and pressure drops at the specified ambient temperatures and acoustic levels. Units shall be inspected at the factory and the tests witnessed by the Engineer as indicated elsewhere. Where required the contractor shall provide business class travel on the national carrier and 4 star accommodation to allow for the factory witness testing by the engineer.

1.40 Submittals

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

  1. Rated capacities
  2. Coefficient of Performance & Non-Standard Part Load Value
  3. Refrigerant details

4. Chiller Plant Manager Specification
5. Chiller DEWA compliance statement and in-rush current curve
6. Acoustic Data
7. Operating characteristics
8. Testing certificates
9. Detailed assembly drawings
10. Dimensions
11. Weights
12. Required clearances
13. Method of field assembly
14. Components
15. Wiring Diagrams (Power, Signal & Control)

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats
- Startup service report
- Acoustic Data
  1. Provide acoustical sound power or sound pressure level data in decibels (dB) at the scheduled eight (8) octave band center frequencies. A-weighted sound data alone is not acceptable.
  2. Provide all sound power or sound pressure level data at 100%, 75%, 50%, and 25% load.
  3. Supplied equipment shall not exceed scheduled sound power or sound pressure level data at any load point. The mechanical Contractor shall be responsible for any additional costs associated with equipment deviation.
  4. Acoustical performance ratings shall be in accordance with ISO 9614 and the requirements of Eurovent certification
- Warranty
- Operation and maintenance data.

PRODUCTS

1.41 Operating Characteristics

- Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
- Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.
- The unit shall be able to start up with an evaporator entering fluid temperature up to 45°C
- The unit shall be able to operate as standard with an outside air temperatures from -10°C to 55°C and an evaporator leaving fluid set point between 3.3°C and 15°C

1.42 Compressors

- General

  Compressors: Shall be hermetic, scroll-type, including:
  1. Compliant design for axial and radial sealing.

2. Refrigerant flow through the compressor with 100% suction cooled motor.
3. Large suction side free volume and oil sump to provide liquid handling capability.
4. Compressor crankcase heaters to provide extra liquid migration protection.
5. Annular discharge check valve and reverse vent assembly to provide low-pressure drop, silent shutdown and reverse rotation protection.
6. Initial oil charge.
7. Oil level sight glass.
8. Brazed-type connections for fully hermetic refrigerant circuits.
9. Compressor Motor overloads capable of monitoring compressor motor current. Provides extra protection against compressor reverse rotation, phase-loss and phase-imbalance.

- Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, induction type with inherent thermal-overload protection on each phase.
3. Where specified all variable frequency drives shall comply with Division 26 of this specification

- Compressor Motor Controllers:

Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

- Capacity Control

1. Compressors shall be equipped with a capacity control slide valve capable to adjust the chiller capacity from 100 to 15% load.
2. Compressors shall start at minimum load.
3. Compressor capacity shall be microprocessor controlled to maintain the required chilled water temperature, and protect the motor against overload or the refrigeration circuit against high pressure cut out.

- Compressor Mounting

1. All rotating parts shall be statically and dynamically balanced
2. Compressor rails shall be mounted on rubber in shear anti-vibration blocks.
3. Compressor shall have a discharge gas muffler to dampen gas pulsation.
4. Compressor and oil separator shall have an acoustic enclosure with large access doors easily removable with 1/4 turn screws.

- Lubrication

1. The lubrication system shall be arranged with an interlock or other means to ensure adequate oil pressure at all bearings before the compressor starts.
2. External oil separator for each compressor with no moving parts
3. Oil separator shall include a temperature actuated heater and an oil level safety switch
4. Refrigerant system differential pressure shall provide oil return through 5 micron replaceable oil filter external to the compressor. Oil filter shall be equipped with service shut off valve for easy replacement
5. A replaceable or cleanable filter shall be positioned in the oil delivery pipe.
6. A thermostatically controlled oil cooling system shall be used to remove heat gained by the oil. The oil sump shall have a thermostatically controlled electric heater

1.43 Refrigerant Circuit Components

- The refrigerant shall be R-134A

- Chiller shall have independent circuit for each compressor to provide maximum redundancy.
- In the event that the proposed manufacturer does not have independent circuits per compressor, manufacturer shall provide owner one spare compressor of each unique size.
- Each refrigerant circuit shall include: a discharge service ball type isolation valve, high side pressure relief, liquid line shutoff valve with charging port, low side pressure relief device, filter-drier, solenoid valve, sight glass with moisture indicator, electronic expansion valves, and flexible, closed-cell foam insulated suction line and suction pressure transducer.Instrumentation and safety devices shall include : high-pressure safety switch, low pressure safety relief valve, low and high pressure transducers accessible without draining the refrigerant charge
- Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
- Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
- All refrigerant circuits shall be factory pressure tested with certificates provided as part of the technical submittal.

1.44 Evaporator

- Evaporator shall be brazed-plate type 316 stainless steel construction capable of refrigerant working pressure of 650 psig (3103 kPa) and liquid side pressure of 150 psig (1034 kPa) [Option for 300 psig (2068 kPa) available].
- Brazed plate heat exchangers shall be UL listed.
- Exterior surfaces shall be covered with 3.4" (19mm), flexible, closed cell insulation, thermal conductivity of 0.26k ([BTU/HR-Ft^2 - °F]/in.) maximum.
- Water nozzles shall be provided with grooves for field provided ANSI/AWWA C-606 mechanical couplings.
- Evaporator shall include vent and drain fittings and thermostatically controlled heaters to protect to -20°F (-29°C) ambient in off-cycle.
- A 20-mesh, serviceable wye-strainer and mechanical couplings shall be provided for field installation on evaporator inlet prior to startup.
- Evaporator shall be provided with piping extension kit and mechanical couplings to extend liquid connection from evaporator to edge of unit. Thermal dispersion type flow switch shall be factory installed in the evaporator outlet pipe extension and wired to the unit control panel. Insulation and heat trace on piping shall be responsibility of installing contractor. Extension kit nozzle connections shall be ANSI/AWWA C-606 (grooved).

1.45 Air Cooled Condenser

- Coils: Condenser coils shall be constructed of a single material to avoid galvanic corrosion due to dissimilar metals. Coils and headers are brazed as one piece. Integral sub cooling is included. Coils shall be designed for a design working pressure of 650 PSIG (45 bar). Condenser coil shall be washable with potable water under 100 psi (7 bar) pressure.

- Low Sound Fans: Shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise, full-airfoil cross section, providing vertical air discharge and low sound. Each fan shall be provided in an individual compartment to prevent crossflow during fan cycling. Guards of heavy gauge, PVC (poly- vinylchloride) coated or galvanized steel shall be factory installed.
- Fan Motors: High efficiency, direct drive, 6 pole, 3 phase, insulation class "F", current protected, Totally Enclosed Air-Over (TEAO) , rigid mounted, with double sealed, permanently lubricated, ball bearings.
- Coils shall be insulated from the chiller frame by rubber insulating mount
- Air Cooled Condenser fans shall be equipped with an impeller with aerodynamic blades and a rotating shroud to ensure optimal leak-tightness between the blades and fan mouth.
- The impeller shall be a one-piece type and made of a corrosion-resistant composite material, and statically and dynamically balanced. The air shall be discharged vertically upwards.
- The fans shall be protected by polyethylene-coated steel wire grilles.
- Where specified all variable frequency drives shall comply with Division 26 of this specification

1.46 Unit Frame

- Cabinet: External structural members shall be constructed of heavy guage, galvanized steel coated with baked on powder paint which, when subject to ASTM B117, 1000 hour, 5% salt spray test, yields minimum ASTM 1654 rating of "6".

1.47 Unit Insulation

- Factory-applied insulation over cold surfaces of liquid chiller components including evaporator shell, water boxes, and suction line. Liquid nozzles shall be insulated by Contractor after pipe installation.
- Insulation to be as per section 23 0716 - HVAC Equipment Insulation of this specification

1.48 Power and Electrical Components

- Power Panels:
  1. NEMA 3R/12 rain/dust tight, powder painted steel cabinets with hinged, latched, and gasket sealed outer doors. Provide main power connection(s), control power connections, compressor and fan motor start contactors, current overloads, and factory wiring.
  2. Power supply shall enter unit at a single location, be 3 phase of scheduled voltage, and connect to individual terminal blocks per compressor. Separate disconnecting means and/or external branch circuit protection (by Contractor) required per applicable local or national codes.
- Compressor, control and fan motor power wiring shall be located in an enclosed panel or routed through liquid tight conduit.
-
- Power requirement
  1. The unit shall operate at 415 volts, 3 phases, 50 hertz.

2. Chillers with two compressors shall have single power connection and for chillers having more than two compressors shall have dual power connection to have electrical redundancy, ease of maintenance & small cable size.
3. Main disconnect switch with lockable handle for each compressor shall be provided at point of incoming.

- Power and control cabinets

1. Powder painted steel cabinet with hinged and gasket sealed doors. Power box doors shall be interlocked with main disconnect switch handle so that doors opening may not be possible without disconnecting power, but a special opening system should be provided to troubleshoot while power is on.
2. Power cabinet includes: compressor short circuit and overload protection, fan and control circuit breakers
3. Separate control cabinet for safe and easy access to control display.
4. Each circuit must be protected with fuse.
5. Each circuit must have control transformer.
6. Each transformer must be protected with breaker at input and fuse at output.

- Power Factor:

1. Provide equipment with power factor correction capacitors as required to maintain a displacement power factor of 95% at all load conditions.
2. The installing contractor is responsible for additional cost to furnish and install power factor correction capacitors if they are not factory mounted and wired.

- Compressor starter

1. Motor starter shall be Wye–Delta or VFD as specified type for minimum inrush current, Wye-Delta transition shall be managed electronically without electromechanical relays.
2. Proposed Chillers must comply with DEWA requirements for inrush current
3. Compressor motor winding should have two sensors one on line and one spare.
4. The temperature of the refrigerant cooling motor winding should be managed by the microprocessor a sensor installed in the suction housing.

1.49 Control Transformer

- Control Power Transformer: Converts unit power voltage to 120-1-60 (500 VA capacity). Factory-mounting inclusive of primary and secondary wiring between the transformer and the control panel.

1.50 Unit Controls

- General: Automatic start, stop, operating, and protection sequences across the range of scheduled conditions and transients.

- Power/Control Enclosure: Rain and dust tight NEMA 3R powder painted steel cabinet with hinged, latched, and gasket sealed door.

- Microprocessor Control Center:

1. Automatic control of compressor start/stop, anti-coincidence and anti-recycle timers, automatic pumpdown at system shutdown, condenser fans, evaporator pump, evaporator heater, unit alarm contacts, and chiller operation from 0°F to 125°F (-

18°C to 52°C) ambient. Automatic reset to normal chiller operation after power failure.

2. Software stored in non-volatile memory, with programmed setpoints retained in lithium battery backed real-time-clock (RTC) memory for minimum 5 years.
3. Forty character liquid crystal display, descriptions in English (or Spanish, French, Italian, or German), numeric data in English (or Metric) units. Sealed keypad with sections for Setpoints, Display/Print, Entry, Unit Options & clock, and On/Off Switch.
4. Programmable Setpoints (within Manufacturer limits): display language; chilled liquid temperature setpoint and range, remote reset temperature range, daily schedule/holiday for start/stop, manual override for servicing, low and high ambient cutouts, low liquid temperature cutout, low suction pressure cutout, high discharge pressure cutout, anti-recycle timer (compressor start cycle time), and anti-coincident timer (delay compressor starts).
5. Display Data: Return and leaving liquid temperatures, low leaving liquid temperature cutout setting, low ambient temperature cutout setting, outdoor air temperature, English or metric data, suction pressure cutout setting, each system suction pressure, liquid temperature reset via a 4-20milliamp or 0-10 VDC input, anti-recycle timer status for each compressor, anti-coincident system start timer condition, compressor run status, no cooling load condition, day, date and time, daily start/stop times, holiday status, automatic or manual system lead/lag control, lead system definition, compressor starts/operating hours (each), status of hot gas valves, evaporator heater and fan operation, run permissive status, number of compressors running, liquid solenoid valve status, load & unload timer status, water pump status.
6. System Safeties: Shall cause individual compressor systems to perform auto shut down; manual reset required after the third trip in 90 minutes. System Safeties include: high discharge pressure, low suction pressure, high pressure switch, and motor protector. Compressor motor protector shall protect against damage due to high input current or thermal overload of windings.
7. Unit Safeties: Shall be automatic reset and cause compressors to shut down if low ambient, low leaving chilled liquid temperature, under voltage, and flow switch operation.
8. Alarm Contacts: Low ambient, low leaving chilled liquid temperature, low voltage, low battery, and (per compressor circuit): high discharge pressure, and low suction pressure.

- BAS Communications: BACnet MS/TP, Modbus and N2 communication capabilities
- Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

1.51 Controls Functionality

- Automatic operation

1. The chiller shall be equipped with a programming clock, permitting:
2. On/off control
3. Changeover to the second set point (unoccupied mode)
4. Capacity or current drawn limitation
5. The control shall ensure the following operating modes:

   g. On/off mode based on the outside temperature
   h. Set point reset based on the outside air temperature or the return water temperature

- Remote Control

1. The chiller shall include dry contacts permitting:
2. On/off control
3. Capacity or current drawn limitation (one stage)
4. Changeover to the second set point (unoccupied mode)
5. Integration of customer safety device
6. The chiller shall include output contacts permitting:
7. Signalling that the unit is ready to start
8. Signalling the occurrence of a minor incident (alert relay)
9. Signalling the occurrence of a major incident (alarm relay)
10. Water pump on/off control (single or dual pump with automatic changeover)
11. The chiller shall be equipped with an RS485 serial port for remote control via a communication bus.

- Programmable set points (within Manufacturer limits):

  i. Display language,
  j. chilled liquid cooling mode,
  k. local/remote control mode,
  l. display units mode,
  m. system lead/lag control mode,
  n. remote temperature reset,
  o. remote current limit,
  p. remote sound limit,
  q. low ambient temperature cutout enable/disable,
  r. leaving chilled liquid setpoint and range,
  s. maximum remote temperature reset.

- Display Data:

  a. Chilled liquid leaving and entering temperatures;
  b. outside ambient air temperature;
  c. lead system;
  d. evaporator pump status;
  e. active remote control;
  f. compressor suction, discharge, and oil pressures per refrigerant circuit;
  g. compressor discharge, motor, and oil temperatures per refrigerant circuit;
  h. saturation temperatures per refrigerant circuit;
  i. compressor speed; condenser fan status;
  j. condenser subcooling temperature;
  k. condenser drain valve percentage open;
  l. compressor capacity in percentage of Full Load Amps;
  m. compressor number of starts;
  n. run time;
  o. operating hours;
  p. evaporator heater status;
  q. history data for last ten shutdown faults;
  r. history data for last 20 normal (non-fault) shutdowns.

- Predictive Control Points:

  Unit controls shall avoid safety shutdown when operating outside design conditions by optimizing the chiller controls and cooling load output to stay online and avoid safety limits being reached. The system shall monitor the following parameters and maintain the maximum cooling output possible without shutdown of the equipment.

- System Safeties:

Shall cause individual compressor systems to perform auto-reset shut down if: high discharge pressure or temperature, low suction pressure, low motor current, high/low differential oil pressure, low discharge superheat, high motor temperature, system control voltage.

- Unit Safeties:

  Shall be automatic reset and cause compressors to shut down if: high or low ambient temperature, low leaving chilled liquid temperature, under voltage, flow switch operation. Contractor shall provide flow switch and wiring per chiller manufacturer requirements.

1.52 Digital Chiller Plant Manager

- A factory-furnished, programmed, microprocessor-based controller shall be provided to supervise and optimize the operation of the individual controllers for each chiller. All application software actually performing the required control functions shall be factory-supplied with the controller and shall be pre-tested and pre-configured.
- The CPM The chiller plant manager shall be provided by the chiller manufacturer and shall optimize performance of the plant under various load conditions. The chiller plant manager shall consider chiller power, condenser fan power in determining the optimum set points and plant operation to arrive at the lowest kw/Tr combination to achieve the defined CHW flow temperatures
- The networked chiller controllers shall interface with a Chiller System Manager (CSM) installed on the network. The CSM shall include software that allows dynamic interaction between the CSM and the chiller controllers to create a complete chilled water plant system as described within this specification. This system shall function to optomise the operation all chiller units in the plant to maximise efficiency
- The CSM shall include inherent input and output capability. The input/output capability shall include as a minimum a combination of standard HVAC sensor inputs (5k, 10k, 4-20mA and discrete) an output to drive an alarm annunciator and/or alarm light, and two analog outputs for differential pressure control. Each analog input channel shall include an operator-adjustable sensor trim (adjustable to 1/10°F) and programmable low and high alarm/alerts, as applicable.
- The CSM shall not interfere with the PIC's stand-alone operating or safety algorithms but shall enhance the operation by providing the following inherent capabilities as a minimum:

  1. Control of up to all chillers (staged or rotary) of equal or unequal sizes
  2. Enable/disable the chiller plant based on its internal time schedules, remote contact closure, analog temperature override, network command, or time schedule override
  3. Chiller fault logic and automatic starting of lag chiller(s)
  4. Automatic alarming and switching to backup sensors if any primary sensor fails
  5. Diverse operator selectable chiller sequences including a sequence with a designated chiller to perform "feathering" functions
  6. Algorithms that properly match the chillers with the load
  7. Chiller inhibit timers
  8. Bypass valve control
  9. kW balancing and ramp loading
  10. Demand limiting
  11. Chilled water reset
  12. Power fail restart

- The CSM shall contain factory-programmed software for the following types of mechanical systems:
  1. Multiple chillers with dedicated chilled water pumps and no secondary piping.
  2. Multiple chillers with chilled water pumps in a parallel arrangement and no secondary piping
  3. Two chillers piped in series with a single chilled water pump and no secondary piping.
  4. Multiple chillers with dedicated primary (production loop) pumps and secondary (distribution loop) pumps piped in a parallel arrangement.
  5. Multiple parallel chillers, common primary pumps, constant flow (common constant speed secondary pumps), variable flow (two-way valves) with a differential pressure valve and bypass line
  6. Multiple parallel chillers, common primary pumps, variable flow (two-way valves), with a differential pressure valve and bypass line.
- The controller shall include a 365-day real time clock and watchdog timer diagnostic indicator provided by an LED. The watchdog timer shall reset upon power on and be resettable by software thereafter. Should the watchdog timer not be resettable during the timing period, it shall time out and set all outputs to their non-powered state. The LED shall illuminate solidly to indicate this failure.
- All configuration data will be stored in nonvolatile memory. The controller shall provide a minimum of two days data retention for the time clock.
- The controller shall include the capability to provide a local interface for all operating values, alarms, etc., via a panel mounted, Local Interface Device. The controller shall also be capable of interfacing to a portable PC for configuring or altering the configuration, setting the address, performing uploads/downloads, etc., through a separate, additional RJ14 plug.
- The CSM shall utilize common chilled water supply and return water temperature sensors wired to the CSM as its primary control sensors. An optional load return sensor shall be supplied if the I/O summary requires such or the sequence of operation requires the starting and stopping of equally sized chillers as a function of how much water is being bypassed.
- The CSM shall monitor the status of each chiller's present local/auto selector position, through network communications. Whenever the position is indexed to local, the PIC shall perform its stand-alone control functions. When the PIC is indexed to the local mode the CSM shall determine that the chiller is not available for chiller plant control and shall be bypassed by the CSM. When the mode is indexed to the remote position the chiller PIC shall have the following programs superseded by the CSM:
  1. Lead/lag
  2. Chilled water reset
  3. Remote contact start
  4. Demand limiting
- The CSM shall include the ability to rotate the chiller sequence while chillers are running. If the chiller sequence changes while the chiller(s) are running, the CSM shall start all required chillers before the unneeded chillers are stopped to prevent any interruption in the supply of chilled water to the facility. The CSM shall include the capability to automatically change the rotation based on runtimes and a rotation day and time entered by the operator.

- Occupancy: The occupancy status shall determine when to operate the chilled water plant. When occupied, the chiller plant shall be enabled and when unoccupied, disabled. Occupancy status shall be automatically indexed by any of the following factors:

  1. System Force: A networked force (option module, custom programming in a field-installed controller, etc.) shall override the occupancy until it is autoed or forced to a different value by the operator.
  2. Operator Override: The operator shall have the ability to override the unoccupied mode by entering an override value (0-1-2-3-4 hours) through any of the interface devices. If the timed override option is initiated during an occupied period, the time schedule shall remain occupied for the duration of the time entered. If the operator initiates an override during the unoccupied period, the time schedule shall be indexed to occupied for the duration of the value entered.
  3. Occupancy Override: The CSM shall include the ability of monitoring a remote on/off discrete input wired to it. Whenever the switch is indexed to on, the CSM shall index itself to the occupied mode. Refer to the Input/Output Summary and/or the Sequence of Operation to determine if this input is required.
  4. Water System Manager (WSM): A WSM shall send an enable signal through the network to index the system to the occupied mode to satisfy the needs of the loads (i.e. Air Handler adaptive optimal start, terminal occupancy timed override).
  5. Temperature Override: The CSM shall be capable of monitoring an analog input override sensor (thermistor, or 4-20mA) and shall disable the chilled water plant whenever the system has been indexed to the occupied mode and the override sensor is below its configured setpoint value.

- Time Schedule Occupied:

  When the CSM time of day reaches the operator adjustable occupancy time the CSM shall be occupied. When the time of day reaches the unoccupied time the CSM shall be unoccupied unless one of the above overrides are initiated or a network command has initiated an override.

- Pull-down Timer:

  This delay time shall allow the lead chiller a chance to cool down the building chilled water loop before starting the lag chillers during system start-up.

- Chiller Faulting:

  A chiller shall be considered faulted if a fault status is reported to the CSM by the chiller PIC. Chillers having a communication failure (after the operator adjustable start time value has expired) shall be left in their last commanded state. Chillers faulted for any other reason shall be commanded off. All faulted chillers shall be automatically replaced, if applicable, to maintain on-line capacity.

- Power Fail Restart:

  If the CSM loses power, it shall be capable of selecting one of two different recovery control schemes based on how long the power was off and whether the operator adjustable threshold time has been exceeded. If the power was lost for less than the threshold time, it shall start the chillers at one-minute intervals until the on-line capacity before the power failure is restored.If power was lost for more than the threshold time, the configured pulldown timer shall be skipped and the chillers shall be started at the lag start delay time interval until the load has been satisfied.

- Chiller Inhibit Timers:

Additional chillers shall not be started if the length of time remaining before the next unoccupied period is less then the input value entered by the operator to avoid starting additional chillers that will be turned off shortly.

- Start/Stop Delay Timers:

  The CSM shall include operator adjustable time delay values to prevent chillers from cycling due to short duration conditions.

- Additional Cooling Required Algorithm (ACR): The starting of additional chillers beyond the lead shall be enabled if the following criteria are met:

  1. Supply water temperature is to be used as the control criteria and the ACR temperature sensor is above the current chilled water supply setpoint, plus an adjustable delta temperature value.
  2. The pulldown rate is less than 0.5°F/minute for the running chillers.
  3. Load Indicator Timer has timed out. (This operator-adjustable value is used by the CSM to determine how long the ACR load indicators must be true before an additional chiller is started).
  4. New chiller inhibit timer is not active. (This operator-adjustable value is used by the CSM to determine how many hours before the start of the unoccupied cycle to stop performing the ACR load indicator tests). This shall help prevent the starting of a chiller that will have to be stopped shortly thereafter when the CSM becomes unoccupied).
  5. The chiller(s) are not faulted, ramping, or in a power fail restart condition.
  6. Resequencing is not occurring.
  7. The percent demand limit being sent to all running chillers is above a calculated value.
  8. An alarm shall be generated if the algorithm determines that an additional chiller is required to maintain setpoint and no chillers are available

- Reduced Cooling Required Algorithm (RCR):

  1. The chiller plant control system shall initiate the shut down of the next chiller in the sequence whenever excess chilled water capacity exists, as determined by percent run load amps / VFD frequency / common water flow sensors, for [20] minutes (adjustable).
  2. The CSM shall include a load target equation to determine when a lag chiller shall be stopped. The load target program shall calculate a RCR kW setpoint based on present chiller plant tonnage, capacity of the lag chiller to be stopped, operator-adjustable deadband to prevent short cycling and an operator-entered correction factor to compensate for non-linearities in the relationship between %kW and cooling capacity under low load conditions.
  3. If the average %kW for all running chillers is below the corrected RCR kW setpoint, plus the control temperature sensor's value is below the setpoint including an adjustable delta temperature value, and the stop requirements for the delay timers are clear, the next lag chiller shall be stopped.

- CSM User Interface

  1. The chiller plant manager shall consist of web server operator interface. A web server shall gather data from chiller plant system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface. Operators with sufficient access level shall have an ability to make changes to all system and equipment graphics in the web server in

addition to having full chiller plant system access to make configuration changes to the control system. Any tools required for making graphic changes shall be provided with web server.

2. The Webserver shall have the ability to view and configure the trends, reports and alarms of chiller plant manager.
3. The chiller plant data shall interface with the BMS (Building Management Control System) via open standard BACnet/IP protocol for monitoring.

- Chiller Minimum Flow Bypass Control

1. The chiller minimum flow shall be determined by direct measurement using a flow meter on each chiller. The flow meter setpoint shall be determined based on the manufacturers recommended minimum chiller flow rate. The flow meters shall be supplied and installed by the contractor to the chiller suppliers requirements. The contractor shall co-ordinate with the chiller manufacturer for these requirements
2. For verification of minimum flow the chiller minimum (and in the event of meter failure) the flow shall also be determined based on the pressure drop across the chiller evaporator barrel using a high accuracy pressure differential sensor. The differential pressure setpoint shall be determined based on the manufacturer's chiller pressure drop rating curves.
3. The Chiller Plant Manager shall control the modulation of the Minimum Flow Bypass valve to maintain the required minimum flow of a single chiller under all load conditions

1.53 Accessories

- Thermal Dispersion Flow Switch (Factory installed and wired in piping extension kit): Normally open, 30bar pressure rating, stainless steel 316L construction, IP67, -4℉ to 158℉ ambient rating.
- Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
- Vibration Isolation (Field installed):
- 1.1" Deflection Spring Isolators: Level adjustable, spring and cage type isolators for mounting under the unit base rails.

EXECUTION

1.54 CHILLER INSTALLATION

- Shipment

1. The unit shall be completely assembled, with all main, auxiliary, and control piping installed, controls wired, leak tests completed, air runs tested, and charged with dry nitrogen.
2. The oil charge and miscellaneous materials shall be shipped in the oil sump or packed separately.
3. The refrigerant charge shall be shipped concurrently or separately in cylinders for field evacuation and charging of unit.
4. The chillers shall be fully shrink wrapped at the factory before shipment.
5. Provide protective covering over vulnerable components for unit protection during shipment. Fit nozzles and open ends with plastic enclosures.
6. Unit shall be stored and handled per Manufacturer's instructions.
7. Install chillers on support structure indicated.

- Installation
  1. Rig and Install in full accordance with Manufacturer's requirements, Project drawings, and Contract documents.
  2. Locate chiller as indicated on drawings, including cleaning and service maintenance clearance per Manufacturer instructions. Adjust and level chiller on support structure.
  3. Installing Contractor shall provide and install all auxiliary devices and accessories for fully operational chiller.
  4. Coordinate electrical requirements and connections for all power feeds with Electrical Contractor.
  5. Coordinate all control requirements and connections with Controls Contractor.
  6. Installing Contractor shall paint damaged and abraded factory finish with touch-up paint matching factory finish.

1.55 STARTUP SERVICE

- The manufacturer shall furnish a factory trained service engineer to start the units.
  1. A start-up log shall be furnished by the manufacturer to document the chiller's start-up date and shall be signed by the owner or his authorized representative prior to commissioning the chillers.
  2. The manufacturer shall provide two day's of training on chiller operation for facility service personnel Training shall be provided by manufacturers Service Engineer and will occur during regular working hours.
- As a minimum the following start up checks shall be carried out
  1. Complete installation and startup checks according to manufacturer's written instructions.
  2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
  3. Verify that pumps are installed and functional.
  4. Verify that thermometers and gages are installed.
  5. Operate chiller for run-in period.
  6. Check bearing lubrication and oil levels.
  7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
  8. Verify proper motor rotation.
  9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
  10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
  11. Verify and record performance of chiller protection devices.
  12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- Prepare test and inspection startup reports.

7.3.32 23 6426 - Rotary Screw Water Chillers

GENERAL

1.1 SUMMARY

- Section Includes:

  Packaged, air-cooled screw chillers.

- Related Section:

  1. 23 0516 - Expansion Fittings and Loops for HVAC Piping
  2. 23 0523 - General-Duty Valves for HVAC Piping
  3. 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment
  4. 23 0593 - Testing, Adjusting and Balancing for HVAC
  5. 23 0993 - BMS Sequence of Operation for HVAC Controls
  6. 23 2113 - Hydronic Piping
  7. 23 2123 - Hydronic Pumps

1.2 References

1. BS EN 14511-1:2004 Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling. Terms and definitions
2. ISO 9614 Acoustics. Determination of sound power levels of noise sources using sound intensity . Measurement at discrete points
3. ISO 3744 Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane.
4. 97/23/EC Pressure equipment and gas appliances: Pressure Equipment Directive
5. EN 60204-1 Safety of machinery. Electrical equipment of machines. General requirements
6. 2006/42/EC Machinery directive
7. 2006/95/EEC Low-voltage directive
8. ARI Standard 550/590-2003 code for rating and testing of water chillers.
9. UL 1995 for Safety for Heating and Cooling Equipment.
10. ARI 550/590 – Water Chilling Packages Using the Vapour Compression Cycle
11. ARI 370 – Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment
12. ANSI/ASHRAE Standard 15 – Safety Code for Mechanical Refrigeration
13. ASHRAE 34 – Number Designation and Safety Classification of Refrigerants
14. ASHRAE 90.1 – Energy Standard for Buildings except Low-Rise Residential Buildings

1.3 General requirements

- Furnish, Install, and Commission factory assembled, charged, and operational run tested air-cooled screw compressor chiller as specified herein and shown on the Drawings. Chiller shall include, but is not limited to: a complete system with multiple independent refrigerant circuits, semi hermetic twin screw compressors, shell and tube flooded or hybrid falling film type evaporator, air-cooled condenser, R134a refrigerant, lubrication system, interconnecting wiring, safety and operating controls including capacity controller, control center, motor starting components, and special features as specified herein or required for safe, automatic operation.
- The manufacturer and specific model offered shall be Eurovent Certified.
- Factory must be ISO-9001 certified.

- Packaged chillers shall be selected to achieve the cooling duty necessary to satisfy the design requirements when operating under the temperature conditions stated elsewhere.
- Refrigerants used shall be as stated elsewhere. No refrigerant comprising or containing CFC or HCFC's shall be used. All refrigerants used shall be approved by the Engineer
- The design maximum cooling rate shall be achieved at the maximum ambient conditions indicated. Each unit shall be capable of running continuously at the lowest step of cooling capacity without any adverse effect. The plant shall be charged with lubricant, and be provided with a holding charge of refrigerant or inert gas before dispatch from the Works where a full charge is impractical.
- Chillers shall be Eurovent class A certified for high efficiency and shall comply with EC requirements for machinery, electromagnetic and pressure equipment directives.
- Major components shall be readily accessible for safe maintenance and arranged to facilitate removal without disturbing other system components. Plant shall be arranged to ensure tube removal or maintenance is unobstructed.
- Venting of refrigerant to atmosphere will not be allowed during installation, commissioning and maintenance. Connections shall be provided to allow abstraction of the refrigerant charge into purpose gas bottles using refrigerant recovery equipment. Each machine shall be provided with a liquid receiver to hold the full refrigerant charge. In case the chiller design allows the refrigerant charge to be stored entirely in the condenser coil, refrigerant recovery unit is not required.
- The chiller manufacturer shall start-up, run, test and commission each chiller before dispatch from the factory and during the commissioning period. Factory testing shall include a demonstration that the chiller is capable of delivering the design duty with the required temperatures, flow rates and pressure drops at the specified ambient temperatures and acoustic levels. Units shall be inspected at the factory and the tests witnessed by the Engineer as indicated elsewhere. Where required the contractor shall provide business class travel on the national carrier and 4 star accommodation to allow for the factory witness testing by the engineer.

1.4 Submittals

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

  1. Rated capacities
  2. Coefficient of Performance & Non-Standard Part Load Value
  3. Refrigerant details
  4. Chiller Plant Manager Specification
  5. Chiller DEWA compliance statement and in-rush current curve
  6. Acoustic Data
  7. Operating characteristics
  8. Testing certificates
  9. Detailed assembly drawings
  10. Dimensions
  11. Weights
  12. Required clearances
  13. Method of field assembly
  14. Components
  15. Wiring Diagrams (Power, Signal & Control)

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats
- Acoustic Data
  1. Provide acoustical sound power or sound pressure level data in decibels (dB) at the scheduled eight (8) octave band center frequencies. A-weighted sound data alone is not acceptable.
  2. Provide all sound power or sound pressure level data at 100%, 75%, 50%, and 25% load.
  3. Supplied equipment shall not exceed scheduled sound power or sound pressure level data at any load point. The mechanical Contractor shall be responsible for any additional costs associated with equipment deviation.
  4. Acoustical performance ratings shall be in accordance with ISO 9614 and the requirements of Eurovent certification

PRODUCTS

1.5 Operating Characteristics

- The unit shall be able to start up with an evaporator entering fluid temperature up to 45°C
- The unit shall be able to operate as standard with an outside air temperatures from -10°C to 55°C and an evaporator leaving fluid set point between 3.3°C and 15°C

1.6 Compressors

- General
  1. Compressors to be of Semi-hermetic twin screw type. Compressors shall be mounted on sliding rail and equipped with discharge gas shut-off valve for ease of service
  2. Design working pressure of entire compressor, suction to discharge, shall be 305 psig (21 barg) or higher
  3. Rotary seals shall be provided on the drive shaft to prevent leakage of refrigerant or oil.
  4. A device shall be fitted to prevent the pressure differential across the compressor causing backward rotation at a normal or emergency stop.
  5. Compressors using oil injection for rotor sealing shall incorporate arrangements to prevent excessive oil carry-over with refrigerant from the compressor and ensure adequate oil return to the compressor over the full operating range.
- Compressor Motors:
  1. Hermetically sealed and cooled by refrigerant suction gas.
  2. High-torque, induction type with inherent thermal-overload protection on each phase.
  3. Where specified all variable frequency drives shall comply with Division 26 of this specification
- Capacity Control
  1. Compressors shall be equipped with a capacity control slide valve capable to adjust the chiller capacity from 100 to 15% load.
  2. Compressors shall start at minimum load.
  3. Compressor capacity shall be microprocessor controlled to maintain the required chilled water temperature, and protect the motor against overload or the refrigeration circuit against high pressure cut out.

- Compressor Mounting
  1. All rotating parts shall be statically and dynamically balanced
  2. Compressor rails shall be mounted on rubber in shear anti-vibration blocks.
  3. Compressor shall have a discharge gas muffler to dampen gas pulsation.
  4. Compressor and oil separator shall have an acoustic enclosure with large access doors easily removable with 1/4 turn screws.

- Lubrication
  1. The lubrication system shall be arranged with an interlock or other means to ensure adequate oil pressure at all bearings before the compressor starts.
  2. External oil separator for each compressor with no moving parts
  3. Oil separator shall include a temperature actuated heater and an oil level safety switch
  4. Refrigerant system differential pressure shall provide oil return through 5 micron replaceable oil filter external to the compressor. Oil filter shall be equipped with service shut off valve for easy replacement
  5. A replaceable or cleanable filter shall be positioned in the oil delivery pipe.
  6. A thermostatically controlled oil cooling system shall be used to remove heat gained by the oil. The oil sump shall have a thermostatically controlled electric heater

1.7 Refrigerant Circuit Components

- The refrigerant shall be R-134A
- Chiller shall have independent circuit for each compressor to provide maximum redundancy.
- In the event that the proposed manufacturer does not have independent circuits per compressor, manufacturer shall provide owner one spare compressor of each unique size.
- Each refrigerant circuit shall include all necessary components for designed operation including but not limited to: discharge gas shut-off valve, liquid shut off valve, electronic expansion valve controlled by a stepper motor, liquid sight glass, filter drier with removable cartridge, refrigerant economizer controlled by an auxiliary electronic expansion valve and complete charge of both refrigerant and oil shall be filled in the factory.
- Instrumentation and safety devices shall include : high-pressure safety switch, low pressure safety relief valve, low and high pressure transducers accessible without draining the refrigerant charge
- Discharge lines shall be provided with manual compressor shut-off service valves
- All refrigerant circuits shall be factory pressure tested with certificates provided as part of the technical submittal.

1.8 Evaporator

- Evaporator shall be shell and tube flooded or hybrid falling film type to optimize efficiency and refrigerant charge. Tubes shall be high-efficiency, internally and externally enhanced type copper tubes.
- Each tube shall be roller expanded into the tube sheets providing a leak proof seal, and be individually replaceable. Independent refrigerant circuits shall be provided per compressor.

- The evaporator shall be tested with pressurised dry. Water or oil pressure is not acceptable.
- The weld-free copper tubes shall be internally finned and expanded into the tube sheets.
- The evaporator shall be mounted on support feet with thermal bridge rupture
- Shell shall be integrally insulated with polyurethane foam mechanically protected by factory fitted Aluminium cladding for external aggression (Mechanical & UV protection).
- The chiller shall have only one inlet/outlet water connections of grooved coupling type connections to ensure mechanical decoupling between the unit and the hydronic installation. The evaporator shall be equipped with a water drain and a purge plug.
- Water boxes shall be removable to permit tube cleaning and replacement

1.9 Air Cooled Condenser

- Condenser coils shall be multiple transversal V shaped microchannel type, parallel flow aluminum alloy tubes metallurgically brazed automatically in oven as one piece to enhanced aluminum alloy fins. Condenser coils shall be made of a single material to avoid galvanic corrosion due to dissimilar metals. Post coating flexible epoxy coating shall be applied on chiller microchannel condenser that is finished with a polyurethane UV resistant top coat. A letter signed by authorized factory engineer confirming that the chiller capacity in the chiller data sheet includes any derating on account of this coating. Condenser coil shall be easily cleanable using high pressure water jet and coil shall be guaranteed for 3 years. Tube and fin type condenser coils are an acceptable alternate when tubes and fins are fabricated of the same metal material to avoid galvanic corrosion due to dissimilar metals.
- Coils shall be insulated from the chiller frame by rubber insulating mount
- Air Cooled Condenser fans shall be equipped with an impeller with aerodynamic blades and a a rotating shroud to ensure optimal leak-tightness between the blades and fan mouth.
- The impeller shall be a one-piece type and made of a corrosion-resistant composite material, and statically and dynamically balanced. The air shall be discharged vertically upwards.
- The fans shall be protected by polyethylene-coated steel wire grilles.
- The three-phase electric motors shall have class F insulation, IP 55 protection with a minimum efficiency of 80%. They shall have individual overload protection via a circuit breaker.
- Where specified all variable frequency drives shall comply with Division 26 of this specification

1.10 Unit Frame

- Frame shall be made of U steel beam with hot dip galvanization or electrophoresis treatment completed with paint
- Panels and electrical box shall be made of galvanised sheet steel with oven-baked polyester powder paint finish in manufacturers standard finish and be capable of withstanding a 500-hour salt spray test in accordance with the ISO 9227.

1.11 Unit Insulation

- Factory-applied insulation over cold surfaces of liquid chiller components including evaporator shell, water boxes, and suction line. Liquid nozzles shall be insulated by Contractor after pipe installation.
- Insulation to be as per section 23 0716 - HVAC Equipment Insulation of this specification

1.12 Power and Electrical Components

- Power requirement
  1. The unit shall operate at 400 volts, 3 phases, 50 hertz (400 V ± 10%) without neutral.
  2. Chillers with two compressors shall have single power connection and for chillers having more than two compressors shall have dual power connection to have electrical redundancy, ease of maintenance & small cable size.
  3. Main disconnect switch with lockable handle for each compressor shall be provided at point of incoming.
- Power and control cabinets
  1. Powder painted steel cabinet with hinged and gasket sealed doors. Power box doors shall be interlocked with main disconnect switch handle so that doors opening may not be possible without disconnecting power, but a special opening system should be provided to troubleshoot while power is on.
  2. Power cabinet includes: compressor short circuit and overload protection, fan and control circuit breakers
  3. Separate control cabinet for safe and easy access to control display.
  4. Each circuit must be protected with fuse.
  5. Each circuit must have control transformer.
  6. Each transformer must be protected with breaker at input and fuse at output.
- Power Factor:
  1. Provide equipment with power factor correction capacitors as required to maintain a displacement power factor of 95% at all load conditions.
  2. The installing contractor is responsible for additional cost to furnish and install power factor correction capacitors if they are not factory mounted and wired.
- Compressor starter
  1. Motor starter shall be Wye–Delta or VFD as specified type for minimum inrush current, Wye-Delta transition shall be managed electronically without electromechanical relays.
  2. Proposed Chillers must comply with DEWA requirements for inrush current
  3. Compressor motor winding should have two sensors one on line and one spare.
  4. The temperature of the refrigerant cooling motor winding should be managed by the microprocessor a sensor installed in the suction housing.

1.13 Control Transformer

The control circuit voltage should be 24 V maximum, supplied by a factory-installed transformer as well as 115 volts for Y D contactors.

1.14 Unit Controls

- General:

1. The chiller shall be equipped with microprocessor control, regulating all unit operating and safety parameters in order to optimise energy efficiency and minimise the risk of the refrigerant circuit shutting down due to a fault.
2. Provide automatic control of chiller operation including compressor start/stop and load/unload, anti-recycle timers, condenser fans, evaporator pump, evaporator heater, unit alarm contacts and run signal contacts.
3. Chiller shall automatically reset to normal chiller operation after power failure.
4. Unit operating software shall be stored in non-volatile memory. Field programmed set points shall be retained in lithium battery backed regulated time clock (RTC) memory for minimum 5 years.
5. Alarm contacts shall be provided to remote alert for any unit or system safety fault

- Display & Key Pad

1. Colour, touch screen display for easy access to all operating parameters. Icon driven menu for self intuitive navigation and display of full test message in English or other language
2. Display and keypad shall be accessible through display access door without opening main control/electrical cabinet doors.
3. Display shall provide a minimum of unit setpoints, status, electrical data, temperature data, pressures, safety lockouts and diagnostics without the use of a coded display.
4. Quick test function to verify correct operation of compressor, fan , electronic expansion valve, probes and sensors for easy & fast commissioning
5. Chiller diagnostics with alarm history for quick trouble shooting and min. 5 alarms current will be displayed.

1.15 Controls Functionality

- Automatic operation

1. The chiller shall be equipped with a programming clock, permitting:
2. On/off control
3. Changeover to the second set point (unoccupied mode)
4. Capacity or current drawn limitation
5. The control shall ensure the following operating modes:
   a. On/off mode based on the outside temperature
   b. Set point reset based on the outside air temperature or the return water temperature

- Remote control

1. The chiller shall include dry contacts permitting:
2. On/off control
3. Capacity or current drawn limitation (one stage)
4. Changeover to the second set point (unoccupied mode)
5. Integration of customer safety device
6. The chiller shall include output contacts permitting:
7. Signalling that the unit is ready to start
8. Signalling the occurrence of a minor incident (alert relay)
9. Signalling the occurrence of a major incident (alarm relay)
10. Water pump on/off control (single or dual pump with automatic changeover)
11. The chiller shall be equipped with an RS485 serial port for remote control via a communication bus.

- Programmable set points (within Manufacturer limits):

a. Display language,
b. chilled liquid cooling mode,
c. local/remote control mode,
d. display units mode,
e. system lead/lag control mode,
f. remote temperature reset,
g. remote current limit,
h. remote sound limit,
i. low ambient temperature cutout enable/disable,
j. leaving chilled liquid setpoint and range,
k. maximum remote temperature reset.

- Display Data:

a. Chilled liquid leaving and entering temperatures;
b. outside ambient air temperature;
c. lead system;
d. evaporator pump status;
e. active remote control;
f. compressor suction, discharge, and oil pressures per refrigerant circuit;
g. compressor discharge, motor, and oil temperatures per refrigerant circuit;
h. saturation temperatures per refrigerant circuit;
i. compressor speed; condenser fan status;
j. condenser subcooling temperature;
k. condenser drain valve percentage open;
l. compressor capacity in percentage of Full Load Amps;
m. compressor number of starts;
n. run time;
o. operating hours;
p. evaporator heater status;
q. history data for last ten shutdown faults;
r. history data for last 20 normal (non-fault) shutdowns.

- Predictive Control Points:

  Unit controls shall avoid safety shutdown when operating outside design conditions by optimizing the chiller controls and cooling load output to stay online and avoid safety limits being reached. The system shall monitor the following parameters and maintain the maximum cooling output possible without shutdown of the equipment.

- System Safeties:

  Shall cause individual compressor systems to perform auto-reset shut down if: high discharge pressure or temperature, low suction pressure, low motor current, high/low differential oil pressure, low discharge superheat, high motor temperature, system control voltage.

- Unit Safeties:

  Shall be automatic reset and cause compressors to shut down if: high or low ambient temperature, low leaving chilled liquid temperature, under voltage, flow switch operation. Contractor shall provide flow switch and wiring per chiller manufacturer requirements.

1.16 Digital Chiller Plant Manager

- A factory-furnished, programmed, microprocessor-based controller shall be provided to supervise and optimize the operation of the individual controllers for each chiller. All application software actually performing the required control functions shall be factory-supplied with the controller and shall be pre-tested and pre-configured.
- The CPM The chiller plant manager shall be provided by the chiller manufacturer and shall optimize performance of the plant under various load conditions. The chiller plant manager shall consider chiller power, condenser fan power in determining the optimum set points and plant operation to arrive at the lowest kw/Tr combination to achieve the defined CHW flow temperatures
- The networked chiller controllers shall interface with a Chiller System Manager (CSM) installed on the network. The CSM shall include software that allows dynamic interaction between the CSM and the chiller controllers to create a complete chilled water plant system as described within this specification. This system shall function to optomise the operation all chiller units in the plant to maximise efficiency
- The CSM shall include inherent input and output capability. The input/output capability shall include as a minimum a combination of standard HVAC sensor inputs (5k, 10k, 4-20mA and discrete) an output to drive an alarm annunciator and/or alarm light, and two analog outputs for differential pressure control. Each analog input channel shall include an operator-adjustable sensor trim (adjustable to 1/10°F) and programmable low and high alarm/alerts, as applicable.
- The CSM shall not interfere with the PIC's stand-alone operating or safety algorithms but shall enhance the operation by providing the following inherent capabilities as a minimum:
    1. Control of up to all chillers (staged or rotary) of equal or unequal sizes
    2. Enable/disable the chiller plant based on its internal time schedules, remote contact closure, analog temperature override, network command, or time schedule override
    3. Chiller fault logic and automatic starting of lag chiller(s)
    4. Automatic alarming and switching to backup sensors if any primary sensor fails
    5. Diverse operator selectable chiller sequences including a sequence with a designated chiller to perform "feathering" functions
    6. Algorithms that properly match the chillers with the load
    7. Chiller inhibit timers
    8. Bypass valve control
    9. kW balancing and ramp loading
    10. Demand limiting
    11. Chilled water reset
    12. Power fail restart
- The CSM shall contain factory-programmed software for the following types of mechanical systems:
    1. Multiple chillers with dedicated chilled water pumps and no secondary piping.
    2. Multiple chillers with chilled water pumps in a parallel arrangement and no secondary piping
    3. Two chillers piped in series with a single chilled water pump and no secondary piping.
    4. Multiple chillers with dedicated primary (production loop) pumps and secondary (distribution loop) pumps piped in a parallel arrangement.
    5. Multiple parallel chillers, common primary pumps, constant flow (common constant speed secondary pumps), variable flow (two-way valves) with a differential pressure valve and bypass line

6. Multiple parallel chillers, common primary pumps, variable flow (two-way valves), with a differential pressure valve and bypass line.

- The controller shall include a 365-day real time clock and watchdog timer diagnostic indicator provided by an LED. The watchdog timer shall reset upon power on and be resettable by software thereafter. Should the watchdog timer not be resettable during the timing period, it shall time out and set all outputs to their non-powered state. The LED shall illuminate solidly to indicate this failure.
- All configuration data will be stored in nonvolatile memory. The controller shall provide a minimum of two days data retention for the time clock.
- The controller shall include the capability to provide a local interface for all operating values, alarms, etc., via a panel mounted, Local Interface Device. The controller shall also be capable of interfacing to a portable PC for configuring or altering the configuration, setting the address, performing uploads/downloads, etc., through a separate, additional RJ14 plug.
- The CSM shall utilize common chilled water supply and return water temperature sensors wired to the CSM as its primary control sensors. An optional load return sensor shall be supplied if the I/O summary requires such or the sequence of operation requires the starting and stopping of equally sized chillers as a function of how much water is being bypassed.
- The CSM shall monitor the status of each chiller's present local/auto selector position, through network communications. Whenever the position is indexed to local, the PIC shall perform its stand-alone control functions. When the PIC is indexed to the local mode the CSM shall determine that the chiller is not available for chiller plant control and shall be bypassed by the CSM. When the mode is indexed to the remote position the chiller PIC shall have the following programs superseded by the CSM:

  1. Lead/lag
  2. Chilled water reset
  3. Remote contact start
  4. Demand limiting

- The CSM shall include the ability to rotate the chiller sequence while chillers are running. If the chiller sequence changes while the chiller(s) are running, the CSM shall start all required chillers before the unneeded chillers are stopped to prevent any interruption in the supply of chilled water to the facility. The CSM shall include the capability to automatically change the rotation based on runtimes and a rotation day and time entered by the operator.
- Occupancy: The occupancy status shall determine when to operate the chilled water plant. When occupied, the chiller plant shall be enabled and when unoccupied, disabled. Occupancy status shall be automatically indexed by any of the following factors:

  1. System Force: A networked force (option module, custom programming in a field-installed controller, etc.) shall override the occupancy until it is autoed or forced to a different value by the operator.
  2. Operator Override: The operator shall have the ability to override the unoccupied mode by entering an override value (0-1-2-3-4 hours) through any of the interface devices. If the timed override option is initiated during an occupied period, the time schedule shall remain occupied for the duration of the time entered. If the operator initiates an override during the unoccupied period, the time schedule shall be indexed to occupied for the duration of the value entered.

3. Occupancy Override: The CSM shall include the ability of monitoring a remote on/off discrete input wired to it. Whenever the switch is indexed to on, the CSM shall index itself to the occupied mode. Refer to the Input/Output Summary and/or the Sequence of Operation to determine if this input is required.
4. Water System Manager (WSM): A WSM shall send an enable signal through the network to index the system to the occupied mode to satisfy the needs of the loads (i.e. Air Handler adaptive optimal start, terminal occupancy timed override).
5. Temperature Override: The CSM shall be capable of monitoring an analog input override sensor (thermistor, or 4-20mA) and shall disable the chilled water plant whenever the system has been indexed to the occupied mode and the override sensor is below its configured setpoint value.

- Time Schedule Occupied:

  When the CSM time of day reaches the operator adjustable occupancy time the CSM shall be occupied. When the time of day reaches the unoccupied time the CSM shall be unoccupied unless one of the above overrides are initiated or a network command has initiated an override.

- Pull-down Timer:

  This delay time shall allow the lead chiller a chance to cool down the building chilled water loop before starting the lag chillers during system start-up.

- Chiller Faulting:

  A chiller shall be considered faulted if a fault status is reported to the CSM by the chiller PIC. Chillers having a communication failure (after the operator adjustable start time value has expired) shall be left in their last commanded state. Chillers faulted for any other reason shall be commanded off. All faulted chillers shall be automatically replaced, if applicable, to maintain on-line capacity.

- Power Fail Restart:

  If the CSM loses power, it shall be capable of selecting one of two different recovery control schemes based on how long the power was off and whether the operator adjustable threshold time has been exceeded. If the power was lost for less than the threshold time, it shall start the chillers at one-minute intervals until the on-line capacity before the power failure is restored.If power was lost for more than the threshold time, the configured pulldown timer shall be skipped and the chillers shall be started at the lag start delay time interval until the load has been satisfied.

- Chiller Inhibit Timers:

  Additional chillers shall not be started if the length of time remaining before the next unoccupied period is less then the input value entered by the operator to avoid starting additional chillers that will be turned off shortly.

- Start/Stop Delay Timers:

  The CSM shall include operator adjustable time delay values to prevent chillers from cycling due to short duration conditions.

- Additional Cooling Required Algorithm (ACR): The starting of additional chillers beyond the lead shall be enabled if the following criteria are met:

1. Supply water temperature is to be used as the control criteria and the ACR temperature sensor is above the current chilled water supply setpoint, plus an adjustable delta temperature value.
2. The pulldown rate is less than 0.5°F/minute for the running chillers.
3. Load Indicator Timer has timed out. (This operator-adjustable value is used by the CSM to determine how long the ACR load indicators must be true before an additional chiller is started).
4. New chiller inhibit timer is not active. (This operator-adjustable value is used by the CSM to determine how many hours before the start of the unoccupied cycle to stop performing the ACR load indicator tests). This shall help prevent the starting of a chiller that will have to be stopped shortly thereafter when the CSM becomes unoccupied).
5. The chiller(s) are not faulted, ramping, or in a power fail restart condition.
6. Resequencing is not occurring.
7. The percent demand limit being sent to all running chillers is above a calculated value.
8. An alarm shall be generated if the algorithm determines that an additional chiller is required to maintain setpoint and no chillers are available

- Reduced Cooling Required Algorithm (RCR):

1. The chiller plant control system shall initiate the shut down of the next chiller in the sequence whenever excess chilled water capacity exists, as determined by percent run load amps / VFD frequency / common water flow sensors, for [20] minutes (adjustable).
2. The CSM shall include a load target equation to determine when a lag chiller shall be stopped. The load target program shall calculate a RCR kW setpoint based on present chiller plant tonnage, capacity of the lag chiller to be stopped, operator-adjustable deadband to prevent short cycling and an operator-entered correction factor to compensate for non-linearities in the relationship between %kW and cooling capacity under low load conditions.
3. If the average %kW for all running chillers is below the corrected RCR kW setpoint, plus the control temperature sensor's value is below the setpoint including an adjustable delta temperature value, and the stop requirements for the delay timers are clear, the next lag chiller shall be stopped.

- CSM User Interface

1. The chiller plant manager shall consist of web server operator interface. A web server shall gather data from chiller plant system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface. Operators with sufficient access level shall have an ability to make changes to all system and equipment graphics in the web server in addition to having full chiller plant system access to make configuration changes to the control system. Any tools required for making graphic changes shall be provided with web server.
2. The Webserver shall have the ability to view and configure the trends, reports and alarms of chiller plant manager.
3. The chiller plant data shall interface with the BMS (Building Management Control System) via open standard BACnet/IP protocol for monitoring.

- Chiller Minimum Flow Bypass Control

1. The chiller minimum flow shall be determined by direct measurement using a flow meter on each chiller. The flow meter setpoint shall be determined based on the manufacturers recommended minimum chiller flow rate. The flow meters shall be supplied and installed by the contractor to the chiller suppliers requirements. The contractor shall co-ordinate with the chiller manufacturer for these requirements
2. For verification of minimum flow the chiller minimum (and in the event of meter failure) the flow shall also be determined based on the pressure drop across the chiller evaporator barrel using a high accuracy pressure differential sensor. The differential pressure setpoint shall be determined based on the manufacturer's chiller pressure drop rating curves.
3. The Chiller Plant Manager shall control the modulation of the Minimum Flow Bypass valve to maintain the required minimum flow of a single chiller under all load conditionsd

EXECUTION

1.17 CHILLER INSTALLATION

- Shipment
  1. The unit shall be completely assembled, with all main, auxiliary, and control piping installed, controls wired, leak tests completed, air runs tested, and charged with dry nitrogen.
  2. The oil charge and miscellaneous materials shall be shipped in the oil sump or packed separately.
  3. The refrigerant charge shall be shipped concurrently or separately in cylinders for field evacuation and charging of unit.
  4. The chillers shall be fully shrink wrapped at the factory before shipment.
  5. Install chillers on support structure indicated.
- Installation
  1. Rig and Install in full accordance with Manufacturer's requirements, Project drawings, and Contract documents.
  2. Locate chiller as indicated on drawings, including cleaning and service maintenance clearance per Manufacturer instructions. Adjust and level chiller on support structure.
  3. Installing Contractor shall provide and install all auxiliary devices and accessories for fully operational chiller.
  4. Coordinate electrical requirements and connections for all power feeds with Electrical Contractor.
  5. Coordinate all control requirements and connections with Controls Contractor.
  6. Installing Contractor shall paint damaged and abraded factory finish with touch-up paint matching factory finish.

1.18 STARTUP SERVICE

- The manufacturer shall furnish a factory trained service engineer to start the units.
  1. A start-up log shall be furnished by the manufacturer to document the chiller's start-up date and shall be signed by the owner or his authorized representative prior to commissioning the chillers.
  2. The manufacturer shall provide two day's of training on chiller operation for facility service personnel Training shall be provided by manufacturers Service Engineer and will occur during regular working hours.
- As a minimum the following start up checks shall be carried out

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

- Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- Prepare test and inspection startup reports.

7.3.33 23 7200 - Air-to-Air Energy Recovery Equipment

GENERAL

1.1 SUMMARY

- Section Includes:
  1. Wrap Around Heat Pipes
  2. Heat wheels.
  3. Fixed-plate sensible heat exchangers.
- Related Sections
  4. 23 0993 - BMS Sequence of Operation for HVAC Controls
  5. 23 7400 - Central Station Air Handling Units and Outside Air Handling Units

1.2 References

- EN 308:Heat Exchangers - Test procedures for establishing performance of air to air and flue gases heat recovery devices.
- Eurovent 8/C/001- Air to Air Plate Heat Exchangers
- Eurovent 8/C/002- Air to Air Rotary Heat Exchanger

1.3 PERFORMANCE REQUIREMENTS

- Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

- Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

  The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 General Requirements

- The manufacturer and specific model offered shall be Eurovent Certified.
- Factory must be ISO-9001 certified.
- The efficiencies of all heat exchangers must be as specified on the drawings and schedules

1.5 Submittals

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

  1. Rated capacities
  2. Sensible and latent Efficiency
  3. Macimum shirt circuit air volume
  4. Operating characteristics
  5. Testing certificates
  6. Detailed assembly drawings
  7. Dimensions
  8. Weights
  9. Required clearances
  10. Method of field assembly
  11. Components
  12. Wiring Diagrams (Power, Signal & Control)

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

1.6 HEAT WHEELS

- General Requirements

  1. Rotating regenerative air-to-air heat recovery units shall transfer sensible or total heat as indicated between the exhaust and intake airstreams.
  2. The thermal wheel manufacturer shall guarantee wheel efficiency and shall provide certified wheel selection and performance curves for approval. The efficiency shall be guaranteed for 5 years with a maximum drop in efficiency of 10%.
  3. Provision shall be made for adjustment of drive belt or drive chain tension.
  4. The complete wheel and motor drive shall be mounted within an air handling unit section. Access doors shall be located on each side of the heat recovery unit in the adjacent intake and exhaust ductwork.

- Performance Requirements

  1. Thermal wheel heat exchangers shall have a minimum thermal efficieny as stated on the equipment schedules.
  2. The unit shall be provided with an adjustable purge sector designed to limit cross contamination to less than 0.04 % of the exhaust air-stream concentration. This

media shall be rigidly held in place. Where heat wheels are provided the AHU in which they are installed is to be internally pressure tested to verify leakage

3. The wheel shall be certified by an independent test laboratory for cross contamination using tracer gas SF6 or equivalent
4. The rotor shall be speed controlled via an inverter allowing a turn down ratio as indicated and shall be suitable for interfacing with the BMS as indicated elsewhere.
5. The maximum rotation speed shall be 20 rpm and maximum face velocity shall be 2.5 m/s

- Construction Requirements

1. Heat wheels shall consist of a rigid mild steel casing protected against corrosion, containing a sectioned wheel composed of aluminium foil or other indicated heat exchange media, treated with a coating having the necessary hygroscopic properties where total heat extraction is specified e.g. pure aluminium treated with anti-corrosion coating, desiccant 3A molecular sieve or equal approved.
2. The coating or the heat exchange media shall not support bacteria, fungi or mould growth and shall be coated to prohibit corrosion.
3. The media shall be easily cleanable and dry particles up to 800 microns, unless stated otherwise, shall pass freely through the media.

1.7 Plate Heat Exchanger

- General Requirements

1. The PHEX shall guarantee efficiency and shall provide certified PHEX and performance curves for approval. The efficiency shall be guaranteed for 5 years with a maximum drop in efficiency of 10%.
2. The unit shall be adequately sealed to prevent leakage or cross contamination.
3. Access doors shall be located on each side of the heat recovery unit in the adjacent intake and exhaust ductwork.
4. The exchanger shall be mounted over a stainless steel removable drain tray.

- Performance Requirements

The minimum thermal efficiency shall not be less than that stated elsewhere.

- Construction Requirements

1. Plate to plate heat exchangers shall be of the diagonal flow type manufactured from separating aluminium plates with a PVC coating or stainless steel plates as indicated elsewhere.
2. The heat exchanger elements shall be designed to withstand the external and differential pressures without deformation.

1.8 Heat Pipes (wrap around type)

- General Requirements

1. Heat pipes shall be included within the AHU and wrapped around the main cooling coil. The wrap-around heat pipes precool the fresh/return air allowing more of the cooling coil surface to be utilized for the removal of moisture. The dehumidified air is then passively reheated by the heat pipe to the supply condition.
2. Heat pipes for enhanced dehumidification will comprise a precool fin block upstream of the main cooling coil linked to a reheat fin block downstream of the cooling coil by means of 'wrap-around' pipes. The heat pipes will be delivered to the AHU

manufacturer fully charged and sealed, for inclusion in the air treatment section of the AHU.

3. A minimum of 100mm gap should be allowed between the leaving face of the cooling coil and the entering face of the heat pipe reheat section. This gap will permit the installation of sensors or other instrumentation to monitor the condition of the air after the cooling coil.
4. Heat pipes shall be formed from an array of complete loops such that the working fluid flows around the loop in only one direction i.e. liquid and vapour flow in the same direction to ensure that returning liquid is not entrained by the vapour.
5. There shall be a multitude of loops in the height of the heat pipe and each loop shall be individually charged. Heat pipes with header assemblies containing a single circuit are not suitable as a single leak will render the entire heat pipe inoperative.
6. When multiple row heat pipes are used the rows shall be connected together in a counter flow orientation to optimize the performance of the heat pipe. Rows shall not be manifolded together.
7. Heat pipe loops shall be arranged to slope down to the precool side to allow gravity assisted liquid return to maximize the internal heat transfer.

- Performance Requirements

1. The minimum thermal efficiency shall not be less than that stated elsewhere.
2. Heat pipe performance shall be independently type tested and certified in line with the requirements of British Standards BS 5141 pt1 or European Standards EN 305 & 306 or American Standards ARI 410 for testing and rating of heat exchangers
3. The number of rows and fins spacing shall be selected at the most common ambient conditions i.e. 33 °C (DB) & 27.5 O C (WB) to achieve the most optimum performance of heat pipe throughout the year

- Construction Requirements

1. Fins

   a. The external fins shall be of aluminium with a minimum thickness of 0.15mm. Fins shall be of the continuous plate type to maximize the external surface area rather the individually finned tube pattern.
   b. The fins shall be of the louvered type to optimize the airside heat transfer and spaced at such a distance as required by the conditions specified.

2. Tubes

   Tubes shall be of refrigeration standard seamless copper C106 for heat exchanger use. Tube diameter shall be 12mm with a grooved inner surface to enhance the internal surface area and prevent pooling of liquid. The minimum root thickness of the tube shall be 0.35mm. The number of rows of tubes shall be selected to suit the application. Multiple row heat pipes shall have tubes in a staggered, equilateral pattern to optimize the airside heat transfer. Tubes and fins shall be provided with electro tined coating and provided with 5 year corrosion warranty.

3. Casing

   a. Casings shall be from stainless sheet steel with a minimum thickness of 1.6mm. The casing shall incorporate tube plates and top and bottom plates around both the precool and reheat heat pipe blocks.

b. Cover boxes shall be provided around the wrap-around pipes both to protect the exposed pipes and to rigidly join the two sections. Extra sheet metal shall be provided to ensure rigidity during manufacture and transport.

4. Working Fluid

a. The working fluid shall be refrigerant type classified as ASHRAE safety group A1. The refrigerant shall be either R134a. The heat pipe circuits shall be factory charged and hermetically sealed with the calculated weight of refrigerant.

EXECUTION

1.9 INSTALLATION

- Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
  1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
  2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
  3. Access doors and panels are specified in Division 23 Section "Air Duct Accessories."
- Equipment Mounting: Install air-to-air energy recovery equipment on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section Cast-in-Place Concrete.
  1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- Install units with clearances for service and maintenance.
- Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
- Pipe drains from units and drain pans to nearest floor drain; use ASTM B 88, Type L (ASTM B 88M, Type B), drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

1.10 CONNECTIONS

- Comply with requirements for piping specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- Install piping adjacent to unit to allow service and maintenance.
- Connect piping to units mounted on vibration isolators with flexible connectors.

7.3.34 23 7400 - Central Station Air Handling Units and Outside Air Handling Units

GENERAL

1.1 SUMMARY

- This Section includes indoor and outdoor, central-station air-handling units for both Air Conditioning and Outside Air Processing with the following components and accessories:
  1. Chilled Water Cooling
  2. Electric-heating coils.
  3. Economizer outdoor- and return-air damper section.
  4. Integral, space temperature controls.
- Related Sections
  1. 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment
  2. 23 0593 - Testing, Adjusting and Balancing for HVAC
  3. 23 0716 - HVAC Equipment Insulation
  4. 23 0800 - Commissioning of HVAC
  5. 23 3416 - Centrifugal HVAC Fans
  6. 23 3413 - Axial HVAC Fans
  7. 23 4000 - HVAC Air Cleaning Devices
  8. 23 4100 - Particulate Air Filtration
  9. 23 7200 - Air-to-Air Energy Recovery Equipment

1.2 References

- BS 848-1 (ISO 5801) - Fans for general purposes. Performance using standardized airways.
- BS EN 12451 - Copper and copper alloys. Seamless, round tubes for heat exchangers
- BS ISO 13347 - Industrial fans. Determination of fan sound power levels under standardized laboratory conditions
- BS EN ISO 5136 - Acoustics. Determination of sound power radiated into a duct by fans and other air moving devices. In-duct method.
- PD 5304 - Safe use of machinery
- BS EN 60529 - Specification for degrees of protection provided by enclosures (IP code)
- BS 5141-1 - Specification for air heating and cooling coils. Method of testing for rating of cooling coils.
- BS 5141-2 - Specification for air heating and cooling coils. Method of testing for rating of heating coils.
- BS EN 10226-1 (BS 21) - Pipe threads where pressure tight joints are made on threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation.
- BS EN 1092 - Flanges and their joints.
- BS EN ISO 1461 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.
- BS EN 779 - Particulate air filters for general ventilation. Determination of the filtration performance.
- BS 5588-9 - Fire precautions in the design, construction and use of buildings. Code of practice for ventilation and air conditioning ductwork.
- BS 476-4 - Fire tests on building materials and structures. Non-combustibility test for materials

- HSE L8 - Legionnaires' disease. The control of legionella bacteria in water systems. Approved Code of Practice.
- CIBSE TM 13 - Minimising risk of legionnaires' disease NFPA Compliance:
- NFPA 90A and NFPA 90B.
- Comply with UL 1995.
- Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.3 General Requirements

- Manufacturer's selections shall be subject to approval by the Engineer. Air Handling unit manufacturers and the specific unit models shall be Eurovent certified and in accordance with the requirements of EN1886.
- The duties and performance of the units shall be in accordance with the details indicated elsewhere and include any allowance required to meet manufacturing tolerances.
- Individual components shall, in addition to the requirements of this section, comply with other relevant sections of this specification.
- Air handling units shall be fully assembled and tested at the manufacturer's works to demonstrate that aerodynamic performance, leakage air flow, design resistance and noise levels are in compliance with the specification and performance requirements.
- The results and a compliance statement shall be submitted to the Engineer prior to delivery to site.
- The contractor shall provide suitable bases and anti-vibration measures as required in the relevant sections of the specification.
- The contractor shall provide power supplies form DBs to all internal AHU lighting and small power supplies. The AHUs lighting and small power systems shall be prewired at the factory to an isolator mounted in the unit.
- The cooling medium is chilled water with the air handling unit cooling coil to be provided with a pressure independent modulating 2-port control valve as indicated on the drawings. The cooling coil shall be provided with stainless steel condensate drain pans and borosilicate condensate traps of sufficient depth of seal to match the internal operating static pressures.
- The Contractor shall replace all air handling unit filters with new panel and bag filters in accordance with the equipment schedules, supplied by the air handling unit manufacturer post commissioning and prior to handover. Return air openings shall be projected during construction with Merv 13.
- The Contractor shall allow for one complete belt/pulley change for fan, to be changed subject to the provision of satisfactory commissioning results (the submitted commissioning figures shall demonstrate that measured air-flow rates are in accordance with the design flow rates).
- Fresh air and exhaust connections shall be provided with tight shut-off dampers arranged to close when the system shuts down unless otherwise stated.

- All necessary penetrations in the air handling unit casing e.g. to accommodate controls items etc, shall be undertaken at the factory. Penetrations shall not be permitted on site.
- The AHUs shall be provided with Variable frequency drives (VFDs) on all fan motors

1.4 Submissions

- The Contractor shall calculate the external static pressure for the each air handling unit supply fan and exhaust/return air fan after finalizing the shop drawings, and prior to selecting the air handling units. The calculations shall be submitted and approved prior to the issue of the air handling unit material submittals.
- Submit the following information, where applicable, to the Engineer for approval in accordance with the requirements of this specification:

  1. Schedule of starting and full load currents
  2. Details of connections for fans
  3. Fan characteristic curves with operating point indicated
  4. Sound pressure spectrums
  5. Vibration mounting details, including isolation efficiency on high and low speed
  6. Coil pressure drops, air side and water side
  7. Coil air on and air off conditions
  8. Coil water on and water off temperatures
  9. Fan motor rating and design absorbed power
  10. Fan and motor speeds
  11. Drive belt sizes
  12. Filter sizes and efficiencies
  13. Fan static and total pressures
  14. External to unit, static and total pressures
  15. Humidifier model and rating
  16. Attenuator insertion losses
  17. Electric heater model and rating
  18. Heat pipe selection details
  19. Heat Recovery selection details

- Fully dimensioned manufacturing drawings shall be submitted to the Engineer of all units for approval prior to manufacture.

PRODUCTS

1.5 CONSTRUCTION

- Units shall be designed and constructed to minimise distortion, damage and drumming in operation and at the maximum pressures generated by the fan operating under closed head conditions.
- Each air handling unit section shall have a heavy duty, fully welded, chassis frame fabricated from rectangular hollow section aluminium steel tube, reinforced and stiffened where necessary to provide a rigid frame work.
- Panels shall be manufactured from heavy gauge galvanised mild steel sheets at least 1.2 mm thick. Panels shall be double skinned with heavy density acoustic and thermal insulation between the skins.
- The casing insulation properties:

  1. Compliant with BS 476 -6 and BS 476-7
  2. CFC and HCFC free

3. Inorganic, vermin proof and non-hygroscopic
4. Unless otherwise indicated, minimum thickness shall be:
5. 50 mm for units 1.0 m^3/s or greater and all external located units
6. 25 mm for units less than 1.0 m^3/s where installed in air conditioned plantrooms
7. Thermal conductivity no greater than 0.03 W/mK

- Casing insulation shall be fixed securely to the panel and protected to prevent migration of fibre into the air flow.
- All insulation components shall be made from materials with zero ozone depletion potential (CFC and HCFC free). Submit to the Engineer, prior to ordering, written confirmation that the products to be installed are CFC and HCFC free.
- For all insulation infill material test evidence must be available and submitted to the Engineer showing that the fibres from which the products are made are not classified as a possible carcinogen as detailed by European Directive 97/69/EC. Fibres shall also comply with the requirements as stated elsewhere and with HSE guidelines. The Insulation shall comply with M1 fire class according to the technical laboratory CSTB
- Each section shall be identified by a clear descriptive label on the external surface.
- Air handling unit sections shall be mounted on a common rolled steel channel base frame construction, completely welded to provide a rigid construction. The clearance between the underside of the AHU and finished grade level shall not less than 300mm.
- Insulation shall be factory applied and contained within an impervious membrane designed to last the life of the AHU.
- Any surface liable to condensation formation shall be insulated and provided with a vapour barrier. Where free moisture may be present, a waterproof membrane shall be provided.
- Readily removable access panels or hinged doors complying with DW/144, incorporating air seals shall be provided to facilitate access to upstream and downstream faces and internal parts of all sections in the AHU.
- Access panels shall be provided wherever indicated on the design drawings and in addition shall be provided to allow all large items of plant such as coils, fans, motors and the like to be easily removed. Access doors shall be of sufficient size to allow reasonable man access and the passage of tools and equipment required for the replacement of these items.
- The overall appearance of the unit, including such access panels, shall be of a flush finish on the top and the sides and varying heights and widths of components will not be allowed.
- Access panels shall be secured with a minimum number of proprietary quick-release captive fastenings consistent with effective air sealing. Hinged doors shall be retained with clamping type latches. Access panels and hinged doors shall be 500mm wide minimum and sized for the full height of the AHU or be 1.35m maximum. Self-tapping screws and set screws are not acceptable as panel fastening. Access doors to components or access chambers shall be fixed with floating hinges as detailed elsewhere and shall be arranged to allow the access door to move away from the unit before the door swings open to prevent damage to the gasket sealing system. The doors shall clamp without imposing a strain on these hinges. All sealants and gaskets shall comply with water research association requirements for the non-support of bacterial growth.

- Protection shall be provided to avoid damage to insulation in sections having walk-in access. Floor decking, suitable for 1.5kN/m2 loading, shall be provided to all accessible sections.
- Sections of AHU's shall be arranged with adequate separation to avoid evaporation of condensate from the cooling coil by the heating coil and generally to promote even air distribution across the face of all components.
- Units shall have corrosion-resistant drain trays of adequate size to collect waste water. These shall be extended as necessary, or other means of collection provided, to drain away any water deposited or condensed in adjacent sections. Drain trays shall be provided with drain connections and traps. Where the drain tray forms the outer surface of the AHU, the outer surface shall be insulated and vapour sealed.
- Airtight sleeves shall be provided for control sensors, instruments and test holes.
- Sections of each air handling unit likely to contain components producing moisture i.e. cooling coils shall have double skinned insulated bottom panels which slope to a plugged drain socket built into the side of the bottom member such that moisture will drain off in the event of an overflow emergency from the normal drip trays. The inner surface of such panels shall be finished with a high build bitumastic sprayed paint.
- Each air handling unit shall be delivered to site and be pre-wired for internally mounted controls and bulkhead lights. Lights shall be installed in the unit within all main sections and shall be of a fully waterproof bulkhead type fully suitable for their application. The lights shall be suitable for a 24 volt AC supply and shall be fully pre-wired to a terminal box and transformer on the outside of the units for connections on site by the Controls Specialist to the relevant motor control centre power ring circuit.
- All such conduits required shall be in galvanised steel. One such junction box will be required per air handler. The air handler manufacturers shall include all necessary pre-wiring and site conduit installations, and the sizing and installation of suitable transformer to accept 220 volt incoming supply.
- Inspection ports shall be no less than 200mm diameter and shall be of the double-skinned type and shall be provided on all main sections of the AHU.
- In addition the air handling unit manufacturers shall liaise with the Contractor to make themselves fully aware of any control items such as temperature detectors, filter pressure switches, air flow switches and the like as required.
- The air handling unit manufacturers shall allow for all necessary pockets or internal pneumatic tubing and shall allow for factory fitting and air testing of the same.
- Finally 50mm screwed fumigation points shall be provided at 2 No. locations (either side of each cooling coil) and these shall be complete with a sealing gasket and blanking cap and be of brass manufacture.

1.6 OUTDOOR UNITS

- AHU's for outdoor installation shall have a weatherproof outer casing, a pitched roof constructed of watertight metal decking with water seals in all joints and lockable access doors.
- Bulkhead light fittings shall be provided in each section with a weatherproof external switch and all wiring in galvanised mild steel conduit. Penetrations through the casing

made for cabling, controls and other ancillary equipment shall be airtight and weather tight and purpose made during manufacture.

1.7 FANS

- The final selection of plant duties by the installer, such as filters, coils, attenuators, diffusers etc., and the actual ductwork fabrication drawings may produce different pressure drops and therefore the installer shall recalculate the total system resistances based on the final selection of plant and revise the fan resistance as necessary to achieve the design air volume flow.
- Fan drives or impellers shall be arranged to allow a 10% variation in airflow either volume flow rate or pressure drop for final site adjustment as agreed with the Engineer. A set of replacement belts and pulleys shall be provided for each AHU and fitted where required at no additional cost to the contract.
- All fans shall be tested in accordance with BS 848 - 1 and BS ISO 13347. Fan impellers shall be statically and dynamically balanced at the works of the manufacturer and test certificates issued to the Engineer.
- Manufacturer's test certificates, acoustic data and fan curves shall be submitted to the Engineer. Fan curves shall indicate performance under all likely operating conditions.
- Centrifugal fans shall be belt-driven unless otherwise stated.
- Fans shall generally be of the high efficiency (minimum 75% efficiency) backward curved bladed type, double inlet double width and for casings shall be of the lock-form casing type, all welds heavy sheet steel, or split flanged type on the larger fans, adequately braced and stiffened with steel angle with the bottom of the discharge outlet level with the axis of the impeller.
- Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- Fans shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty, during starting, during stopping and during speed and duty changes. Belt-driven fans shall be capable of running continuously at 10% in excess of the selected duty speed and shall have a minimum of two belts.
- Fan casings shall be rigidly constructed and stiffened and braced where necessary to prevent drumming and vibration.
- Fans shall be installed using bolts, nuts and washers with all nuts properly locked and secured. All 'as cast' bearing surfaces for bolt heads and washers shall be machine counterfaced. Holding-down bolts for fans and motors shall be provided with means to prevent the bolts turning when the nuts are tightened. Anti-vibration mountings shall be provided. Fans heavier than 20kg shall be provided with eyebolts or other safe means of lifting.
- Fan bearings shall be of a type suitable for the size, speed, loads and discharge angle of the fan and shall be greased/oil ball and/or roller type, oil lubricated sleeve type or sealed type. Bearing housings shall be precision aligned and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust. For grease lubricated systems, the bearings shall be provided with grease in the quantity and quality recommended by the bearing manufacturer. Oil lubricated systems shall have an adequate reservoir of oil. All bearing lubricators shall be located to facilitate maintenance.

- Provisions shall be made for inspection and removal of internal components including impellers and motors. Casings shall have an access panel incorporating an air seal to facilitate cleaning and maintenance. The inlet and outlet of duct mounted fans shall be flanged to facilitate fixing and removal.
- Mounting feet shall be provided where necessary for bolting to a base or supports.
- Finishes and materials of construction shall be suitable for the operating conditions. Mild steel components shall be protected against corrosion.
- Safe access shall be provided to roof mounted fans for inspection and maintenance.

1.8 Belt Drivers

- Belt drives shall comply with BS 3790 and be capable of transmitting at least the rated power output of the driving motor at any stage of operation with one belt removed. Unless otherwise indicated, not less than two belts per drive shall be used and all multi-belt drives shall use matched sets. Belts shall be of rubber and fibre V section unless otherwise indicated.
- Pulleys shall be correctly aligned in accordance with the manufacturer's requirements.
- Where duplicate motors are provided and fixed, the spare motor shall be complete with an adjusting device to allow belt tensioning and shall be in all respects ready for operation. The centre-to-centre dimensions between the common driven pulley and the duplicate driving pulleys shall be the same.
- Provision shall be made to permit drive alignment and adjustment of belt tension.

1.9 AIR FILTRATION

- Filters within air handling units shall be as detailed elsewhere and shall operate with not less than the efficiencies specified.
- Filter performance shall be measured in accordance with Eurovent standard 4/5 and BS EN 779. Air velocity at the filter face shall not exceed 2.5m/s and panel and bag filter shall be provided within each AHU.
- High efficiency filters shall be having average synthetic dust arrestance efficiency not less than 95% to ASHRAE 52-76 standard. Filters shall be listed by Underwriters Laboratories as class 2.
- Filters classes shall be selected to suit the application. Where panel and bag filters are fitted in series the minimum class provided shall be:
- Panel Filters
  1. The average arrestance shall be 87% when tested in accordance with BS EN 779 clause G3 or G4 as stated elsewhere.
  2. Final pressure drop shall not exceed: 170Pa clean and 250Pa dirty.
- Bag or Extended Surface Type Filters
  1. The media cartridge shall be pre-formed and shall be in accordance with BS EN 779 class F7 with an average efficiency of 80-90% or class F9 with an average efficiency of 95% as indicated elsewhere.
  2. Final pressure drop shall not exceed: 250 Pa clean and 350 Pa dirty.
  3. Filters shall be fully self-supporting without external ties or stiffening frames. Filters shall inflate fully, shall not sag or flutter, nor have effective medium area reduced by

obstruction due to contact with other filter faces or housing surfaces when operating between 60% and 110% of design air volume flow rate for fixed volume systems.

4. Filter length shall not exceed 760mm.

- General

1. Filter material or wetting agents shall not be carried over in the air stream.
2. Adequate access shall be provided for removal and refitting of filter cells or replacement of gaskets in filter holding frames.
3. Filter differential pressure indication shall be provided for each filter assembly.
4. Filter assemblies including casings, filter media, protective cappings and sealing gaskets shall be of materials compatible with the system operating environment. Casings shall not warp, splinter or corrode.
5. Filter cell holding frames shall be purpose-made from non-ferrous metal, plastic, or steel protected against corrosion, of adequate strength and stiffened to prevent distortion in use.
6. Holding-down frames shall be capable of retaining air filters in a rigid manner and shall be securely fixed in position with all edges and joints effectively sealed to prevent air leakage.
7. Purpose-made gaskets shall be provided to minimise air leakage around the filters. The effectiveness of the seal shall not be impaired by removal and refitting of filter cells. Gasket material shall be fitted in the holding frames.
8. Retaining clips, or other securing devices, shall be capable of pulling the filter on to its seating and shall exert equal pressure on all faces.
9. The air handling unit manufacturer should specifically note the requirements for access for filter removal and he shall allow for providing suitably calibrated pressure differential gauges to the filter sections which shall be fully pre-piped and fitted to the air handling unit frames in addition to the electronic sensors mentioned earlier. These gauges shall be complete with engraved marker plates positioned alongside to detail filter normal and dirty pressure drops and shall also be engraved on the gauge themselves with the dirty pressure drop.
10. The air handling manufacturer shall include for a complete set of filters for installation following commissioning and a complete set of spare filters which shall be handed over to the Client at project handover for installation into the air handling units.
11. The Mechanical Sub-Contractor shall include for the removal and disposal of the dirty filter media and for the installation of the clean filter media when the Project is handed over.

- Fire Properties

1. Filter media (other than for adsorption filters), all materials of construction, adhesives, coatings and wetting agents shall permanently retain self-extinguishing properties. Surfaces of filters shall be non flammable.
2. When exposed to heat or flame, the filter shall not generate significant quantities of smoke or toxic fumes into the air stream. In no case shall the total toxic vapour emission into the air stream, calculated over a period of 10 minutes, result in the 10 minute exposure level of any toxic constituent, being exceeded.
3. Where flameproof filters are used, the frames, casings and filter cell holding frames shall be classified non-combustible.

1.10 COOLING COILS

- Coils shall be selected and located to ensure the full design air flow is evenly dispersed across the full coil face area.

- Coil design and sizing shall be based on figures obtained from performance tests described in BS 5141 for cooling and heating coils.
- To combat the area acid and salt atmospheric conditions the unit cooling coils assemblies shall protected against corrosion. The coils shall have a warranty of 10 years against corrosion. Acceptable methods of protection are as follows:
  1. Copper Coils, Copper Fins: Electro-tinned
  2. Copper Coils, Copper Fins: Factory Applied Heresite
  3. Copper Coils, Copper Fins: Factory Applied Bly-Gold
  4. Copper Coils, Aluminum Fins: Factory Applied Heresite
  5. Copper Coils, Aluminum Fins: Factory Applied Bly-Gold
- Watertight drain trays shall be provided and fabricated from stainless steel.
- Intermediate drain trays shall be provided where the coil height exceeds 950mm. The general arrangement shall ensure that collected water is drained towards one end of the tray and through the lowest point in the tray to the lower tray, via a down pipe, without splashing. Further drain trays shall be provided for each additional 950mm of coil height.
- Eliminator sections shall be positioned to avoid damage from adjacent heating coils and shall be of materials unaffected by such heat.
- Coils shall be arranged to provide equal fluid flow through all coil circuits. Multi-row coils shall be arranged in contra flow with the water entering at the air leaving end and leaving at the air entering end. The flow and return coil connections shall be labelled and the air flow direction shall be indelibly marked on the coil casing. Coils shall be eight rows maximum depth.
- Heat exchanger finned surfaces shall extend for the full width of the coil casing except where baffles, suitably protected against corrosion, are provided to prevent air by-passing the finned surface. Sealing devices shall be fitted to top and bottom of coils to prevent air by-pass and water carry-over.
- Fins shall make firm and continuous contact with the primary tubes. Where more than one primary tube is required, tube rows shall be staggered in the direction of air flow to maximise heat transfer and provide even air distribution across the face of the coils.
- The completed battery shall be tested to 210kPA air under water after manufacture and shall be hydraulically tested and certified to 21 bar.
- Batteries mounted in ductwork shall be supported so that the ductwork does not take the weight.
- Chilled water cooling coils and access sections shall be lined with polished 304 stainless steel with manually operated isolating dampers on the access sections. Isolation dampers shall be tight shut off type construction with polished 304 stainless steel and the cooling coil shall be constructed with copper tube and copper fins electro-tinned after manufacture. The cooling coil section must have an easily removable and oversized polished 304 stainless steel drain trays. The drain tray serving the cooler shall be extended or a separate tray shall be provided to collect water from the eliminator. Drain trays shall be sloped to fall (1 in 20) towards a flush drain connection so that no water is retained in the drain tray. A pipework drain connection, complete with quick-release refillable trap, shall be extended from the lowest point on the underside of the tray to the nearest sump or gully to discharge through an air break. A water seal of sufficient depth shall be provided to prevent entry or exit of air to or from the system and additionally maintain a 75mm seal when the plant is de-energised. The distance between the

underside of the tray and the crown of its trap is to be sufficient to ensure the tray is fully drained during operating periods.

- The coils shall be easily removable to facilitate regular cleaning and the limiting of legionella growth risk.
- On large coils constructed in two horizontal sections they shall have separate connections headers and shall be assembled correctly to ensure that the top section condensate flows evenly onto the lower section. Where this is not possible a separate condensate baffle/catch plate shall be installed with a separate condensate baffle/catch plate shall be installed with a separate drain to the coil drain pan.
- Face velocities across the cooling coil shall not exceed 2.25 metres per second and the maximum pressure drop across the cooling coils shall not exceed 100 Pa (air side) and 30kPa (water side). The cooling coil shall be fabricated from a stainless steel casing and mounted on slide tracks for future coil removal.
- Header connections on CHW cooling coils shall be screwed to up to and including DN 50 and flanged for DN 65 and above.
- Screwed connections shall be made using ground-in spherical seated unions.
- Water coils shall have a means of venting and draining.
- Isolating valves shall be provided on the inlet and outlet connections arranged to facilitate removal of the coil. Steam coils shall have an air release tapping.
- Accessible temperature sensor pockets shall be provided to all flow and return headers for monitoring purposes.
- Water coils shall have self-sealing test points on the inlet and outlet connections to each water coil.
- Coils shall be supported so that their weight is not transmitted to ductwork or pipework and so that removal can be achieved without disturbing adjacent ductwork and other services.
- Minor damage to fins shall be rectified by combing. Coils with extensively damaged fins shall be replaced where damage results in an increase in pressure drop of greater than 10% of the design value.
- Coils shall be tested before leaving the manufacturer's works. A test certificate shall be provided for each coil.
- Each water coil shall be tested for leaks by using air under water to 1.5 times the working pressure or 8 bar gauge pressure, whichever is greater, for 30 minutes.
- Each steam heating coil shall be hot soaked for 1 hour followed by live steam purged for 30 minutes at a minimum pressure of 140 mbar gauge and then tested for leaks by using air under water as for water coils.
- Each direction-expansion refrigerant cooling coil shall be tested for leaks by using air under water to 19 bar gauge pressure for 30 minutes.

1.11 Electric Heater Batteries

- Electrical heater batteries shall consist of a number of heating elements of the enclosed type mounted in a sheet steel casing. Elements shall be so arranged to permit removal without dismantling

- Unless otherwise indicated the resistance to the air flow through the battery shall not exceed 25 Pa and the face velocity shall not exceed 6m/s nor be less than 2m/s.
- An isolator and a hazard warning sign clearly indicating the operating voltage shall be fitted immediately adjacent to the heater access opening.
- In the proximity of hot areas, the electrical wiring insulation shall be suitable for the maximum temperature.
- The connections from each element shall be extended to a terminal box housed in an accessible position with conduit/cable entry provision. They will be secured to the terminal box with air tight glands and will be linked with either copper busbars or terminals as necessary to achieve step control requirements stated elsewhere.
- The number of elements in the heater shall be the same as or a multiple of the number of steps in the controller. All heaters and heater sections of more than 3kW loading shall be balanced over three phases and the complete heater bank shall be arranged for balanced operation on a three-phase, four-wire system.
- The elements shall be equally spaced over the open duct area.
- The whole unit will be housed in a casing manufactured to the same dimensions as the air handling unit.
- Each electrical heater battery shall be complete with a manually reset thermal cut that provides an audible or visual alarm signal on high temperature cut-out as indicated elsewhere.
- Unless otherwise indicated, the control of electrical heater batteries, except for remote boosters, shall be interlocked with the system fan motor starter and an air flow sensing device to ensure that the heater operates only when the fan is running and air flow is established. Capacity control shall be via thyristor.
- Electrical heater batteries which are installed as boosters in branch ducts shall each have a local air flow sensing device to ensure that the heater operates when air flow is established.

1.12 Condensate Drains

- Provide condensate drains to all cooling coils, humidifier sections and recuperator sections of the air handling units.
- Condensate drains shall be run in a safe manner to discharge over an appropriate gully or to a sump as indicated.
- Connections shall be made by the installer, with glass "U" traps having a water seal depth of not less than twice the fan static pressure, together with a tapping for maintaining the water seal. Where necessary the trap shall be protected against accidental damage.
- The drains shall discharge into a copper turndish.
- Drains on pans under negative pressure are to have the outlet positioned low enough to prevent condensation being held in the drip tray.
- Where drains have to run across a walkway the installer shall provide a permanent step over.
- Drains shall comply with recommendations in CIBSE Technical Memorandum TM13 and HSE L8 in connection with Legionnaires' disease.

1.13 DAMPERS

- Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with motorized damper filter. Motorised dampers shall be of the multi-leaf type. Blades shall be limited in length to prevent twisting, vibration or binding during operation. Each set of blades shall interlock when closed. Blade attachment to spindles shall be by a positive mechanical connection. Spindles shall be mounted in bearings.
- Dampers to be mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
  1. Damper Motor: Modulating with adjustable minimum position.
  2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1-2004, with bird screen and hood.
- Damper assemblies shall be of corrosion resistant materials to suit the application and shall be electrolytically compatible.
- Motorised dampers shall be constructed to withstand the differential pressures without permanent distortion and when the dampers are closed.
- Damper leakage shall not exceed 20 l/s.m2 at 500 Pa.
- Linkage systems shall transmit torque to blades so that they move equally. Linkage system shall be arranged to eliminate any 'slack' movement. Linkage systems type shall be geared.
- Damper actuators shall be of the direct-coupled direct-transmission type, clamped to the blade spindle and secured to prevent motor rotation. A rigid mounting bracket shall be provided for each damper actuator. Each damper module shall have at least one actuator and where more than one actuator is provided their operation shall be synchronised.
- Dampers shall be sized to provide a linear characteristic over the full operating movement of the damper, unless otherwise indicated.
- The fresh air intake exhaust air, isolation damper blades, mechanisms and frames shall be made from stainless steel (316L) and shall be parallel double skin aerofoil blade (maximum closed leakage at system pressure of two percent). Parallel blade dampers are required for linear control characteristics.
- All dampers shall be air tight shut off, to assist with building air leakage testing.
- All motor drives for dampers shall be mounted external to the air handling units.
- The Contractor should note that the dampers may require multiple actuators, and they shall be costed for after consultation with the AHU supplier. Where multiple actuators are required it may also be necessary to sequence the operation of the damper. The Contractor shall liaise with the Controls Specialist to ensure that this is included, where required.
- All mixing damper arrangements shall be as detailed above, using opposed double skin aerofoil blades.

1.14 AHU Internal Vibration Isolation Devices

- The AHU shall have internal spring mounts fitted below the fan frame having a static deflection of not less than 25mm.

- The selection of vibration isolation systems shall allow for forces and movement due to pressure differences at flexible connections. Mountings shall be laid out and sized for their loadings at all operating speeds.
- Spring type vibration isolators shall be constructed from suitably treated and finished steel or steel alloys. They shall be manufactured with rubber, neoprene or fiberglass acoustic pads' to prevent transmission of high frequencies. The material of the pad shall be selected to suit the location. Holes shall be provided for fixing both to the supported machine and the supporting structure.

1.15 AHU External Vibration Isolation Devices

- AHU anti vibration control to be as per Section 23 0548 - Vibration and Seismic Controls for HVAC Piping and Equipment of this specification.
- The AHU casing shall be mounted on ribbed neoprene pad having a static deflection of 2 to 3mm.
- The material used for 'pad' or 'mat' type mounting may be cellular, ribbed, or studded. Pads and mats shall normally be bonded both to supported and to supporting surfaces. Material and bonding agent shall be resistant to lubricating oil and water.
- The pad materials shall comply with all relevant local fire regulations

1.16 ELECTRICAL POWER CONNECTION

- Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

1.17 CONTROLS

- Control equipment and sequence of operation are specified in Division 23 Section "Instrumentation and Control for HVAC."

EXECUTION

1.18 Outside Air, Air Handling Unit Particular Requirements

- Ventilation air handling units shall typically operate at constant volume but shall be provided with VFDs on supply and return/exhaust air fans for initial commissioning, adjustment of pressure to filter condition and for night/unoccupied set back operation.
- Each air handling unit shall be provided with duct mounted attenuator on supply, return, fresh and exhaust air as indicated on the drawings to ensure served spaces comply with specified noise criteria.
- The air handling units comprise:-

1. Supply Air Section

   a. Fresh air intake c/w motorised damper.
   b. Pre filter (G4)
   c. Bag filter (F7)
   d. Heat Recovery Device
   e. Cooling Coil (Chilled Water)
   f. Secondary Heat Recovery Device
   g. Belt driven centrifugal supply fan
   h. Access sections
   i. Controls Sensors as noted on the BMS drawings

2. Exhaust Air section shall

   j. Pre filter (G4)
   k. Heat Recovery Device
   l. Secondary Heat Recovery Device
   m. Belt driven centrifugal extract fan
   n. Controls Sensors as noted on the BMS drawings
   o. Access sections
   p. Motorised damper

1.19 Supply-only Make-up Air Units

- Full fresh air make up air handling units shall typically operate at constant volume but shall be provided with VFDs on the supply for initial commissioning and for adjustment of pressure to filter condition and for night/unoccupied set back operation. The AHUs shall be interlocked with exhaust fans as described in the BMS section of the specifications.
- Each air handling unit shall be provided with duct mounted attenuator as indicated on the drawings to ensure served spaces comply with specified noise criteria.
- The air handling units shall typically comprise:-

  Supply Air Section

  a. Fresh air intake c/w motorised damper.
  b. Pre filter (G4)
  c. Bag filter (F7)
  d. Pre Cool heat pipe (R134a)
  e. Cooling Coil (Chilled Water)
  f. Re Heat pipe (R134a)
  g. Belt driven centrifugal supply fan
  h. Controls Sensors as noted on the BMS drawings
  i. Access sections

1.20 Installation

- Units shall be installed on concrete frames or steel sub frames as indicated with vibration isolation devices
- Unless otherwise indicated, there shall be a clearance of at least 150mm between the underside of the AHU and its base or the plant room floor. The bottom of the unit shall be located at such a height that an adequate water seal, to suit the air pressure inside the unit, can be provided on coil drains.
- Supplementary steelwork necessary to support the unit shall be provided by the installer. The steelwork shall be galvanised after manufacture and painted to match the air handling unit.
- Pipework and electrical cable entry points to the unit shall be sealed after installation to maintain the air-tightness of the unit.
- External connections passing through panels shall be provided with flexible air tight gaskets.
- Airtight sleeves shall be provided for control sensors, instruments and test holes
- The discharge ductwork connection shall be suitable to maintain the aerodynamic performance of the fan.

1.21 Acoustic Testing

- Unless otherwise stated, sound pressure levels shall be measured in all spaces containing supply or extract terminals, all plantrooms, all rooms immediately adjacent to plantrooms and all rooms located above or below plantrooms.
- The results shall incorporate a spectrum band analysis made at octave band centre frequencies from 63 Hz to 8k Hz. Results shall be both tabulated and plotted on NR curves.
- Noise readings shall be taken at the site boundaries and adjacent facades to demonstrate the acoustic performance of the systems complies with the noise levels stated elsewhere.
- Locations for noise readings shall be agreed with the Engineer prior to measurements being undertaken.
- Measuring of environmental noise shall be in accordance with BS 4142 and the local authority guidelines.
- All measurements undertaken to demonstrate compliance with the specification shall be performed using sound measuring equipment conforming to BS EN 61672 and other relevant standards.
- Calibration certification for all measuring equipment shall be submitted to the Engineer prior to measurements being undertaken.
- Duplicate records of all such shall be provided to the Engineer within 3 days of testing and copies included in the operating and maintenance documentation. All records shall be signed by a competent person and witnessed. Results shall be submitted to the Engineer for examination before any system is offered for final acceptance.
- Any witnessing or independent checking by the Engineer shall be carried out solely at the discretion of the Engineer as considered necessary.
- All necessary apparatus, measuring equipment, instruments, and meters required for acoustic testing of the Works shall be provided by the installer at no additional cost.

1.22 QUALITY ASSURANCE

- Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-87.
- Constant Volume Air Handling Units: Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430.

1.23 REGULATORY REQUIREMENTS

- Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.24 DELIVERY, STORAGE, AND PROTECTION

- Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

- Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
- Deliver products to site under provisions of Section 1 and Section 22. Units shall ship fully assembled on factory- installed base rails up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Each section shall have lifting lugs or shipping skid to allow for field rigging and final placement of section.
- Deliver units to site with fan motors, sheaves, and belts completely assembled and mounted in units.
- Store and protect products under provisions of Section 1 and Section 22.
- Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.25 OPERATION AND MAINTENANCE DATA

- Submit operation and maintenance data under provisions of Section 1 and this Division.
- Include instructions for lubrication, filter replacement, motor and drive replacement, belt tension adjustments, and wiring diagrams.

1.26 ENVIRONMENTAL REQUIREMENTS

- Do not operate units for any purpose, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.27 EXTRA MATERIALS

- See Section 01 - Product Requirements, for additional provisions.
- Supply one set for each unit of fan belts.

1.28 WARRANTY

- See Section 01 - Closeout Submittals, for additional warranty requirements.
- Provide five year manufacturer warranty for air terminal units and integral controls.

7.3.35 23 8126 - Split System Cooling

GENERAL

1.1 SUMMARY

- Section Includes:
  1. Air cooled condensing units.
  2. Indoor air handler (fan & coil) units for duct connection.
  3. Controls.
  4. Refrigerant Unit.

5. Computer Room Air Conditioning Units (CRAC) Units

- Related Sections:

1. Section 22 1005 - Plumbing Piping: Indoor coil condensate drain.
2. Section 22 1005 - Plumbing Piping: Water supply for humidifier.
3. Section 23 3100 - HVAC Ducts and Casings.
4. Section 23 0913 - Instrumentation and Control Devices for HVAC: Thermostats, humidistats, time clocks.
5. Section 26 2726 - Equipment Wiring: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

1.2 REFERENCES

- ASHRAE Std 15 - Safety Standard for Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2007.
- ASHRAE Std 23 - Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2005.
- ASHRAE Std 90.1 - Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2004.
- ASHRAE Std 90.2 - Energy-Efficient Design of New Low-Rise Residential Buildings; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2007.
- NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems; National Fire Protection Association; 2002.
- NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association; 2006
- UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical; Underwriters Laboratories Inc.; 2001.
- BS EN 378-1 to – 4 Refrigerating systems and heat pumps - Safety and environmental requirements.
- BS EN 12263:1999 - Refrigerating systems and heat pumps. Safety switching devices for limiting the pressure. Requirements and tests
- BS EN 1861:1998 - Refrigerating systems and heat pumps. System flow diagrams and piping and instrument diagrams. Layout and symbols
- BS EN 12284:2003 Refrigerating systems and heat pumps. Valves. Requirements, testing and marking
- BS EN 12693:2008 Refrigerating systems and heat pumps. Safety and environmental requirements. Positive displacement refrigerant compressors
- BS EN 1736:2008 Refrigerating systems and heat pumps. Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes. Requirements, design and installation
- BS EN 13313:2010 Refrigerating systems and heat pumps. Competence of personnel

- BS EN 16084:2011 Refrigerating systems and heat pumps. Qualification of tightness of components and joints
- BS EN 14276-1:2006+A1:2011 Pressure equipment for refrigerating systems and heat pumps - Vessels. General requirements
- BS EN 14276-2:2007+A1:2011 Pressure equipment for refrigerating systems and heat pumps - Piping. General requirements
- BS ISO 14903:2012 Refrigerating systems and heat pumps. Qualification of tightness of components and joints
- BS EN 14624:2012 Performance of portable leak detectors and of room monitors for halogenated refrigerants
- BS ISO 13971:2012 Refrigeration systems and heat pumps. Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes. Requirements and classification
- BS EN 378-1:2008+A2:2012 Refrigerating systems and heat pumps. Safety and environmental requirements - Basic requirements, definitions, classification and selection criteria
- BS EN 378-3:2008+A1:2012 Refrigerating systems and heat pumps. Safety and environmental requirements - Installation site and personal protection
- BS EN 378-4:2008+A1:2012 Refrigerating systems and heat pumps. Safety and environmental requirements - Operation, maintenance, repair and recovery
- BS EN 378-2:2008+A2:2012 Refrigerating systems and heat pumps. Safety and environmental requirements - Design, construction, testing, marking and documentation
- BS EN 12178:2003 Refrigerating systems and heat pumps. Liquid level indicating devices. Requirements, testing and marking
- BS ISO 17584:2005 Refrigerant properties

1.3 SUBMITTALS

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

  1. Rated capacities
  2. Operating characteristics
  3. Testing certificates
  4. Detailed assembly drawings
  5. Dimensions
  6. Weights
  7. Required clearances
  8. Method of field assembly
  9. Components
  10. Wiring Diagrams (Power, Signal & Control)

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

1.4 QUALITY ASSURANCE

- Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- Installer Qualifications: Company specializing in performing the work of this section with minimum five years of experience and approved by manufacturer.

1.5 EXTRA MATERIALS

- See Section 01 - Project Requirements, for additional provisions.
- Provide two filters for each indoor unit.
- Provide two pilot thermocouples.

PRODUCTS

1.6 SYSTEM DESIGN

- Split-System Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
  1. Cooling electric condensing unit with evaporator coil in central ducted unit
  2. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- Performance Requirements: See Drawings for additional requirements.

  Efficiency: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1; seasonal efficiency to ASHRAE Std 103.

1.7 INDOOR UNITS FOR DUCTED SYSTEMS

- Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
  1. Air Flow Configuration: Horizontal.
  2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
- Supply Fan: Centrifugal type rubber mounted with direct or belt drive with adjustable variable pitch motor pulley.

  Motor: NEMA MG 1; 1750 rpm single speed, permanently lubricated, hinge mounted.
- Air Filters: 25 mm thick urethane, washable type arranged for easy replacement.
- Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
  1. Construction and Ratings: In accordance with ARI 210/240 and UL listed.
  2. Manufacturers: System manufacturer.
- Operating Controls:

  Control by room thermostat to maintain room temperature setting.

1.8 Wall-Mounted, Evaporator-Fan Components:

- Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
- Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
- Fan: Direct drive, centrifugal.
- Fan Motors:
  1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  2. Multitapped, multispeed with internal thermal protection and permanent lubrication.
  3. Retain first subparagraph below if enclosure is not open-dripproof type. Retain second subparagraph for premium efficiency.
  4. Enclosure Type: Totally enclosed, fan cooled.
  5. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
  6. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  7. Mount unit-mounted disconnect switches on [exterior] [interior] of unit.
- Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- Condensate Drain Pans:
  1. Fabricated with onepercent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
     b. ASHRAE compliance option in "Length" Subparagraph below may be required to comply with Project requirements or authorities having jurisdiction. Retain option in first subparagraph to comply with LEED Prerequisite IEQ 1; otherwise, insert distance.
     c. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1
     d. Depth: A minimum of 1 inch (25 mm)
  2. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
  3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on [one end] [both ends] of pan.
     e. Minimum Connection Size: NPS 1 (DN 25).
- Air Filtration Section:
  1. General Requirements for Air Filtration Section:
     a. Comply with NFPA 90A.
     b. Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
     c. Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
  2. Disposable Panel Filters:

a. Factory-fabricated, viscous-coated, flat-panel type.
b. Thickness: 1 inch (25 mm).
c. Media: Interlaced glass fibers sprayed with nonflammable adhesive[and antimicrobial agent].
d. Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

1.9 OUTDOOR UNITS

- Units shall be assembled on heavy gauge steel mounting/lifting rails and shall be weather proofed.
- Units shall include hermetic scroll compressors, plate fin condenser coils, fans and motors, control and holding charge of nitrogen. Operating conditions shall be between 10°C and 50°C. Units shall be UL listed, certified and rated in accordance to ARI Standard 340/360 or 365.
- Outdoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, with compressor and condenser.
  1. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
  2. Construction and Ratings: In accordance with ARI 210/240 with testing in accordance with ASHRAE Std 23 and UL listed.
- Compressor: ARI 520; hermetic, two speed 1800 and 3600 rpm, resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- Air Cooled Condenser: ARI 520; Aluminum fin and copper tube coil, with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
- Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gage ports, thermometer well (in liquid line).

  Provide thermostatic expansion valves.
- Operating Controls:

  Control by room thermostat to maintain room temperature setting.
- Mounting Pad: Pre-cast concrete parking bumpers, minimum 100 mm square; minimum of two located under cabinet feet.

1.10 ACCESSORY EQUIPMENT

- Humidifiers: ARI 610; wetted plate, pan type with float controlled water supply, thermoplastic water pan for mounting on furnace return air plenum.
  1. Duct Connection: 6 inches (150 mm) diameter flexible duct, starting collar and damper.
  2. Accessories: Permanently lubricated synchronous low voltage motor, transformer and wiring harness, and replaceable evaporator media.
  3. Water Supply Tubing: Copper or plastic; include saddle valve.
- Room Thermostat: Wall-mounted, electric solid state microcomputer based room thermostat with remote sensor to maintain temperature setting; low-voltage; with following features:

1. System selector switch (on-off-auto) and fan control switch (auto-on).
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set-up for four separate temperatures per day.
4. Instant override of set point for continuous or timed period from one hour to 31 days.
5. Short cycle protection.
6. Programming based on weekdays, Saturday and Sunday.
7. Selection features including degree F or degree C display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.
8. Battery replacement without program loss.
9. Thermostat display:

   e. Time of day.
   f. Actual room temperature.
   g. Programmed temperature.
   h. Programmed time.
   i. Duration of timed override.
   j. Day of week.
   k. System mode indication: cooling, fan auto, off, and on, auto or on, off.

1.11 REFRIGERATION SYSTEMS

1. Mechanical vapour compression refrigeration plant shall use hydrofluorocarbons (HFC) or other refrigerant having zero Ozone Depletion Potential (ODP). Any refrigerant used shall be fully compatible with all materials comprising the complete refrigeration system.
2. Operatives engaged on work to refrigeration systems shall be registered with ACRIB as registered Safe Refrigerant Handlers. Operatives shall have a Certificate of Achievement for Safe Handling of Fluorocarbon Refrigerants showing the registration reference number and date of registration. The operative shall also be registered to International Standards to be approved by the Engineer.
3. The plant shall include all accessories necessary to ensure continuous and reliable automatic operation. The design maximum cooling rate shall be achieved at the maximum design ambient conditions. Each unit shall be capable of running continuously at the lowest step of cooling capacity without any adverse effect. Plant shall be charged with lubricant, and be provided with a holding charge of refrigerant or inert gas before dispatch from the manufacturer's works where a full charge is impractical.
4. All parts of refrigerant gas cooled motors shall be proofed against long-term contact with refrigerants and compressor lubricating oil.
5. The motor of a compressor which is refrigerant gas cooled shall have in-built protection against inadequate cooling.
6. All compressor motors shall be protected from current overload by thermal overloads, of appropriate rating, forming part of the starter contactor. Separate overloads shall be arranged to protect each phase of three phase supplies, both windings of dual wound motors and part windings in motors arranged for part wound start.
7. The oil pump of three-phase semi-hermetic and hermetic compressors shall, either operate equally well under each direction of rotation, or the compressor motor have special arrangements made to prevent reverse rotation.
8. Every individual refrigeration circuit shall be protected by:
9. All refrigerant circuits shall be provided with high pressure relief valves from the high and low pressure side, constructed so that pressure due to fire conditions would be safely relieved. High pressure relief valves, two at each location, shall be installed

on a manifold with isolation valves, to allow each valve to be independently removed for testing and maintenance purposes, without loss of refrigerant.

10. The means of discharge and equipment provided shall comply with BS EN 378, the Pressure Equipment Directive and this Specification, with the outlet piped to discharge outside the building in a safe location.
11. High and low refrigeration pressure safety cut-outs with adjustable differential and set point with hand reset to the high pressure switch. Hermetic units of less than 7.5kW input power may be fitted with factory-set high and low pressure safety devices.
12. All refrigeration plant shall be provided with a stand-alone microprocessor control system, including a visual display panel with indication of all operating parameters for all refrigeration circuits and compressors. Operating parameters include running amps.
13. A resiliently mounted control panel on the refrigeration plant shall house the control and protection equipment. The control panel shall include separate sections for motor starters and automatic controls. Compressor motor contactors overload relays and termination strips shall be contained in the starter section. System protection switches, compressor hours run, compressor starts limiter, all associated controls components, including ambient temperature/pressure control devices, shall be contained in the controls section.
14. Visual indication of operation of all safety protection devices shall be provided. Hours-run meters shall be provided to compressors 6kW input power and above.
15. Multiple units shall be provided with selective lead-lag controls.
16. Provision shall be made for remote indication of each alarm condition and for remote indication of all outputs to the BMS or other control system.
17. Refrigeration plant shall be provided with suitable connections for the safe removal of the entire refrigerant charge.
18. A liquid receiver shall be fitted to systems using an evaporative condenser or a remote air-cooled condenser, unless the system is critically charged and uses capillary tube flow control.
19. The entire charge shall be stored in 80% of the receiver volume. For systems having a water-cooled condenser with insufficient capacity to take the complete refrigerant charge, a liquid receiver shall be provided to make up the deficiency. Liquid receivers shall have means of venting, and means of determining liquid refrigerant level.
20. Where systems use a thermostatic expansion valve, the following components shall be provided upstream in the refrigerant liquid line:

    a. Hand shut-off valve.
    b. Capped refrigerant charging valve.
    c. Refrigerant drier (replaceable element type).
    d. Refrigerant strainer.
    e. Combination liquid sight glass and moisture indicator.
    f. Solenoid valve.

21. Compressors which may be required to start with exceptionally high evaporating temperatures shall either have sufficient motor power available to meet this condition or be fitted with a device or system to limit the maximum suction pressure.
22. Where the compressor is expected to start in cold ambient conditions and the setting of the low pressure cut-out is such that it may operate during the start sequence, a device or system shall be incorporated to override this cut-out until suitable operating pressures have been established.

23. Units having a direct-expansion evaporator at a higher level than the compressor shall operate on a pump-down cycle. On water chilling installations, the chilled water pump shall continue running during pump down.
24. The flow of refrigerant to a multiple circuit direct-expansion evaporator shall be controlled by an externally equalised thermostatic expansion valve which shall not 'hunt' at any step of compressor unloading.
25. In a system where oil circulation or rectification is difficult, an oil separator shall be included.
26. Two compressors may be connected in parallel if arrangements are incorporated to:
    a. Ensure adequate oil rectification and oil balancing within compressors, and
    b. Eliminate accumulation of liquid refrigerant within delivery side fittings during any compressor-off cycle.
    c. Starting arrangements are suitable for the lag compressor starting against the head pressure developed by the lead compressor.
27. Refrigerant service valves shall be of the capped type and incorporate a spindle gland of the back-seating type in which the gland is serviceable with the valve 'in situ'.
28. Flow sensing arrangements shall be provided in the chilled water pipeline to each shell and tube evaporator to prevent compressors starting or continuing to run if the water flow is below the minimum stipulated by the evaporator manufacturer. Flow switches shall incorporate a damping device.
29. A low temperature thermostat with hand reset shall be provided for each shell and tube evaporator to stop compressors if the chilled water flow temperature falls below 3°C.
30. For air cooled applications, provision shall be made to automatically off-load compressors when the design ambient temperature is exceeded and the discharge pressure approaches the safety cut out setting of the high pressure switch.
31. The combined noise level of all units operating at any duty point shall not exceed the level as indicated.
32. Vibration eliminators shall be fitted to the compressor suction and discharge pipes to minimize transmission of vibration or noise.
33. Where required, a gas pulsation damper shall be fitted in the refrigerant discharge pipe, in the plant room, as close as possible to the refrigeration compressor.

- Remote compressor / condensing units

1. The remote units are to be suitable for maintaining the internal temperature of the rooms as specified assuming an ambient temperature not exceeding of 50ºC. They are to all be semi-hermetically sealed/hermetically sealed water-cooled refrigeration systems suitable for operation using R134A and R404a refrigerant as appropriate to the rooms being serviced.
2. The refrigeration unit is to be air-cooled positioned as stated in the detailed specification. Unless otherwise stated the remote units are to be floor mounted with suitable anti-vibration / sound attenuator pads and provided with adequate ventilation. The contractor should allow for the design supply and installation of a suitable support frame and weatherproof housing.
3. The remote unit is to be installed in such a manner that easy access is maintained for the routing servicing, cleaning, general maintenance and repairs.
4. Allowance is to be made for the supply and installation of refrigerant line containment and for making final refrigerant line connections to the units. A suitable route for pipework and control wiring is too agreed and fully coordinated.

- Noise Emission

Unless otherwise specified the noise emission from remote refrigeration units is not exceed 45dB during normal operations, measured at a distance of 1 metre from the equipment in any direction in free field condition.

- Electrical supply

  Unless otherwise specified the electrical supplies to all cold rooms will be routed to the control panels. The Contractor should allow for the supply and installation of all cabling between the control panels and the remote refrigeration units.

- Refrigerant Lines and Electrical Cables

  All cables and pipework are to be installed in a neat and orderly manner to agreed routes, with all lines identified by cold room/compartment designation. All refrigerant lines and wiring is to be the requirements of the general specification. The route for all refrigeration lines and wiring is to be fully coordinated. All cables and pipework are to be installed in a neat and orderly manner.

- Evaporators

  1. Each room shall have a ceiling mounted cooling unit. They are to be finished in a hygienic white shock-resistant ABS and supplied complete with a thermostatic expansion valve.
  2. Condensate drains from each compartment shall terminate in the tundish drains indicated on the drawings. A heater tape is to be provided to cold rooms operating below 0ºC. All condensate lines and fittings are to be stainless steel and supported off the walls using easily cleanable brackets giving a clearance for cleaning purposes of not less than 20mm.

- Refrigerant and oils

  The systems are to be fully charged with refrigerant and lubricating oil at the time of commissioning. Refrigerant R134A is to be utilised for high temperature systems (0/+4ºC), and refrigerant R404A is to be used for low temperature systems (-18/-40ºC).

- Refrigerant line insulation

  All refrigerant lines running between evaporators and compressors are to be insulated in 19mm thick Class 0, Armaflex.

1.12 Computer Room Air Conditioining (CRAC) Units

- General Requirements

  1. The system shall be designed to maintain temperature and relative humidity conditions within the room.
  2. The system shall pull room air through ductwork at high level and shall deliver conditioned air via floor mounted grilles or as indicated on the tender drawings.
  3. The units are to operate utilising a dedicated direct expansion system with an air cooled condensing unit located within the basement. Power for the units shall be supported by the emergency generator system. The heat transfer surface is to be a copper cooling coil with aluminum fins treated with hydrofile styrol paints to enhance corrosion resistance.
  4. The unit shall be specifically designed for service from the front or top of the unit. The system shall be designed for draw-through air arrangement to insure even air distribution to the entire face area of the coil.

- Performance Requirements

1. Indoor units to deliver air flow and capacity based on the schedules.
2. The control system shall allow programming of the following (adjustable) room conditions:
   a. Temperature Set point: 24ºC
   b. Temperature Sensitivity: 0.1 ºC
   c. Humidity Set point: 50% RH
   d. Humidity Sensitivity: +1% RH
3. All set points shall be adjustable from the individual unit front monitor panel. Temperature and Humidity Sensors shall be capable of being calibrated using the front monitor panel controls to coordinate with other temperature and humidity sensors in the room.
4. The microprocessor shall calculate the moisture content in the room and prevent unnecessary humidification and dehumidification cycles by responding to changes in dewpoint temperature.
5. The control system shall include a program to prevent compressor short-cycling.
6. For start-up after power failure, the system shall provide automatic restart with a programmable (up to 9.9 minutes in 6-second increments) time delay. Programming can be performed either at the unit or from the central site monitoring system.
7. During start-up, or after power failure, the microprocessor shall sequence operational load activation to minimize inrush current. Systems allowing multiple loads to start simultaneously are unacceptable.
8. The microprocessor shall provide a front monitor LCD backlit display panel with 4 rows of 20 characters with adjustable contrast. This display (along with five front mounted control keys) shall be the only operator interface required to obtain all available system information such as room conditions, operational status, alarms, control and alarm set points, and all user selections including alarm delays, sensor calibration, DIP switch selections, and diagnostics. All indicators shall be in language form. No symbols or codes shall be acceptable.
9. High efficiency filter, filtration class F9 in accordance with the CEN EN 779 standard, made of fibre glass filter media shall be provided within the unit. The filters shall be come in "V" sections with a solid external frame in polypropylene, and shall withstand pressure and flow variations. These filters will be installed within an additional duct on the unit top.

- Construction Requirements

1. The units shall be compact and have metal structural frame, with cold dipped zinc plated sheet steel and with the external panels being epoxy polyester coated. Internally the units shall have heat and sound proofing insulation to Class 1.
2. The exterior panels shall be double skinned and lined with insulation. The exterior panels shall be 18gauge and shall be powder painted. The cabinet shall be designed so that all components are serviceable from the front or top of the unit. The manual disconnect switch shall be mounted in the high voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the door closed, and prevent access to the high voltage electrical components until switched to the "OFF" position.
3. The fans shall be direct drive, single inlet backwardly curved, centrifugal type positioned to draw air over the coil to ensure even air distribution and maximum coil performance. The fan impeller is statically and dynamically balanced and equipped with permanently lubricated bearings.
4. The fans shall be mounted on vibration absorbing rubber supports to reduce vibration. The motor shall have a high and low operating speed and internal thermal

protection. A field adjustable autotransformer shall be provided for modifying unit operating speeds.

- Air Cooled Condensing Unit
  1. The CRAC unit evaporator sections shall include an evaporator coil, a thermostatic expansion valve, filter dryer and blower. A reheat assembly and a steam generating humidifier are shall also be provided. The evaporator unit shall be provided with a power source and a power disconnect switch.
  2. The evaporator coil shall be constructed of copper tubes and aluminum fins and shall be designed for the high sensible heat ratio required for electronic equipment. Coils to be constructed for work pressure up to 1725kPa.
  3. The system shall be air cooled with an outdoor propeller fan condensing unit.
  4. The propeller fan unit shall be used for outdoor locations and shall include a scroll compressor with crankcase heater, high-pressure switch, condenser coil; propeller fan and Lee-Temp flood back head pressure control. The standard design pressure is 150 psig.
- Humidifier
  1. The steam-generating humidifier shall be factory-installed and tested. It shall add water vapor (up to 3 lb/hr) to the room air to control humidity within levels recommended for computer equipment.
  2. The humidifier components shall include the steam canister with automatic flushing circuit, strainer, inlet tube, drain, solenoid valve and copper discharge nozzle.
- Condensate Pump Kit
  1. A condensate pump shall be provided when the evaporator is installed below the level of the gravity-fed drain line available. Components shall include the pump, check valve, sump, level sensor and controls.
  2. The pump shall automatically be controlled by the water level in the sump. The condensate pump kit shall be field-installed in the evaporator housing.

EXECUTION

1.13 EXAMINATION

- Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- Verify that proper power supply is available and in correct location.
- Verify that water supply is available for humidifier.

1.14 INSTALLATION

- Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- Install in accordance with NFPA 90A and NFPA 90B.
- Install refrigeration systems in accordance with ASHRAE Std 15.
- Install humidifiers in accordance with ARI 610.
- Condensate drain pan connection shall be carried out with approved type stainless steel clamps.

1.15 SCHEDULE

- Refer to schedule on drawings.

7.3.36 23 8219 - Fan Coil Units

GENERAL

1.1 SUMMARY

- This Section includes fan-coil units and accessories.
- Related Sections
  1. 23 0513 - Common Motor Requirements for HVAC Equipment
  2. 23 0529 - Hangers and Supports for HVAC Piping and Equipment
  3. 23 0800 - Commissioning of HVAC

1.2 REFERENCES

- BS 4856 Methods for testing and rating fan coil units, unit heaters and unit coolers
- BS 7671:2008+A1:2011 – Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.
- EUROVENT 6/3 Thermal test method for Fan Coil units
- EUROVENT 8/2 Acoustical testing of Fan Coil Units in reverberation room
- EUROVENT 6/9 Thermal test method for Ducted Fan Coils
- EUROVENT 6/10 Air Flow test Method for Ducted Fan Coil Units
- EUROVENT 8/12 Sound test method for Ducted Fan Coil Units
- ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.3 GENERAL REQUIREMENTS

- The manufacturer and specific model offered shall be Eurovent Certified.
- Factory must be ISO-9001 certified.
- Units shall be capable of meeting the performance requirements indicated when operating against the required external air side resistance. Performance figures shall be in accordance with BS 4856 Parts 1 to 4 as appropriate to the unit selection. Independently certified thermal, hydraulic, air flow and acoustic data for each type of unit shall be submitted to the Engineer before orders are placed.
- Prior to fan coils being ordered sample units shall be provided to Engineer for approval. The samples shall be of a size selected by the Engineer, the selection being representative of the sizes and types to be supplied. The sample units shall be maintained on site as a benchmark for evaluation of the units installed.
- Units shall be selected to meet the required duty and noise levels when operating at medium speed unless otherwise stated.

1.4 Submittals

- Contractor to provide the following information as part of a complete and comprehensive technical submittal:

  1. Rated capacities
  2. Operating characteristics
  3. Testing certificates
  4. Detailed assembly drawings
  5. Dimensions
  6. Weights
  7. Required clearances
  8. Method of field assembly
  9. Components
  10. Wiring Diagrams (Power, Signal & Control)

- Refer to the MEPF General Requirements and Scope of Work document for submittal procedure and formats

PRODUCTS

1.5 MANUFACTURERS

- Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

- Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.6 GENERAL REQUIREMENTS

- Units shall be horizontal or vertical as indicated. Horizontal units shall be arranged with the filter and coils on the fan suction side of the unit. Vertical units shall have the coil face and fan discharge sufficiently separated to ensure adequate development of the air-stream to permit an even velocity distribution across the coil face.

- The control valve assembly shall comprise pressure independent control valves, pressure tappings, isolating valves, drain cocks all as indicated or otherwise stated. The valve arrangement shall be as detailed elsewhere.

- Provide a flushing bypass on each fan coil unit to enable the chilled water and heating water systems (where applicable) to be thoroughly flushed clean without passing dirty water through the coils.

- Each fan coil unit is to be complete with a unique identification reference label fitted at the manufacturer's works. The identification reference shall be clearly visible through the wrapping. The text and method of reference shall be as agreed with the Engineer prior to ordering and shall be utilised in the record documentation.

- Provide access panels for inspection of all moving parts in a safe manner.

- Fan coil units shall meet the EMC regulations as stated elsewhere.

- The limiting specific fan power (W/litre s-1) at the design flow rate for fan coil units shall be no higher than 0.8 (rating weighted average).

1.7 Casing

- Unless otherwise indicated, casings shall be provided as part of the unit.

- Casings shall be corrosion resistant and of rigid construction being adequately stiffened to prevent drumming, vibration and distortion. Sharpe edges shall be removed and joints sealed with mastic.
- Unless otherwise stated all chassis components shall be manufactured from a minimum of 1.2mm thickness galvanised mild steel. Fan coil units in excess of 1000l/s shall be of double skin construction.
- Casings shall be lined with thermal and acoustic insulation to maintain air borne and breakout noise within the specified limits. Insulation shall be high density being CFC and HFC free with class 'O' rating and to the required thickness to prevent condensation and a minimum of 15mm. It shall be securely attached to the unit without leaving any pockets or un-insulated casing.
- Access covers shall be provided to allow maintenance access to fans, coils and filters. Covers shall close onto air-tight seals with retained fixings capable of being easily released and replaced with the unit in position. Access covers shall be insulated and finished in a similar manner to the rest of the unit.
- Units shall be provided with integral plenum chambers for discharge connections as indicated. Fresh air supply inlet spigots shall be provided as indicated. Any spigots not used shall be capped off with a blanking plate.

1.8 Filters

- Each fan coil unit shall be complete with a replaceable or cleanable air filter panel, as indicated, located at the inlet section.
- Filters shall be contained in lightweight frames arranged to facilitate replacement. They shall seal positively against sealing strips fixed to the unit. Filters shall be capable of being removed without contacting the dirty media. Access to the filter shall be obtained without major dismantling of the unit, ceiling where applicable or connecting ductwork.
- Prior to practical completion all fan coil unit filters shall be cleaned or replaced with new as applicable.
- Adequate spare replaceable or cleanable filter media shall be provided to permit replacement of all filters. Filters shall be from 6 mm thick synthetic washable filter media in a metal frame to provide ease of cleaning. New media shall be provided at practical completion for each filter.
- Air filters shall have a performance classification of grade 3 when tested in accordance with BS EN 779 unless otherwise indicated i.e. EU3 80–90% average arrestance.

1.9 CHILLED WATER COOLING

- Unless otherwise indicated, cooling coils and heating coils shall be formed of copper tubes with aluminum fins and shall have the duties as indicated.
- Cooling coils shall be four rows minimum.
- Coil water velocities shall be no greater than 1.5 m/s and air velocities no greater than 2.5 m/s at the specified speed unless otherwise stated.
- Coils shall be selected so that the waterside pressure drop does not exceed 5 kPa on heating coils or 15 kPa on cooling unless otherwise stated.

- Each coil shall be fitted with a manual air vent positioned to eliminate all air from the units. Vents shall be extended to the unit casing allowing ease access after installation and shall not be hindered or restricted by the valve sets.
- Coils shall be manufactured from seamless copper tube with aluminium fins. Fins to be punched with die formed collars to afford maximum heat transfer surface area with the tubes. All coils are to be unhanded and circuited to optimise output but ensure free venting and free draining. Coils shall as a minimum be constructed from 3/8 copper tubing with 0.1 mm thick aluminium fins at a pitch of 2.1 mm (12 fins per inch). For locations with a saline environment, where a proportion of untreated outdoor air is supplied to the unit or if the project boundary is within 1 km of coastline the fins shall be coated aluminium, copper, or tinned copper.
- Maximum air velocity across the coils shall be 2m/s to minimize risk of carry over.
- The manufacturer shall provide independent test certificates showing the chilled water delta T under design selection conditions. In high delta T applications (>7oC) the Engineer shall witness factory performance tests. The contractor shall allow for all testing and witnessing expenses (minimum 4* Accommodation and Business class travel)
- The number of coil rows shall be as required to achieve the required sensible and latent cooling capacities
- Every coil should be leak tested using dry air under water to 20 bar. Every coil to valve connection should be tested under water
- Drain pans shall be one piece and positioned to collect and retain all condensate generated by the coil and valve assemblies. The bottom of the pan shall be graded in both directions towards the drain connection. A drain connection shall be provided, capable of adequately discharging condensate to waste without allowing condensate to collect in pockets or remain as standing water in the drain pan.
- Where the connection cannot be taken from the bottom of the pan a local sump shall be formed in the bottom of the pan and a side outlet drain connection provided.
- The entire underside of the drain pan shall be insulated with closed cell insulation material fire rated Class 'O'. Drain pans shall be fabricated from non-corrosive material or be protected against corrosion as stated elsewhere.
- Drain pans shall be thoroughly cleaned prior to setting the units to work.
- Any necessary disturbance of the galvanized finish shall be treated with zinc based surface treatment.
- The operation of condensate pumps shall be checked by pouring a small quantity of water into the drip tray prior to setting the units to work.

1.10 Direct Expansion Refrigerant Cooling Coils (Dx)

- Unless otherwise indicated coils shall be constructed from continuous aluminium/plate fins, mechanically bonded to seamless refrigerant quality copper tubes.
- All coils shall be provided with suitable corrosion resistant coating to the approval of the Engineer and provided with a minimum 10 year warranty.
- The tube and fin spacing shall be arranged to ensure maximum heat transfer efficiency with minimum coil depth and air resistance.

- Direct-expansion refrigerant cooler coil materials shall be selected to minimise electrolytic action.
- Coils shall be mounted in the unit casing so that they can be removed from the side without dismantling the entire unit.
- Refrigerant circuitry shall be designed to ensure equal distribution of refrigeration to each circuit across the whole face of the coil.
- Return or suction connections shall be arranged to ensure complete drainage of oil in the evaporator.
- The design of the refrigerant passages in direct expansion type evaporators shall be such that any oil present is always carried back to the compressor at the lowest stage of capacity reduction.
- The complete evaporator coil shall be pressure tested at the manufacturer's works to twice the working pressure. After testing, the coils shall be dehydrated under vacuum and charged with nitrogen before sealing.
- Coil face velocity shall not exceed 2.5 m/s.
- Evaporator and refrigeration shall be compatible with regard to duty and capacity control.
- Evaporators shall be dehydrated and charged with an inert gas and sealed after manufacture.
- Cooling coil casings shall incorporate a watertight drain tray complete with drain connection. Trays and drains shall be arranged with longitudinal and cross gradients to ensure total removal of all condensate.
- Unless otherwise indicated drain trays shall be insulated and fabricated from mild steel galvanised after manufacture prior to finishing with a two coat rubberised paint finish, or be otherwise equally corrosion resistant and watertight.
- Where coil connections pass through the casing they shall be complete with sealing rings and removable plates.

1.11 FANS

- Fans shall be directly driven, forward curved, double inlet width (DIDW) centrifugal type and capable of delivering the required air volume against the external resistance as indicated. Bearings shall be sealed for life.
- The fan layout and suction chamber design shall be arranged to provide as even a velocity profile as possible across the coil.
- Fan motors shall be totally enclosed, external rotor type with standard overload protection and comply with BS 5000 and BS EN 60034. Fan motors shall be 4-pole with IP44 rating.
- Each fan shall have its own resiliently mounted motor. The fan and motor unit shall be statically and dynamically balanced.
- Transformers shall be provided as necessary to give the correct electrical supply to the unit controls

1.12 CONTROLS

- A temperature or temperature and humidity detector shall control each fan coil unit. The detector shall be provided with sufficient cable to allow it to be fitted up to 15m from the

unit. Where the detector is fixed to the unit, it shall be on the side remote from the fresh air intake, and mounted external to the unit in the return air path.

- Refer to the BMS specifications for fan coil unit controller requirements.
- The fan coil and controls package shall be fully wired and tested by the fan coil manufacturer to an approved wiring diagram by the controls specialists. All components shall be housed in an adequately sized and ventilated controls enclosure which shall be part of or securely fitted to the fan coil chassis.
- Electrical supply shall be via a suitably rated connection mechanism within the controls enclosure.
- Waterside control of the units shall be by 2-port pressure independent control valves with flow limiting function unless otherwise indicated. Valves shall be selected to ensure authority of 1.0 and selected based on design flow through the coil. .
- The control of the unit shall incorporate an adjustable dead zone and shall prevent simultaneous opening of both the heating and cooling valves where heating and cooling coils are provided.
- Fan speed will be affected through a multi tapped unit mounted transformer. As a minimum, three speeds and three trimming speeds shall be provided which will be selected through a pair of speed selection switches. These shall be easily accessible. Any relays required to control fan on/off or fan speed switching shall be fully wired by the fan coil manufacturer and, unless otherwise stated, shall be supplied by the controls specialist as part of a free issue package. Refer to BMS specifications for further details if unit control.
- The 3 speeds shall result in a minimum variation of 20% in air flow for each speed selected.

1.13 ACOUSTICS

- Fan coil units shall be selected to meet the specified noise criteria as defined with this specification and to the satisfaction of the project acoustician. Ensure that due allowance is made for the accumulative effect of a number of fan coils operating in the same space.
- Tests requested to establish the NC level of individual units shall be conducted at the design condition for the unit on test. The NC level recorded will be the maximum level of two recordings taken at 1.5m from the discharge grille and 1.5m from the intake grille.
- Acoustic insulation shall be provided to 20 mm thick, which gives greater attenuation. Common acceptable materials are high density polyester, polyether or polyurethane foams impregnated to offer flame retardancy capable of satisfying BS 476: Parts 6(7) and 7(8) and Building Regulations(9) Class 0.
- Low density open cell elastic melamine foams may also be used, offering where it provides fire and heat resistance to Class 0 without chemical treatment.

EXECUTION

1.14 INSTALLATION

- Vulnerable chassis components shall be adequately protected during transit, site location and installation
- Fan coil units shall be installed in accordance with the manufacturer's recommendations for the particular application. The installation shall prevent the

transmission of noise and vibration to the building or to adjacent services. Anti vibration mountings shall be provided on the fan coil unit support arrangement.

- Units shall be installed to permit commissioning and maintenance. The installer shall ensure that casings, false ceilings, suspended floors and other concealment are arranged to permit these functions to be carried out in a proper and satisfactory manner.
- Suspend fan-coil units from structure with elastomeric hangers or spring isolators. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- Verify locations of thermostats and other exposed control sensors with the project engineer before installation.
- Install new filters in each fan-coil unit within two weeks after Substantial Completion.
- Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  1. Install piping adjacent to machine to allow service and maintenance.
  2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
  3. Connect condensate drain to indirect waste or dedicated condensate drain as dictated by the project specifics.
     a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.
- Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

1.15 FIELD QUALITY CONTROL

- The method of commissioning the units shall be in accordance with CIBSE guidance and as stated within this specification. The exact method of commissioning shall be agreed with the Engineer to suit the particular installation.
- In addition perform the following field tests and inspections in line with the requirements of this specification and prepare test reports:
  1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- Remove and replace malfunctioning units and retest as specified above.

7.3.37 23 8999 Schedule of Approved Manufacturers

1.1 Proposed Manufacturers

- Preferred Manufacturers are given in Appendix I. All other Manufacturers shall be submitted for Kahramaa formal review and Approval.

7.3.38 23 9999 MPF Services – Schedule of Guarantees, Warranties and Spares for MPF Service

Where there are any discrepancies between the spare parts and warranties listed in the MEPF General Requirements and Scope of Works / MEPF Standard Material and Workmanship Specifications and the table below then the following table shall take precedence.

In addition to the items identified in the table below the Contractor shall also provide a list of spares required for ALL installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the equipment. The contractor shall also deliver all spare parts to site in protective containers where practicable.

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
Division 10 – Specialities		
10 4413 - Fire Extinguisher Cabinets	NA	2 years
10 4416 - Fire Extinguishers	NA	2 years
Division 21 – Fire Suppression		
21 0100 - Operation and Maintenance of Fire System	NA	
21 0513 - Common Motor Requirements for Fire Suppression	NA	1 year for motors smaller than 15kW. 5 years for motors larger than 15kW.
21 0516 - Expansion Fitting and Loops for Fire Piping	Supply two sets of packing for each packed expansion joint.	2 years
21 0517 - Sleeves and Sleeve Seals for Fire-Suppression Piping	-	2 years
21 0548 - Vibration & Seismic Controls for Fire Suppression Piping & Equipment	Provide 1% spares of each type installed.	2 years
21 0553 - Identification for Fire Suppression Piping & Equipment	Provide 1% spares of each type installed.	2 years
21 0900 - Instrumentation & Control for Fire Suppression Systems	Provide 1% spares of each type installed.	2 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
21 1200 - Fire Suppression Standpipes	Provide as per NFPA and Local Authority requirements.	2 years
21 1300 - Fire Suppression Sprinkler System	Provide the following: a. 24nos extra sprinklers of each type and size matching those installed and referenced in NFPA13 and to be local authority. b. Suitable wrenches for each sprinkler type. c. Metal storage cabinet for storing sprinklers and shall be placed in room where room temperature shall not exceed 38degC at any time. d. A list of the sprinklers installed in the property shall be posted in the sprinkler cabinet.	2 years
21 1313 - Wet-Pipe Sprinkler Systems	Provide 1% spares of each type installed.	2 years
21 1316 - Dry-Pipe Sprinkler Systems	Provide 1% spares of each type installed.	2 years
21 1339 - Foam-Water Systems	Provide 5% of each type sprinkler	2 years
21 2200 - Clean Agent Fire Extinguishing systems	Furnish two complete sets of special tools required for servicing and maintaining equipment installed. Provide 1% spares of each type installed.	5 year
21 3113 - Electric-Drive, Centrifugal Fire Pumps	N/A	1 year
21 5000 - Fire fighters Override Control Panel	N/A	3 years
Division 22 – Plumbing		
22 0516 - Expansion Fittings and Loops for Plumbing Piping	Provide 1% spares of each type installed.	2 years
22 0517 - Sleeves and Sleeve Seals For Plumbing Piping	NA	2 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
22 0518 - Escutcheons for Plumbing Piping	Provide 5 nos of each type escutcheons	2 years
22 0519 - Meters and Gauges for Plumbing Piping	Provide 1 spare for each type installed.	2 years
22 0523 - General-Duty Valves for Plumbing Piping	Provide 2 of each type of valve Installed.	Material and Workmanship: 3 years Electrical components: 1 year
22 0529 - Hangers and Supports for Plumbing Piping and Equipment	Provide 1% spares of each type installed.	2 years
22 0533 - Heat Tracing for Plumbing Piping	NA	2 years
22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment	Provide 1% spares of each type installed.	2 years
22 0553 - Identification for Plumbing Piping and Equipment	Provide two repacking kits for each size valve.	2 years
22 0700 - Plumbing Insulation	NA	2 years
22 0900 - Instrumentation and Control of Plumbing	Provide 1% spares of each type installed.	2 years
22 1005 - Plumbing Piping	Provide 1% spares of each type installed.	2 years
22 1006 - Plumbing Piping Specialties	Provide the following: a. Supply two loose keys for outside hose bibs. b. Supply two hose end vacuum breakers for hose bibs. c. Provide 1% spares of each type installed. d. The Contractor shall also provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.	2 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
22 1113 - Facility Water Distribution Piping	NA	
22 1116 - Domestic Water Piping	Provide 1% spares subject to minimum of 1 of each type of fittings.	2 years
22 1119 - Domestic Water Piping Specialties	Provide 1 of each type installed.	2 years
22 1300 - Facility Sanitary Sewerage	NA	2 years
22 1319 - Sanitary Waste Piping Specialties	Provide 1% spares subject to minimum of 1 of each type of fittings.	2 years
22 1329 - Sanitary Sewerage Pumps	1 spare pump for each sewer application.	2 year Guarantee.
22 1400 - Facility Storm Drainage	NA	
22 1423 - Storm Drainage Piping Specialties	Provide 1% spares subject to minimum of 1 of each type of fittings.	2 years
22 3100 - Domestic Water Softeners	Fully comprehensive maintenance provided for 1 year.	Mineral tanks: 5 years. Brine tanks / Control Valve: 2 years
22 3200 - Domestic Water Filtration Equipment	Fully comprehensive maintenance provided for 1 year.	2 years
22 3400 - Fuel-Fired Domestic-Water Heaters	Provide 2% spares on all element types.	Storage Tank: 3 years. Controls and other Components: 2 years
Division 23 – Mechanical		
23 0130 - HVAC Air Duct Cleaning	N/A	
230513 - Common Motor Requirements for HVAC Equipment	N/A	5 years
23 0516 - Expansion Fittings and Loops For HVAC Piping	Supply two sets of packing for each packed expansion joint.	2 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
23 0517 - Sleeves and sleeve seals for HVAC Piping	N/A	2 years
23 0519 - Meters and Gauges	Provide 1 of each type installed.	2 years
23 0523 - General-Duty Valves For HVAC Piping	Provide 1 of each type of valve installed. One loose key plus one spare shall be provided for each ten air cocks.	Material and Workmanship: 3 years Electrical components: 2 year
23 0529 - Hangers and Supports For HVAC Piping and Equipment	Provide 1% of each type installed.	2 years
23 0548 - Vibration and Seismic Controls For HVAC Piping and Equipment	Provide 1% spares of each type installed.	2 years
23 0553 - Identification For HVAC Piping and Equipment	N/A	2 years
23 0593 - Testing, Adjusting, and Balancing For HVAC	N/A	2 years
23 0713 - Ductwork Insulation	N/A	2 years
23 0716 - HVAC Equipment Insulation	N/A	2 years
23 0719 - HVAC Piping Insulation	N/A	2 years
23 0900 - Instrumentation and Control for HVAC	Provide 1% of each type of thermostat controller.	5 years
23 0993 - BMS Sequence of Operation for HVAC Controls	N/A	
23 1113 - Facility Fuel-Oil Piping	Provide 5% spares subject to a minimum of 1 of each type installed.	5 years
23 2113 - Hydronic Piping	N/A	5 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
23 2114 - Hydronic Specialties	Provide 1 of each type installed. Specifications shall include details for local suppliers	2 years
23 2123 - Hydronic Pumps	N/A	2 years
23 2300 - Refrigerant Piping	N/A	2 years
23 2500 - HVAC Water Treatment	Supply sufficient chemicals for treatment and testing during five years warranty period.	5 years
23 3113 - Metal Ducts	N/A	2 years
23 3116 - Non Metallic Ducts	N/A	2 years
23 3119 - HVAC Casings	N/A	2 years
23 3300 - Air Duct Accessories	Provide two of each size and type of fusible link.	5 years.
23 3319 - Duct Silencers	N/A	2 years
23 3413 - Axial HVAC Fans	N/A	5 years
23 3416 - Centrifugal HVAC Fans	N/A	5 years
23 3433 - Air Curtains	N/A	5 year
23 3516 - Engine Exhaust Systems	N/A	3 year
23 3600 - Air Terminal Units	N/A	2 years
23 3700 - Air Outlets and Inlets	N/A	5 years
23 4000 - HVAC Air Cleaning Devices	In the original installation of filters and filtering equipment, provide filter media and filters of the several types as specified for each type of filter. On completion of the work, furnish and deliver to the Owner, spare media and filters equal to the complete replacement of such media or filters provided in the original installation.	2 years
23 5700 - Heat Exchangers for HVAC	N/A	2 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
23 5900 - Run-Around Coils	N/A	10 years
23 7400 - Central Station Air Handling Units and Outside Air Handling Units	One complete set of spare filters for each AHU shall be supplied.	10 years for coils. 5 years for other components.
23 8126 - Split System Cooling	Provide two filters for each indoor unit. Provide two pilot thermocouples.	10 years for coils. 5 years for other components.
23 8219 - Fan Coil Units	Provide two filters for each indoor unit.	10 years for coils. 5 years for other components.

APPENDIX A SECTION 7.4

MEPF SPECIFICATION

Electrical

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7 MECHANICAL, ELECTRICAL, PLUMBING AND FIRE FIGHTING

GENERAL REQUIREMENT
Unless otherwise stated in the Project Documentation, the Contractor shall comply with every requirement of the Qatar Construction Specification (QCS) that is relevant to the type of work forming any part of the Contract and shall adopt whichever permissible option or alternative is best suited to the needs of the construction work being undertaken.

The references to supplier in this document shall be taken to mean Sub-Contractor as defined in the General Conditions of Contract. All suppliers must be taken from Kahramaa's approved Vendor list for the Mega Reservoir in Appendix I.

7.4 Division 26 – Electrical

7.4.1 26 0500 - Common Work Results for Electrical

GENERAL

1.1 SCOPE OF THIS SPECIFICATION

A. The following services are specified within this document:

1. Medium voltage cabling.
2. Medium voltage switchgear.
3. Power distribution transformers.
4. Standby power generators.
5. UPS, batteries and battery chargers.
6. Low voltage cabling and busduct.
7. Low voltage switchgear, panel boards and distribution boards.
8. Low voltage motor control centres and motor starters.
9. Earthing, bonding and lightning protection.
10. Energy metering.
11. Final circuit cabling.
12. Lighting and emergency lighting.
13. Small power.
14. Containment systems and supports.
15. External lighting.
16. External power distribution.

B. For the following items please refer to the MEICA specification:

1. Medium voltage phase-shift transformers.
2. Medium voltage VFD's for process pumps.
3. Low voltage VFD's for process pumps.
4. Medium voltage process pump motors.

C. For the following items please refer to the SCADA specification:

1. Security (CCTV, access control etc.).
2. Telecommunications.
3. Automation.

1.2 SUMMARY

A. This Section includes materials and installation methods performed by all electrical services trades including specialist communications, electronic life safety and security installers.

B. This specification section lists a summary of the requirements for the electrical services installation. Where there is a contradiction between this specification section and another, the most stringent shall apply.

C. The Contractor is responsible to verify and confirm all aspects of the design based on the actual equipment / vendor selected. This includes verifying space planning, equipment capacities, verifying calculations and any other aspect of the design.

D. The Contractor shall coordinate with Kahramaa in order to connect to the incoming power supply, wherever its source.

1.3 REFERENCES

A. All references listed in this section are relevant to every aspect of this project. The Contractor shall obtain officially the latest of version of each of the below documents and comply with its requirements in full.

B. Where there is a conflict between any of the below referenced documents or any of these contract specifications the Contractor shall allow for the more stringent requirement.

C. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, Qatar General Electricity and Water Corporation "Kahramaa".

D. Qatar Civil Defence Department requirements.

E. NFPA-72 - National Fire Alarm and Signaling Code.

F. NFPA 70 - National Electrical Code.

G. Qatar Construction Specification (the most recent version). Where there are any discrepancies between these specifications and QCS the more stringent shall apply.

H. Kahramaa approved materials list.

I. All Kahramaa rules, regulations and requirements.

J. Kahramaa general specifications, including, but not limited to:

1. Distribution Construction Manual.
2. Kahramaa General Technical Requirements.
3. Kahramaa Technical Specifications for Fire Safety.
4. Kahramaa Distribution Regulations.
5. EP-MS-P4-S2-030 - 11kV HRC Oil Immersed Fuses.
6. EP-MS-P4-S2-060 - 11kV Outdoor SF6 Switchgear.
7. EP-MS-P4-S2-082 - 11kV Indoor Switchgear Panels Vacuum Circuit Breaker.
8. EP-MS-P4-S3-030 -11kV XLPE 3-Core Cables.
9. EP-MS-P4-S3-050 - XLPE Insulated Pilot Cables.
10. EP-MS-P4-S4-015 - 11/0.433kV Oil Filled Ground Mounted Distribution Transformers.
11. EP-MS-P4-S4-035 - 11kV Distribution Transformers Dry Type Cast Resin GM-ID Applications.
12. EP-MS-P4-S2-020 - HRC Fuses for Use on Low Voltage Networks.
13. EP-MS-P4-S5-010 - Maximum Demand Indicator Equipment.
14. EP-MS-P4-S6-021 - Tripping Unit (Battery Charger).
15. Section 3 3 3 4 Auxiliary Transformer.
16. Section 3 3 3 5 Auxiliary Dry Type Transformers.
17. Section 3 3 9 Earthing System and Lightning Protection.
18. Section 3 3 15 1 Fire Safety.
19. Section 3.3.14 Heating, Ventilation and Air Conditioning.

20. Section 3.3.15 Building Services.
21. Section 4 Electrical Works in Water Pumping Stations.

K. BS 7454:1991 - Method for calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects

L. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

M. BS 7697:1993 - Nominal voltages for low voltage public electricity supply systems

N. BS EN 50160:2000 - Voltage characteristics of electricity supplied by public distribution systems

O. BS EN 60445:2007 - Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals and conductor terminations.

P. BS EN 62305-1:2006 - Protection against lightning. General requirements

Q. BS IEC 60943:1998 - Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals.

R. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

S. Immediately following the Award of the Contract, the Contractor shall supply an indexed list in the English language, of all standards, codes and their referred associated standards, to which the work is to be performed.

1.4 DESIGN, STANDARDIZATION AND INTERCHANGEABILITY

A. The works shall be designed to facilitate inspection, cleaning, maintenance and repair. Continuity of supply is of prime concern. The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the operation and maintenance of the works. The equipment shall be designed to operate satisfactorily under all variations of load, pressure, and temperature that may be met in normal usage under the variation in climatic conditions given in the Specifications. All apparatus shall also be designed to ensure satisfactory operation in all atmospheric conditions prevailing at the sites and during such sudden variation of load and voltage as may be met with under working conditions on the system, including those due to faulty synchronizing and short circuit.

B. The design shall include all necessary interlocks for the operation and maintenance of the equipment in accordance with KAHRAMAA safety rules, standard interlocking document and system operation/maintenance practices of the Contract Works and of associated works supplied under other contracts.

C. All outdoor apparatus and fittings shall be designed so that water cannot collect at any point.

D. Cast iron shall not be used for chambers of oil filled apparatus or for any part of the equipment that is in tension or subject to impact stresses.

E. Kiosks, cubicles and similar enclosed compartments shall be equipped with anti-condensation heaters actuated by hygrostat and thermostat to restrict condensation. All contactors or relay coils and other parts shall be suitably protected against corrosion.

F. All apparatus shall be designed to obviate the risk of accidental short circuit due to animals, birds, insects, mites, rodents or micro-organisms.

G. Corresponding parts throughout shall be made to gauge and shall be interchangeable.

H. All equipment performing similar duties shall be of the same type and manufacture in order to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed.

1.5 ABBREVIATIONS

A. ANSI: American National Standards Institute.

B. BSI/BS EN: British Standards Institute and European norm.

C. CBM: Certified Ballast Manufacturers.EMI: Electro-Magnetic Interference.

D. IEC: International Electrotechnical Commission

E. IEE: Institution of Electrical and Electronics Engineers

F. IEEE: Institute of Electrical and Electronics Engineers.

G. IES: Illuminating Engineering Society.

H. IPxx: Ingress Protection Rating as defined in international standard IEC 60529

I. EIA: Electronic Industries Association.

J. MEICA: Mechanical, Electrical, Instrumentation, Control and Automation.

K. NEMA: National Electrical Manufacturers Association.

L. NFPA: National Fire Protection Association

M. OEM: Original Equipment Manufacturer

N. QCDD: Qatar Civil Defence Department

1.6 DEFINITIONS

A. "Provide" means to supply, purchase, transport, place, erect, connect, test, and turn over to Owner, complete and ready for regular operation, the particular Work referred to.

B. "Install" means to join, unite, fasten, link, attach, set up, or otherwise connect together before testing and turning over to Owner, complete and ready for regular operation, the particular Work referred to.

C. "Furnish" means to supply all materials, labour, equipment, testing apparatus, controls, tests, accessories, and all other items customarily required for the proper and complete application for the particular Work referred to.

D. "Wiring" means the inclusion of all raceways, fittings, conductors, connectors, tape, junction and outlet boxes, connections, splices, and all other items necessary and/or required in connection with such Work.

E. "Conduit" means the inclusion of all fittings, hangers, supports, sleeves, etc.

F. "As Directed" means as directed by the Consultant, or his representative.

G. "Duct" means an enclosed space specifically intended for the distribution of services, with direct access for personnel.

H. "Trench" means a covered horizontal service space in the floor or ground with access from above.

I. "Cavity" means a space enclosed within the elements of a building within which services are installed, e.g. the space between ceiling and floor above.

J. "Service Areas": includes areas within a building with limited finishes such as loading bays, car parks etc.

K. "Concealed Services": includes installations within ducts, trenches or cavities.

L. "Exposed Services": includes installations within plant rooms, outdoors or unprotected within service or occupied areas.

M. "System": means all equipment, accessories, controls, supports and ancillary items, including supply, installation, connection, testing, commissioning and setting to work necessary for that section of the Works to function.

N. "Services": means the inclusion of one or more systems.

1.7 SUBMITTALS

A. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

B. The Contractor shall follow to the submittal procedures outlined in the "General Requirements and Scope of Works".

C. All calculations shall be submitted with a signature and stamp by an MMUP-registered Grade A electrical engineer employed by the Contractor.

1.8 QUALITY ASSURANCE

A. Approval: No material shall be used on the project without the express written approval by the Owner and Engineer. Any material installed by the Contractor prior to obtaining approval is done so at the Contractor's own risk. If this material subsequently is rejected it shall be removed and replaced with an approved material at the Contractor's own cost.

B. Statutory Authority: The approval of a material by the Owner will not absolve the Contractor of his responsibility to install the material correctly, using materials fit for purpose and obtaining statutory authority approval, where required. Any material installed by the Contractor prior to obtaining statutory authority approval is done so at the Contractor's own risk. If this material subsequently is rejected it shall be removed and replaced with an approved material at the Contractor's own cost.

C. Changes in Drawings and/or Specifications:

1. Should any change in Drawings or Specifications be required to comply with governmental regulations, the Contractor shall notify Consultant prior to execution of the Work and carry out the drawing revisions at no cost to the contract.
2. The work shall be carried out according to the requirements of such code in accordance with the instruction of the Consultant and at no additional cost to the Client.

D. Statutory and Regulatory Requirements:

1. The provisions of Standards, Codes, Laws, Ordinances, etc., shall be considered minimum requirements.
2. In case of conflict between their published requirements, the Consultant shall determine which is to be followed and his decision shall be binding at no cost to the contract.
3. Specific requirements of this specification or the drawings, which exceed the published requirements, shall take precedence over them.

E. Materials Furnished: all materials furnished by the Contractor shall be new and unused and free from defects. No used materials will be accepted.

F. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE, UL, CSA and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handling and Storages:

1. Ship and store all products and materials in a manner that will protect them from damage, weather and entry of debris. Provide conditioned storage either on site or off to store all equipment that is sensitive to extreme temperature.
2. If items are damaged, do not install, but take immediate steps to obtain replacement at no cost to the Client.
3. Store materials suitably sheltered from the elements, but readily accessibly for inspection by the Consultant until installed.

4. Store all items subject to moisture damage in dry locations preferably equipped with suitable environmental conditioning system.

B. Delivery:

1. Deliver materials in manufacturer's unopened container fully identified with manufacturer's name, trade name, type, class, grade, size and colour.
2. The contractor is responsible for associated costs with delivery and storage.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without the Construction Manager's written permission.

1.11 COMPLIANCE STATEMENT

A. A specific compliance (clause by clause up to sub clause level), statement of conformity with the specification and details of non-conformity. The Employer reserves the right to reject any submittals which do not fully comply with the specification.

1.12 APPROVAL

A. No material shall be used on the project without the express written approval by the Employer. Any material installed by the Contractor prior to obtaining approval is done so at the Contractor's own risk. If this material subsequently is rejected it shall be removed and replaced with an approved material at the Contractor's own cost.

1.13 STATUTORY AUTHORITY

A. The approval of a material by the Employer will not absolve the Contractor of his responsibility to install the material correctly, using materials fit for purpose and obtaining statutory authority approval, where required. Any material installed by the Contractor prior to obtaining statutory authority approval is done so at the Contractor's own risk. If this material subsequently is rejected it shall be removed and replaced with an approved material at the Contractor's own cost.

1.14 ENVIRONMENTAL CONDITIONS

A. All equipment shall be rated and de-rated to cope with the environmental conditions stated in Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, Kahramaa, 2010, and QCS 2010, with the following as guidance:

1. Maximum External Ambient Temperature in Shade: 52°C.
2. Maximum External Temperature in Direct Sunlight: 85°C.
3. Minimum External Temperature: 0°C.
4. Maximum Humidity: 100%.
5. Minimum Humidity: 20%.
6. Maximum Ground Temperature: 30°C at a depth of 1m.
7. Maximum Seawater Temperature: 40°C.
8. Maximum Internal Temperature: 50°C.
9. Maximum Internal Temperature in Air Conditioned Room: 35°C.
10. Altitude: Not exceeding 1000m.
11. Yearly rainfall: 80 - 150 mm.
12. Isokeraunic level: 22 days / annum.
13. Lightning current for protective earthing: $60kA_{peak}$.
14. Seismic intensity (Modified Mercalli Scale): Approx. VI

15. Mean hourly wind speed of not less than 30 m/s (as per BS EN 1991-1-4).
16. Pollution level (to IEC 60815, Table 1): Very heavy.
17. Ground Water level: 2m - 70m.
18. Creepage distance (based on Um): 35mm / kV.
19. General: Violent sand and dust storms of several hours duration occur and even on comparatively still days, fine dust is carried in suspension in the atmosphere.
20. Apparatus and material in enclosed metal unit cubicles and switchboards shall be designed for operating temperatures in excess of the maximum internal temperature attained inside the enclosure during continuous full rating operation.

1.15 COORDINATION

A. Coordination with other trades:
   1. Coordinate and schedule work with other trades in accordance with the construction sequence.
   2. Install and coordinate the electrical works in cooperation with all other trades installing inter-related services and systems.
   3. Before installation, make proper provisions to avoid interferences in a manner approved by the Consultant.

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

C. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

D. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

E. Coordinate sleeve selection and application with selection and application of fire-stopping specified in Section 26 0509.

F. It is Contractor's responsibility to verify the design in line with approved vendor equipment during Construction stage.

G. All calculations shall be verified by the Contractor during Construction Stage.

H. Protection schemes are subject of changes during Construction stage.

I. Protection Relay settings and coordination study is within the responsibility of the Contractor.

1.16 MITIGATION OF HARMONICS

A. The Contractor shall perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system.

B. A harmonic analysis report complying with IEEE 399 shall be submitted with the Shop Drawings to verify compliance with the voltage and current distortion limits as specified in the latest version of IEEE-519 Tables 10.2 and 10.3.

C. Analyze possible operating scenarios, including recommendations for harmonic filtering to limit TDD and THD(V) at the defined PCC to specified levels.

D. The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformers.

E. If, as a result of analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid.

F. The Contractor shall provide a full technical submission outlining his proposal taking into consideration all effects this may have on other parts of the design again the cost to be included within the Contractor's scope.

G. Passive Solutions:

1. Interconnected Star Transformer - Good solution to mitigate 3rd harmonic and sized just for the harmonic current and not the entire load.
2. Inline Choke (inductor) - Fairly simple and common with Variable Speed Drive type application and reduces THDI to some degree and harmonic reduction is very much dependent on level of load current.
3. Tuned LC filter - Only attenuates harmonics at tuned frequency. Cost effective solution provided that the harmonic spectrum and the load current remain at planned level. There is a risk of possible resonance by using this solution.
4. Phase shifting - Typical example is a 12 pulse rectifier which utilizes two phase shifted (30 - degrees) six pulse bridges, thus reducing the 5th and 7th harmonics.

H. Active Solutions:

1. Active harmonic filters/conditioners are suitable for almost all types of application and can be preset to eliminate all the dominant harmonics from 2nd to 50th.
2. There is built-in flexibility to cover for any future change in the load harmonic spectrum. However, one must select only the shunt type active harmonic filters rather than the series connected ones to prevent risk due to overload or internal malfunction.
3. There is no risk of resonance with this type of unit. In the long run this is a very cost effective method which is easy to adopt and it is the solution which meets all of the global stringent standards designed to contain harmonics.

1.17 WARRANTY

A. Guarantee all material and workmanship for a period of two (2) years from date of Taking Over Certificate (TOC), except that where guarantees or warranties for longer terms are specified herein, such longer term to apply.

B. For equipment for which a specific vendor is giving warranty longer than 2 years from the date of TOC, Contractor shall hand-over warranty to Kahramaa after this period.

C. Within 24 hours after notification, correct any defects that occur during the warranty period at no additional cost to the Client, all to the satisfaction of the Client and Consultant.

D. Obtain similar warranties and guarantees from subcontractors, manufacturers, suppliers and sub-trade specialists.

1.18 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. The tenderer shall include in his bid, as a minimum, consumables and spare parts for commissioning, and spare parts for guarantee period operation. The CONTRACTOR /MANUFACTURER shall guarantee, the availability of spare parts for a minimum duration of 10 years.

C. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

D. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (305 mm).
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

PRODUCTS

1.19 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Vendors shall be subject of approval through prequalification and material submittals. Only manufacturers with Qatar-based suppliers and more than 10 years of presence in the Gulf shall be acceptable.

C. Kahramaa reserves the right to approve or reject any vendor.

1.20 EQUIPMENT CAPACITIES:

A. All equipment capacities, etc. shall be listed for job site operating conditions.

B. All equipment sensitive to altitudes or ambient temperatures, to be de-rated and method of de-rating shall be as recommended by the manufacturer and, or shown on Shop Drawings or other submittal documents subject to Consultant's approval.

C. Where operating conditions shown differ from the laboratory test conditions, the equipment to be de-rated and the method of de-rating shall be shown in any of the following documents subject to Consultant's approval, but not limited to:

1. Shop Drawings
2. Material submittal
3. Method Statement
4. Request for Information

1.21 LOW VOLTAGE BUILDING SERVICES MOTOR DRIVES – ELECTRIC MOTORS

A. General:

1. Standard use motors which conform to BS 2048-1, BS 4999, BS EN 50347 and BS EN 60034, as applicable, which operate at lowest possible speed, as required by the project, compatible with performance requirements.

B. Ratings:

1. Select maximum continuous rating (MCR) such that driven machine operates at correct speed or speeds at design duty.
2. When running continuously at design rated duty, the temperature of the motor parts is within limits defined in BS EN 60034-1.
3. When provided with excess motor current (over-load) protection of thermal over current release type, ensure operation is within tolerances of tripping as defined in BS EN 60947-4-1.

C. Insulation:

1. Use motors with Class 130 or 155 to BS EN 60085 insulation, with temperature rise as defined in BS EN 62114.
2. Conduit entry: Fit motor bodies with conduit entry terminal box or cable gland as required, and to suit type and size of cable being terminated.

D. Motor Efficiency:

1. Premium Efficiency Motor with a stated efficiency as defined by IEC 60034-30, IE3 Premium Efficiency (%) is presented in the table.

kW	2 pole 50 HZ / 60 HZ	4 pole 50 HZ / 60 HZ	6 pole 50 HZ / 60 HZ
0.75	80.7 / 87.0	82.5 / 85.5	78.9 / 82.5
1.1	82.7 / 84.0	84.1 / 86.5	81.0 / 87.5
1.5	84.2 / 85.5	85.3 / 86.5	82.5 / 88.5
2.2	85.9 / 86.5	86.7 / 89.5	84.3 / 89.5
3	87.1 / -	87.7 / -	85.6 / -
3.7	- / 88.5	- / 89.5	- / 89.5

kW	2 pole 50 HZ / 60 HZ	4 pole 50 HZ / 60 HZ	6 pole 50 HZ / 60 HZ
4	88.1 / -	88.6 / -	86.8 / -
5.5	89.2 / 89.5	89.6 / 91.7	88.0 / 91.0
7.5	90.1 / 90.2	90.4 / 91.7	89.1 / 91.0
11	91.2 / 90.0	91.4 / 92.4	90.3 / 91.7
15	91.9 / 91.0	92.1 / 93.0	91.2 / 91.7
18.5	92.4 / 91.7	92.6 / 93.6	91.7 / 93.0
22	92.7 / 91.7	93.0 / 93.6	92.2 / 93.0
30	93.3 / 92.4	93.6 / 94.1	92.9 / 94.1
37	93.7 / 93.0	93.9 / 94.5	93.3 / 94.1
45	94.0 / 93.6	94.2 / 95.0	93.7 / 94.5
55	94.3 / 93.6	94.6 / 94.4	94.1 / 94.5
75	94.7 / 94.1	95.0 / 95.4	94.6 / 95.0
90	95.0 / 95.0	95.2 / 95.4	94.9 / 95.0
110	95.2 / 95.0	95.4 / 95.8	95.1 / 95.8
132	95.4 / -	95.6 / -	95.4 / -
150	- / 95.4	- / 96.2	- / 95.8
160	95.6 / -	95.8 / -	95.6 / -
185	- / 95.8	- / 96.2	- / 95.8
200	95.8 / -	96.0 / -	95.8 / -
220	95.8 / 95.8	96.0 / 96.2	95.8 / 95.8
250	95.8 / 95.8	96.0 / 96.2	95.8 / 95.8
300	95.8 / 95.8	96.0 / 96.2	95.8 / 95.8
330	95.8 / 95.8	96.0 / 96.2	95.8 / 95.8
375	95.8 / 95.8	96.0 / 96.2	95.8 / 95.8

1.22 SUBSTITUTION OF MATERIALS OR EQUIPMENT

A. General:

1. All requests for substitution of materials or equipment shall be made in writing by the Contractor to be submitted for approval by the Consultant.
2. The request must be in the Consultant's office not less than ten (10) days prior to the bid date.
3. Samples of proposed substitute materials or equipment shall be submitted to the Consultant for review whenever they are requested.
4. Wherever the words "for approval" or "approved" are used in regard to manufactured specialties, or wherever it is desired to substitute a different make or type of apparatus for that specified, submit all information pertinent to the adequacy and adaptability of the proposed apparatus, and secure Consultant's acceptance before apparatus is ordered.
5. If no substitutions are received ten (10) days prior to the bid date the Contractor shall be responsible for sourcing all materials as specified in the Tender documents without any additional cost to the Client.

B. Substantial Conformity to the Specified Product:

1. Wherever quantities or a definite make and size of apparatus are specified, the make and size of apparatus which is proposed must conform substantially (in regard to the operating results) to that specified or implied.
2. Same shall apply to important dimensions relating to operation of apparatus in coordination with the rest of the system, or to properly fitting it into available space conditions.
3. Any substitution of equipment or apparatus shall include all necessary revisions, as required to complete the installation.

C. Acceptance:

1. Acceptance of substitutions will not be given and the Client is not obliged to accept any changes, for equipment specified herein, will not be given merely upon submission of manufacturer's names and will be given only after receipt of complete and satisfactory performance data covering the complete range of operating conditions in tabular and graphical form.
   a. If the contractor submits a substitute the contractor shall be responsible for fully evaluating the effect on the design and provide a fully coordinated submission at no cost to the client. The contractor shall be responsible for the costs incurred by consultant to review any submission. The consultant will not be responsible for such submission/acceptance, it will rest with the contractor
   b. If it is approved the contractor is still responsible for any unforeseen consequence of the substitution and bear the cost that the substitution affects.
2. Furnish complete and satisfactory information relative to equipment dimensions, weight, etc.
3. Acceptance of all equipment specified or shown on the Drawings, or substitutions submitted for that specified or shown on the Drawings, will be granted if such equipment, in the opinion of the Consultant, conforms to the performance requirements, space conditions, weight requirements and quality requirements.
4. Any additional construction and design costs incurred as a result of any accepted substitution shall be borne by the Contractor.
5. The opinion and judgment of the Consultant shall be final, conclusive, and binding.

EXECUTION

1.23 TESTING

A. The Contractor must undertake all testing as specified in this specification and present these to the satisfaction of Kahramaa.

B. Kahramaa reserves the right to request any other requirements or tests to be carried out to satisfy themselves that the materials are adequate and fit for purpose.

1.24 INSTALLATION

A. Pre-requisites:

1. Before commencing Work, examine all adjoining, underlying, etc., Work on which this Work is in any way dependent for perfect workmanship and report any condition which prevents performance of first class work.
2. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

B. Manufacturer's Instructions:

1. Follow manufacturer's instructions for installing, connecting, and adjusting all equipment.
2. Provide four copies of such instructions to the Consultant before installing any equipment.
3. Provide a copy of such instructions at the equipment during any work on the equipment.
4. Provide all special supports, connections, wiring, accessories, etc.

C. Skilled Technicians:

1. Employ technicians skilled in their trade for all work.
2. Keep all items protected before and after installation; clean up all debris.
3. Premium Time Work

D. The following Work shall be performed at night or weekend other than holiday weekends as directed and coordinated with the Client:

1. All tie-in, cut-over and modifications to the existing electrical system and other existing system requiring tie-ins or modifications shall be arranged and scheduled with the Client to be done at a time as to maintain continuity of the service and not interfere with normal building operations.
2. Mount all panels at a maximum height of 2010 mm to top unless otherwise noted.
3. Where flushed mounted, the fire integrity of the wall in which it is installed must be maintained.
4. Neatly arrange branch circuit wires and tie together in each gutter with Thomas & Betts nylon "TV-Raps", or approved equal at minimum 100 mm (4-inch) intervals.

E. Appearance:

1. Arrange conduit, trunking and ducting to present neat appearance, parallel with other service runs and lines of building construction, except where in screed or in-situ concrete.
2. Ensure plumb vertical runs.

F. Cable installation:

1. Install cable in conduit, trunking or equipment enclosures only when completely erected throughout its length.
2. Do not use framework of partitions or similar unless indicated.
3. Where the cables are to be laid direct in the ground, cables shall be marked with lead strip within the minimum 10m. distance.
4. Where the cables are bending follow BS standards for cable bending radius.

5. Where cables are terminated into a panel the cable shall be properly supported so that no direct mechanical load is on the panel.

G. Building expansion and settlement:
1. Make provision in conduit and trunking at expansion and settlement joints to allow for movement of building structure.
2. Provide circular through or adaptable boxes no more than 300 mm either side of expansion or settlement joints for conduit crossing.
3. Join boxes with flexible steel conduit type C or conduits arranged to form a telescopic joint and cover overall with PVC sleeve to provide minimum degree of protection of IP-44 or purpose made telescopic joint protected by a PVC sleeve to at least IP-44.

H. Workmanship Quality
1. Cut conduit clean and square with axis.
2. Remove any burrs prior to erection.
3. Site form 90 degrees in conduit wherever practical or use circular or adaptable boxes.
4. Construct bends and sets cold with a bending machine. Do not apply heat when forming sets or bends.
5. Use bending tools complying with British Standards appropriate to conduit material.
6. Ensure no indentation or reduction in cross sectional area occurs during installation.
7. Use correct tools to assemble conduit.
8. Ensure no tool marks or damage to components occurs.
9. Layout Ensure the maximum circuit lengths and groupings of cables indicated are not exceeded.

1.25 INCIDENTAL REQUIREMENTS

A. Provide all incidentals, equipment, appliances, services, hoisting, scaffolding, supports, tools, supervision, labour consumable items, fees, licenses, etc., necessary to provide complete systems.

B. Perform start-up and checkout on each item and system to provide fully operable systems.

C. Contractor to provide ISO A1 size drawing cabinet (or cabinets) within the Control Room to store "As Built" drawings. The cabinet(s) shall be suitably sized to store 1No. set of "As Built" drawings for all disciplines for the entire site.

1.26 SPACE REQUIREMENTS

A. Carefully check space requirements with other trades and the physical confines of the area to ensure that all material can be installed in the spaces allotted thereto including finished suspended ceilings and the spaces within the building.

B. Make modifications thereto as required and approved.

C. Transmit to other trades all information required for work to be provided under their respective Sections in ample time for installation.

1.27 INTERFACE WITH OTHER TRADES:

A. Wherever work interconnects with work of other trades, coordinate with other trades to ensure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.

B. Identify all items of work that require access so that the ceiling trade will know where to install access doors and panels.

1.28 FINAL ROUTES OF RACEWAYS

A. The Drawings show only the general run of raceways and approximate location of outlets.

B. Any significant changes in location of outlets, cabinets, etc., necessary in order to meet field conditions shall be brought to the immediate attention of the Consultant and receive his approval before such alterations are made. However the contractor is to include for final locations to be moved up to 3-meters away from original locations. All such modifications shall be made without additional cost to the Client.

C. Obtain from the Consultant in the field the location of such outlets or equipment not definitely located on the Drawings.

D. Adjust location of conduits, panels, equipment, pull boxes, fixtures, etc. to accommodate the work to prevent interferences, both anticipated and encountered.

E. Determine the exact route and location of each raceway prior to fabrication.

1.29 CIRCUIT NUMBERS

A. Circuit "tags" in the form of arrows are used to show the home runs of raceways to electrical distribution points.

B. These tags show the circuits in each home run and the panel designation.

C. Show the actual circuits numbers on the finished record drawings and on panel directory card.

D. Where circuiting is not indicated, Electrical Subcontractor must provide required circuiting in accordance with the loading indicated on the drawings and/or as directed.

1.30 CABLE AND WIRE COLOUR CODING

A. Unless otherwise indicated, electrical cables and wires shall be colour-coded as follows:

1. Phase 1 or Phase 'A' or L1 - RED
2. Phase 2 or Phase 'B' or L2 - YELLOW
3. Phase 3 or Phase 'C' or L3 - BLUE
4. Neutral Phase - BLACK
5. Earthing/Grounding Cable - GREEN with YELLOW stripe.

B. The contractor shall not adhere to the latest changes in conductor colouring as indicated in the latest BS7671 unless otherwise noted.

1.31 RIGHT-OF-WAY

A. Lines that pitch have the right-of-way over those that do not pitch.

1. For example: steam, condensate, and plumbing drains normally have right-of way.
2. Lines whose elevations cannot be changed to have right-of-way over lines whose elevations can be changed.

B. Make offsets, transitions and changes in direction in raceways as required to maintain proper headroom in pitch of sloping lines whether or not indicated on the Drawings.

C. Wherever the work is of sufficient complexity, prepare additional Detail Drawings to scale similar to that of the bidding Drawings, prepared on tracing medium of the same size as Contract Drawings.

1. With these layouts, coordinate the work with the work of other trades.
2. Such detailed work to be clearly identified on the Drawings as to the area to which it applies.
3. Submit for review Drawings clearly showing the work and its relation to the work of other trades before commencing shop fabrication or erection in the field.

D. Coordinate with the local power supply authority and local telecommunications authority requirements for service utility connections and provide all necessary materials, labour and testing as required.

E. Coordinate with contractors for work under other Divisions of this specification for all work necessary to accomplish this contractor's work.

1.32 EQUIPMENT ACCESSORIES

A. Supports:

1. Provide supports, hangers and auxiliary structural members required for support of the work per Section 26 0529.

B. Penetrations:

1. Furnish a set of sleeves for passage of raceways through structural, masonry and concrete walls of floors and elsewhere as will be required for the proper protection of each raceway passing through building surfaces.
2. All penetrations through fire rated walls and compartments to be suitably fire stopped using proprietary systems accordingly.

1.33 FIXING

A. Wall mounted equipment may be directly secured to wall by means of steel anchor bolts.

B. Screws

1. The screws used for fixing accessory cover plates shall be of the dome slotted raised head or countersunk type, finished to match the respective plates where metallic plates are used.

1.34 CLEARANCES

A. Maintain at least 25 mm air space between equipment and supporting wall.

B. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars as per approved details shown on drawing.

C. Proprietary prefabricated steel channels providing a high degree of mounting flexibility may be used for mounting arrays of equipment.

1.35 LOCATIONS OF EQUIPMENT, ACCESSORIES AND DEVICES

A. Any locations shown on the employer's requirement drawings are indicative the final location must be agreed by the Consultant prior to final fixing.

B. Where interior designers are designing particular areas or aspects of a project they shall lead the coordination of all areas under their control and the Contractor shall liaise with them accordingly to ensure setting out of accessories meets the aesthetic requirements of the space.

1.36 CONDUIT AND TRUNKING COLOUR CODING

A. In areas of mechanical plant or voids accommodating mechanical services, or where otherwise indicated, identify electrical conduits and ducts in accordance with BS 1710 and Section 26 0553.

B. Unless indicated elsewhere, apply colour orange to BS 4800 by painting on service as a band over 150 mm or applying an adhesive tape type wrap around services over a length of 150 mm.

C. Place identification colours at bulkheads, wall penetrations and any other place where identification is necessary.

1.37 EXCAVATION, TRENCHING AND BACKFILL

A. Excavation:

1. Provide excavation for the Work.

2. Excavate all material encountered, to the depths indicated on the drawings or required.
3. Remove from the site, excavated materials not required or suitable for backfill.
4. Provide grading, as may be necessary, to prevent surface water from flowing into trenches or other excavations. Remove any water accumulating therein.
5. Provide sheeting and shoring as may be necessary for the protection of the Work and for the safety of personnel.

B. Trenches:
1. Provide trenches of widths necessary for the proper execution of the Work.
2. Grade bottom of the trenches accurately to provide uniform bearing and support the Work on undisturbed soil at every point along its entire length.
3. Except where rock is encountered, do not excavate below the depths indicated.
4. Where rock excavations are required, excavate rock to a minimum over depth of four 100 mm below the trench depths indicated on the Drawings or required.
5. Backfill over depths in the rock excavation and unauthorized over depths with loose granular, moist earth, thoroughly machine tamped, to a compaction level of at least 95 percent to standard protector density or 75 percent relative density or as specified by the Consultant.
6. Whenever unstable soil that is incapable of properly supporting the Work, as determined by Consultant, is encountered in the bottom of the trench, remove soil to a depth required and backfill the trench to the proper grade with coarse sand, fine gravel, or other suitable material.

C. Minimum Depths:
1. Excavate trenches for utilities to a depth that will provide the following minimum depths of cover from existing grade or from indicated finished grade, whichever is lower, unless otherwise specifically shown or indicated elsewhere:
   a. Primary electric service: 1200 mm (minimum)
   b. Secondary electric service: 600 mm (minimum)
   c. Telephone service: 600 mm (minimum)
   d. Audio Visual service: 600 mm (minimum)
   e. Trenches shall not be placed within 3000 mm of foundation or soil surfaces which must resist horizontal forces.

D. Backfill:
1. Do not backfill trenches until all required tests and inspection have been pre-formed and the installation observed by the Consultant.
2. Comply with the requirements of other sections of these specifications.
3. Backfill shall consist of non-expansive soil with limited porosity.
4. Deposit in 150 mm layers and thoroughly and carefully tamp until the Work has a cover of not less than 300 mm.
5. Backfill and tamp remainder of trench at 300 mm intervals until complete.
6. Uniformly grade the finished surface.
7. Backfill and tamp with compaction at least equal to the surrounding area.

E. Cutting, Patching and Repairing:
1. Planning and Laying Out:
   a. The work shall be carefully laid out in advance.
   b. Where cutting, channelling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or

anchorage of raceway, outlets or other equipment, the work shall be carefully done.

c. Any damage to the building, piping, equipment or defaced finish plaster, woodwork, metalwork, etc. shall be repaired by skilled mechanics of the trades involved at no additional cost to the Client.

F. Painting:

1. Where conduits, mounting channels, outlet, junction, or pull boxes are mounted on a painted surface, or a surface to be painted, they shall be painted to match the surface.
2. Whenever support channels are cut, the bare metal shall be cold galvanized.
3. Where particular methods of finish and painting are not specified, ensure following requirements are met:
   a. Protect all metal work, plant, equipment, pipelines, duct lines, ancillaries, brackets and supports against corrosion and oxidization.
   b. Provide ferrous metals, machined or otherwise with protective coatings at manufacturer's works.
4. Ensure all items requiring on-site decorative finishes are provided primed to suit base material and required finish.
5. Following delivery to site, storage on site and installation make good any damage to finishes, by cleaning, degreasing and re-furbishing.
6. Paint materials. Use the following materials as appropriate:
   a. Solvent borne priming paint to BS 7956 for bare woodwork.
   b. Red Oxide priming paint for bare iron and steelwork.
   c. Zinc Chromate priming paint for bare ferrous and non-ferrous metals.
   d. Calcium Plumbate priming paint to BS 3698 for galvanized steel or composite wood/metal components.
   e. Undercoating paint for previously primed or painted surfaces before the application of finishing coats.
   f. Gloss finishing paint for previously primed or painted/undercoated surfaces.
   g. Epoxy resin paint for specialist coatings requiring resistance to acids, alkalis, oils, solvents, abrasion or high humidity.
   h. Aluminium paint to BS 388 for structural steelwork, corrugated metallic surfaces and similar applications where moisture and heat resistant properties are required.
   i. Cold galvanizing paint for making good damage to previously galvanized surfaces and protection to galvanized materials modified during installation.
   j. Zinc-rich metallic to BS 4652 for bare iron and steelwork where electrical conductivity has to be assured.
   k. Black tar-based paint to BS 1070 for moisture resistant protection to metal surfaces where decorating appearance is not important.
   l. Bitumen based coatings for cold application to BS 3416 protection to iron and steel, particularly pipelines and fittings for use in contact with potable water.
   m. Bitumen based coatings for cold application to BS 6949 not to be used in contact with potable water.
7. Ensure paints used are of quality and type to suit application and that:
   a. Primers have good adhesion, covering power, rust-inhibiting and grain filling properties.

b. Gloss finishing paints are of machine finish grade having high adhesion and high resistance to solvents, mineral oils, cutting oils, detergents, chipping and impact damage.
c. Use heat resistant paints for applications to surfaces over 80 degrees

8. Ensure paints are applied in accordance with manufacturer's instructions and to BS 6150.
9. Do not apply paints where weather, temperature, humidity or other conditions may have a damaging effect upon finish or paint.
10. Ensure metal surfaces are thoroughly cleaned, all mill and weld scale removed and finally degreased. Clean steel surfaces in accordance with BS EN ISO 8503 and prepare surfaces for painting in accordance with BS EN ISO 4618-3.
11. Ensure metal surfaces are thoroughly cleaned, all mill and weld scale removed and finally degreased.
    a. Prepare surfaces for painting in accordance with BS EN ISO 4618-3.
    b. Wherever possible ensure paint finishes applied by component manufacturers are spray applied.
12. Apply paint evenly and ensure finish shows no excessive brush marks, grinning, runs, sagging, roughness or other application defects.
13. Repair damage to galvanized components due to installation process, i.e. following cutting, drilling or welding, by applying 2 no. substantial coats of cold galvanizing paint.
14. Apply a protective coating to all bright machined parts before dispatch from works.
15. Do not remove protective coatings unless required for installation, testing or commissioning purposes and in such cases reinstate upon completion.
16. Repair any damaged protective coating or bright machined part, or where necessary replace damaged component. Use and apply metal coatings in accordance with manufacturer's instructions.
17. Complete where possible all welding, drilling, bending and other work before metal coating.

G. Cleaning Up:
1. Avoid Accumulation of Debris:
    a. Contractor shall take care to avoid accumulation of debris, boxes, crates, etc., resulting from the installation of his work.
    b. Contractor shall remove from the premises each day all debris, boxes, etc., and keep the premises clean.

H. Fixtures and Equipment:
1. Contractor shall clean up all fixtures and equipment at the completion of the project.
2. All switchboards, panelboards, wireways, trench ducts, cabinets and enclosures shall be thoroughly vacuumed clean prior to energizing equipment and at the completion of the project.
3. Equipment shall be opened for observation by the Consultant as required.

I. Waterproofing:
1. Penetrations:
    a. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement walls, and the like.
    b. Such penetration is necessary, perform it prior to the waterproofing and furnish all sleeves or pitch-pockets required.

c. Advise the Consultant and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.

2. Restoration:

a. If Contractor penetrates any walls or surfaces after they have been waterproofed, he shall restore the waterproof integrity of that surface as directed by the Consultant at his own expense.

J. Supports:

1. Support work in accordance with the best industry practice and the following:

a. Standard Types:

1) Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members.
2) They shall be rigidly bolted or welded together and adequately braced to form a substantial structure.
3) Racks shall be of ample size to assure a workmanlike arrangement of all equipment mounted on them.

b. Supplementary Supports:

1) Include supporting frames or racks extending from building structure for work indicated as being supported from walls where the walls are incapable of supporting the weight.
2) In particular, provide such frames or racks in electric closets.
3) Include supporting frames or racks for equipment, intended for vertical surface mounting, which is required in a free standing position.

c. Support from Raceways and Suspended Ceilings:

1) As a general rule, nothing, (including outlet, pull and junction boxes and fittings) shall depend on electric conduits, raceways, cables for support, suspended ceilings media (tiles, lath, plaster, as well as spleens, runners, bars and the like in the plane of the ceiling), except that threaded hub type fittings having a gross volume not in excess of 1500 cubic centimeters may be supported from heavy wall conduit, where the conduit is securely supported from the structure within 250mm of the fitting on two opposite sides.
2) Provide required supports and hangers for conduit, equipment, etc., so that loading will not exceed allowable loadings of structure.

K. Fastenings:

1. Fasten electric work to building structure in accordance with the best industry practice and the following:
2. Floor or Pad-mounted Equipment:

a. Floor or pad mounted equipment shall not be held in place solely by its own dead weight.
b. Include anchor fastening in all cases.

3. Ceiling-mounted Equipment:

a. For items which are shown as being ceiling mounted at locations where fastening to the building construction element above is not possible, provide

suitable auxiliary channel or angle iron bridging, tying to the building structural elements.

4. Preparation:
   a. Mark-out, set-out and firmly fix all equipment, components and necessary brackets and supports.
5. Manufacturer's Drawings:
   a. Use manufacturer's drawings and templates for purposes of marking and setting out.
6. Fixings:
   a. Ensure structure and fixings are suitable for items to be fixed.
7. Loading Details:
   a. Provide loading details for all fixing types.
8. Building-In:
   a. Provide all necessary assistance to enable any item of building-in type to be built.
9. Size of Fixing:
   a. Use largest size of bolt, screw or other fixing permitted by diameter of hole in item to be fixed.
10. Greasing Of Fixings:
    a. Ensure all bolts, screws or other fixings used are greased or lubricated in accordance with manufacturer's instructions.
11. Standards:
    a. Ensure that fixings such as expanding anchors are tested for tensile loading in accordance with BS 5080-1.
12. Plugs:
    a. Use plugs of suitable size and length for fixings.
    b. Use plastic, fibrous or soft metal non-deteriorating plugs to suit application.
    c. Do not use wood plugs. Ensure that when screw is in place, threaded length is in plug.
    d. Ensure plugs used for screw fixing are set-in to correct depth prior to final tightening.
13. Screws:
    a. Use screws to BS 1210. Generally use sherardized steel wood screws for fixing to concrete, brickwork or block-work.
    b. In damp or exposed situations use greased brass wood screws.
14. Cast-In Fixings:
    a. Where cast-in fixings are permitted, mark out and set fixings in accordance with manufacturer's instructions.
15. Shot Fired Fixings:
    a. Obtain approval prior to using shot fired type fixings.

16. Self Adhesive Fixings:
    a. Obtain approval prior to using self adhesive type fixings.
17. Proprietary Channel Inserts:
    a. Provide proprietary channel inserts for casting in where required.
18. Non-Penetrative Support Systems for Roof Mounted Equipment:
    a. Manufacturer and reference.
    b. Obtain approval prior to using non-penetrative support systems for roof mounted equipment.
19. Drilling:
    a. Drill holes squarely. Use drills of requisite size and depth, and appropriate to fabric. Do not flame–cut holes in metal work.
20. Proprietary Fixings:
    a. Comply with manufacturer's instructions for all fixings.
21. Fixing To Reinforced Concrete:
    a. Take precautions to avoid fixing through reinforcement.
22. Fixing To Brickwork:
    a. Do not fix to unsound material or mortar between brickwork courses.
23. Fixing To Timber Rails:
    a. Fix equipment, brackets and supports by drilling hole through timber rail and fixing with bolt, back plate, washer and loose nut.
24. Fixing To Hollow Stud/Tile/Block Walls:
    a. Fix equipment, brackets and supports where there is access at rear of wall, by drilling hole through wall and fixing with bolt, back-plate, washer and loose nut.
    b. Fix equipment, brackets and supports where there is no access at rear of wall, drill hole and use screw anchor type fixing or gravity type toggle fixing.
25. Fixing To Concrete, Brickwork or Block-work:
    a. Fix equipment, brackets and supports using wood screws in plugs.
    b. Drill holes and fix using steel bolts of grouted bolt type or expanding bolt type fixing.
26. Fixing To Metalwork:
    a. Fix equipment, brackets and supports by drilling holes and fixing using set screws or bolts complete with washers, shake-proof washers and loose nuts.
27. Fixing To Structural Steelwork and Concrete Structures:
    a. Provide manufacturer's information on recommended fixing. Obtain approval for any fixing to structure steel work and concrete structures.
    b. Generally use proprietary fixings to structural steelwork and concrete structures.
    c. Obtain approval to cut holes in structural steelwork or concrete structures or weld to structural steelwork.

1.38 EXPANSION FITTINGS

A. Provide expansion fittings at all building expansion joints.
   1. Expansion fittings shall be bonded to the raceway on both sides.
   2. Provide expansion fittings, in accordance with manufacture recommendations, in all areas subject to swings in temperature of more than 15 degrees C.

B. Install expansion fittings in all locations were expected expansion difference is 6.35mm, or more, between boxes.

1.39 PENETRATIONS, SLEEVES AND FIRE SEALS:

A. Cut floor and wall penetrations neatly and to the minimum size required for installation of the equipment and raceways.

B. Provide pipe sleeves for all conduits penetrating floors, exterior walls and roofs; unless otherwise indicated, pipe sleeves shall be galvanized steel pipe.
   1. Extend floor sleeves above the floor a minimum of 50.8 mm (2 inches).
   2. Embed sleeves in new concrete or step-core concrete and grout sleeves into existing concrete with epoxy grout.
   3. Seal floor sleeves using fire-sealing systems approved by a Nationally Recognised Testing Laboratory applying the manufacturer's application method, and to be executed by a tradesman qualified to do the job.
   4. Seal exterior wall and roof penetrations water tight.

C. Patch both sides of wall penetrations cut for electrical equipment and raceways to seal against the passage of air, sound and fire.
   1. Seal cable tray penetrations in fire rated walls using fire sealant bags approved by a Nationally Recognised Testing Laboratory.
   2. Seal conduit penetrations in fire rated walls using fire sealing caulk approved by a Nationally Recognised Testing Laboratory.
   3. Seal conduit penetrations in non-rated walls using masonry materials that match the wall construction.
   4. Fire seal between recessed outlet boxes located on opposite sides of a fire rated wall if the box openings are over 10,200 sq. mm (16 square inches) and the boxes are less than 610 mm apart.

1.40 CABLE BOXES AND GLANDS

A. All cable boxes shall be suitable for cables entering from below. Cable boxes shall be dust, weather, rodent and insect proof, conforming to IP68 of IEC 60529 and shall be fitted with a suitable pressure relief device and dehydration breather.

B. They shall be fitted with disconnecting links to permit cable testing and shall have bolted inspection covers for each compartment to facilitate maintenance.

C. Resin oil filled boxes are not acceptable.

D. Gland plates shall be insulated from the cable boxes and shall be of non-magnetic, or insulating material.

E. If metallic gland plates are used, single core cable glands shall be insulated from the gland plate. Gland plate insulation shall be capable of withstanding a dry high voltage test (shear voltage) of 10 kV DC for one minute.

F. Cable boxes shall be capable of withstanding on site the cable high voltage test level in accordance with IEC 60859, IEC 60517, IEC 60141 or IEC 60502, as appropriate.

G. The outdoor terminations shall be designed to withstand all atmospheric conditions due to weather, ozone, acids, alkalis, sandstorms or rapid changes of temperature under the working conditions existing at site.

H. The design shall be such that stresses, due to expansion and contraction in each part of the insulator and fittings, shall not lead to the development of defects.

I. The design of all terminations shall be such as to permit easy cleaning.

J. Where the cables are required to be terminated in power transformers, the Contractor shall be expected to provide full details of equipment into which the cables are terminated, in order to clarify the design and manufacture of the cable termination and its enclosure.

K. A separate earth terminal of adequate dimensions shall be provided on the main metalwork of all termination points.

L. The terminations shall be complete with suitable supporting and lifting arrangements.

M. When single - core cables are used, particularly for currents in excess of 500 A, adequate steps shall be taken to minimize the effects of eddy currents in the gland and bushing-mounted plate.

N. Gland plates for externally mounted marshalling boxes shall be in the form of removable gasketted steel plates, forming part of the underside of the box. Indoor marshalling boxes shall be fitted with gland plates on all four sides.

O. Cable glands for extruded solid dielectric insulated cables (PVC, EPR, XLPE) shall be of the double compression type, and as specified in BS 6121 Part 1.

P. All glands shall be provided with an earthing tab or equal facility. For cables having conductors not larger than 4 sq. mm., serrated washers may be used in place of earthing tags to provide earth continuity.

Q. Glands for armoured or screened cables greater than or equal to 240 sq. mm. and all insulated glands for power cables shall be provided with an integral earthing lug.

R. Insulated glands shall be provided with removable connections for bonding across the gland insulation.

S. The gland insulation shall withstand a wet insulation voltage withstand test of at least 2 kV a.c. for 1 minute (or the specified test voltage, whichever is the higher).

1.41 MEDIUM AND LOW VOLTAGE SWITCHGEAR AND MCC's

A. Provide suitable panel lightings for each cubicle/compartments which will operate while opening the panel door for maintenance. This applies to all medium and low voltage main switchgear.

B. Provide cylindrical locks and handle for back side cover of all medium and low voltage switchgear.

C. All panels shall be factory assembled without exception.

1.42 CUBICLE WIRING

A. Cubicle connections shall be insulated with PVC to IEC 60227. Wires shall not be jointed or teed between terminal points. Bus wires shall be fully insulated and run separately from one another along the top or bottom of the cubicle. Fuses and links or miniature circuit breakers (MCBs) shall be provided to enable all circuits in a cubicle, except a lighting circuit, to be isolated from the bus wires.

B. The d.c. trip and a.c. voltage supplies and wiring to the main protective gear shall be segregated from those for back-up protection and also from protective apparatus for special purposes. Control and alarm supplies shall be segregated as well. Each such group shall be fed through separate MCBs from the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group.

C. Each wire connection within the cubicle shall be provided with clearly engraved identification ferrules showing source and destination on either side of the wire. The ferrules shall fit tightly to the wire and shall not fall off when the wire is disconnected from

the terminal block. All wires associated with the tripping circuits shall be provided with red ferrules marked "Trip" in white. KAHRAMAA's practice of wiring numbering should be adopted throughout.

D. It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead.

E. If single conductor is used it shall be annealed copper of circular cross sectional area of not less than 1mm^2. Flexible conductors of 1.5 mm^2 may be employed on indoor independently mounted control and relay panels.

F. Crimped connectors of approved type shall be used to terminate all small wiring.

G. When connections rated at 240 volt and above are taken through junction boxes they shall be adequately screened and "DANGER" notices shall be affixed to the outside of junction boxes or the marshalling kiosk.

H. All metallic cases of instruments, control switches, relays etc. mounted on control panels or cubicles shall be connected by copper conductors of not less than 4 mm2 section to the nearest earth bar.

I. Where connections to other equipment and supervisory equipment are required the connections shall be grouped together.

1.43 TERMINAL BOARDS AND TERMINAL BLOCKS

A. Terminal boards shall be of good quality non-flammable insulating material, with a comparative tracking index (CTI) of not less than 500, to IEC 60112.

B. Terminal boards shall be spaced not less than 100 mm apart and the bottom of each board shall not be less than 200 mm above the incoming cable gland plate. For relay panels, they shall be mounted at the sides of the cubicle, and set obliquely towards the rear doors to give easy access to terminations and to enable ferrule numbers to be read without difficulty. Where plastic cable channels are used, a minimum space of 50 mm shall be left between channel and terminal boards.

C. For crimped type terminations, at least two sets of crimping tools must be supplied for each installation.

D. Terminals shall be of the insertion clamp type incorporating captive pressure screws, which do not bear directly on the wire but on a serrated clamping plate. The pressure screws shall have an inherent locking feature and terminal entries should be shrouded such that no current carrying metal is exposed.

E. Where connections are to be made between the multicore cables supplied and telephone type multicore cables, the terminal boards shall comprise of a clamp type terminal for the multicore cable joined by a withdrawable insulated link. These terminals shall also be provided with facilities for the insertion of test probes on both sides of the link.

F. Terminations shall be grouped according to function and labels shall be provided on the fixed portion of the terminal boards showing the function of the group. Terminals for connections that exceed 125V shall be separated from those of other circuits and shall be fitted with insulating covers.

G. The use of terminal boards as junction points for wires that are not required in the associated cubicle shall be avoided wherever practicable.

H. Terminal boards shall include short circuit and disconnecting links for CT circuits and disconnecting links for VT and other circuits as necessary and shall be suitable for the connection of test plugs.

I. No more than two wires shall be terminated on either side of a terminal. When it is required to terminate more than two wires on the same terminal, the wires shall be

terminated on adjacent terminals and these terminals shall be shorted using suitable shorting links.

J. All spare contacts and terminals of panel mounted equipment and devices shall be wired to terminal blocks.

K. Each terminal block shall have a minimum of 20 percent spare terminals.

1.44 MOULDED CASE AND MINIATURE CIRCUIT BREAKERS AND FUSE LINKS

A. All Moulded Case Circuit Breakers (MCCBs) and miniature circuit breakers (MCBs) shall be constructed to BS EN 60947.

B. For protection and isolation of circuits associated with protection control and instruments, miniature circuit breakers or fuses and links should be used, although miniature circuit breakers are preferred.

C. Miniature circuit breakers shall be designed and tested in accordance with IEC 60127 and supplementary requirements of this specification. They shall be suitable for use over the full range of expected voltage variation as specified in the Schedules.

D. They shall be suitably rated for both the continuous and short circuit loadings of the circuits they are protecting under all service and atmospheric conditions stated in the specification and ensure that correct discrimination is maintained between main and sub-circuits.

E. For three phase circuits, the miniature circuit breakers shall be of the three-pole type; for single-phase circuits they shall be of the single pole type and for d.c. circuits they shall be of the double pole type.

F. Where miniature circuit breakers are used in circuits containing inductive loads, e.g., operating coils, it is essential that they are suitable for satisfactory operation in the circuit in which they are used, i.e. account is taken of the circuit time constant.

G. All miniature circuit breakers shall be provided with auxiliary contact(s) for remote indication of circuit breaker operation.

H. Means shall be provided to prevent the miniature circuit breakers being inadvertently switched to the "OFF" position. Facilities shall be provided for 'locking-off' the miniature circuit breakers for isolation purposes.

I. Miniature circuit breakers shall be mounted in such a manner so as to give easily visible indication of breaker position and shall be grouped and spaced according to their function in order to facilitate identification and easy replacement.

J. Carriers and bases for fuses and links shall be in accordance with IEC 60269 and colour coded to permit identification of the circuit rating.

K. The fuses and links mounted in cubicles for tripping circuits and protective gear test links shall be mounted on the front of the panel. Other links and fuses shall be accommodated within the cubicle or above the cubicle doors. Fuses and links shall be grouped and spaced according to their function in order to facilitate identification.

L. All incoming circuits in which the voltage exceeds 125V shall be fed through insulated fuses and/or links, the supplies being connected to the bottom terminal. The contacts of the fixed portion of the fuse or link shall be shrouded so that accidental contact with live metal cannot be made when the moving portion is withdrawn.

M. Main supply fuse links shall be of the high rupturing capacity cartridge type. Where fuse carriers are mounted vertically the incoming (supply) side shall be the bottom terminal. Where either fuses or circuits breakers are used it should be ensured that proper discrimination between main and sub-circuits is maintained.

1.45 MARSHALLING KIOSKS AND JUNCTION BOXES

A. All outdoor boxes and kiosks shall be of sheet metal construction, formed on a framework of standard rolled sections, with a protection Class IP 65 of IEC 60529, shall be insect and rodent proof. All boxes which are mounted outdoors shall have sunshades with capability to work as rain protection shield.

B. Heaters shall be provided and shall be controlled by a watertight switch mounted externally. Ventilation louvers shall be provided and divisions between compartments shall be perforated. Heaters shall be controlled by suitable hygrostats and thermostats. They shall be suitable for operation with a 240V 50 Hz supply.

C. All cables shall enter boxes and kiosks at the base.

D. Each compartment of all kiosks and junction boxes shall be provided with access doors at the front and rear. Doors and access covers shall not be secured by nuts and bolts but shall be fastened with integral handles with provision for locking. Door-actuated lighting should be provided inside the kiosk/junction boxes.

E. Kiosks doors shall be of the lift-off and hinged type and shall be provided with laminated glass windows of adequate size to facilitate reading of indicators from outside the kiosk. Where appropriate, facilities shall be provided to allow removal of temperature indicators without the need to pass the capillary tubing and bulb through the various compartments.

F. All hinged doors for marshalling kiosks, control cabinets, DBs, etc. shall be provided with stoppers.

G. For indoor installation, doors and covers under 15 kg mass may be of the slide-on pattern, but above this mass, hinged doors shall be used.

H. If three phase connections are taken through a box or kiosk, they shall be adequately screened or insulated and suitably marked with the phase colour code; a danger notice stating the voltage shall be fixed on the inside and outside of the kiosk or box.

I. A durable copy of the circuit wiring diagram shall be affixed to the back of the kiosk door and labels shall be provided inside each kiosk or box to describe the functions of various items of equipment.

J. A watertight BS 1363 socket outlet 240V AC 13 A 3 pin interlocked switched socket with plug for a 240 volt AC supply shall be mounted externally on the marshalling kiosk. This switched socket shall be connected to the kiosk heater supply circuit through a 13 ampere fuse in the line lead. The earth terminal shall be earthed.

1.46 DEGREES OF PROTECTION

A. The following degrees of protection shall be provided in accordance with IEC 60529.

B. For outdoor equipment, the degree of protection shall be IP 68.

C. For indoor applications where the equipment is housed in the same building as that enclosing water and steam operated equipment, the degrees of protection stated in the previous paragraph shall be uprated to IP 68.

1.47 SUPPLY VOLTAGE

A. All incoming supplies of greater than 125V to earth shall have their terminations shrouded by a suitable insulating material.

1.48 ANCILLARY, MULTICORE AND CONTROL CABLE INSTALLATION

A. Outdoor cables shall be laid on cable trays within concrete cable troughs, drawn in ducts or laid direct in the ground, subject to the approval of KAHRAMAA.

B. Indoor cables shall be laid on cable trays or ladder racks.

C. On main cable routes, the disposition of cables shall segregate ancillary, multicore and control cabling, as far as is practicable.

D. Cable entries into buildings shall be via duct banks or cable tunnels and shall prevent the ingress of moisture, gases and vermin.

E. Where a conduit is used, the runs shall be laid with suitable falls and the lowest parts of the run shall be outside the equipment. All conduit runs shall be adequately drained and ventilated. Conduits shall not run at or below ground level.

F. For cable troughs, an appropriate drainage system shall be provided.

G. Trough covers shall be of reinforced concrete, designed to withstand the maximum loads to be encountered during installation and in service.

H. All cables installed in concrete troughs within a substation shall have suitable anti-termite protection, to be approved by KAHRAMAA.

1.49 CABLE TRAYS

A. Cable trays shall be made of hot dip galvanized steel. When installed and loaded with cables the trays shall sag no more than 50 mm at midpoint between supports; the maximum space between supports shall be 3 meters. Open type cable trays shall be used for power and control cables. Cable density in trays shall not exceed 40 percent of the available tray cross sectional area (depth x width).

B. Cable trays arranged one above the other shall have a minimum separation distance of 250 mm between the top of the lower tray to the bottom of the next upper tray.

C. Where cables are installed on trays, or supported on steelwork, above ground level outdoors, stainless steel strapping shall be used for securing the cables. Plastic strapping may be used elsewhere.

D. The cable trays must be so designed that a reserve space of 20% remains free on all trays after laying of all the cables.

E. All cable tray T-junctions, crossovers, incoming and outgoing branches, etc. shall consist of prefabricated tray elements to ensure proper laying of the cables at the transition points and to avoid congestion.

F. The space between the individual cable trays and risers must be large enough to ensure that the power, instrument, control, measuring and signaling cables as well as the cables of the communication systems do not cause mutual interference.

G. All tray sections must be firmly bolted together to form a continuous metallic link end-to-end and shall be connected to the substation grounding system at least within 20 m intervals. If Power cables without metallic screen are laid in a cable tray then a continuous earthed conductor shall be provided along the run of the cable trays.

1.50 DIRECT-BURIED CABLES

A. All cables laid direct in the ground shall be laid in an excavated trench, protected by reinforced concrete cable covers and PVC warning tapes and the route marked by above ground cable markers.

B. Reinforced concrete cable covers shall be precast and constructed in good quality cement with aggregate not exceeding 9.5 mm nominal size. The covers shall be efficiently compacted in the mould with the exposed face off level and have the ends designed to provide an interlocking facility to resist lateral displacement after installation. The width of covers shall preferable be limited to 600 mm for easy lifting. After fabrication, the covers shall be subject to impact test as per BS 2484.

C. The top of the protection covers shall be at a depth not less than 450 mm below the surface of the ground and there shall be a layer of sand backfill 75 mm deep between the cable and the bottom of the trench and between the top of the cable and underside of the covers. Where cables in the same trench are laid over each other they shall be separated by not less than 75 mm of sand backfill.

D. Where cables are buried in the ground, cable warning tapes shall be continuously installed 300 mm directly above the cable tiles.

E. The tape shall have a thickness not less than 0.1 mm gauge, shall be 150 mm wide and manufactured from high-grade polyethylene pigmented in bright colours.

F. The warning message in Arabic and English, as per KAHRAMAA's standard, shall be continuously printed in a contrasting colour in characters not less than 20 mm high, specially protected against deterioration and fading.

G. The tape shall be supplied in rolls on stout reels suitably cleated for shipment.

H. Above ground cable route markers shall be installed where the cable route changes direction and at both ends of road crossing ducts. Route markers shall be installed at a maximum distance apart of 50 meters on straight runs of the cable route. The position of route markers shall be clearly indicated on the route plans.

I. Direct-buried cables will be inspected by KAHRAMAA before the trenches are backfilled.

J. Where cables are installed in positions exposed to direct sunlight, suitable solar-shields shall be fitted.

K. These shall be designed to protect the cables from direct sunlight and to maintain air circulation. The design of the solar shield shall be subject to approval of KAHRAMAA.

1.51 TERMINATION OF CABLES AND WIRES

A. The Contractor shall provide fully detailed wiring diagrams covering all parts of the plant. Detail diagrams shall be cross-referenced and shall show multicore cable schedule reference numbers to facilitate cable identification. Cable schedules listing all cables and their points of termination including details of cable, number of cores, core reference, core size, number of cores in use and cable length, etc. shall be provided for each substation.

B. Multicore cable tails shall be so bound that each wire may be traced to its cable without difficulty. The spare cores of all multicore cables shall be numbered, terminated and earthed at a terminal block in the cubicle. The spare cores shall have sufficient length to allow re-termination on any terminal block in the cubicle. Where cables are terminated in a junction box and the connections to a relay or control cubicle are continued in conduit the spare cores shall be taken through the conduit and terminated in a cubicle.

C. The d.c. trip and a.c. voltage circuits shall be segregated from those for back-up protection.

D. All incoming and outgoing connections shall be terminated at a terminal block. Direct termination into auxiliary switches or relays will not be accepted. Terminals of relays, auxiliary switches, etc. shall not be used as junction points.

E. The screens of screened pairs of multipair cables shall be earthed at one end of the cable only. The position of the earthing connections shall be shown clearly on the diagram.

F. All wires on panels and all multicore cables shall have ferrules that bear the same number at both ends.

G. At those points of interconnection between the wiring carried out by separate contractors where a

H. change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment. The same ferrule number shall not be used on wires in different circuits on the same panels.

I. Auxiliary PVC insulated cables shall be terminated with compression type glands, clamps or armour clamps complete with all the necessary fittings.

J. All cables shall be identified and shall have phase colours marked at their terminations where appropriate.

K. Where cables leave the apparatus in an upward direction the cable boxes shall be provided with a barrier joint to prevent leakage of cable oil or compound into the apparatus.

1.52 AUXILIARY SWITCHES

A. With each circuit breaker, disconnector, contactor and earthing devices, there shall be supplied all necessary auxiliary switches and mechanisms for indication, protection, control, interlocking, supervisory and other services as specified.

B. Where appropriate, auxiliary switches shall be suitable for light current, low voltage applications.

C. The contacts of all auxiliary switches shall be strong and be capable of adjustment in relation to the movement of the circuit breaker or other item of plant.

D. Not less than four spare auxiliary switches of each type shall be provided.

E. All auxiliary switches shall be wired up to a suitable terminal board on the fixed portion of the switchgear whether they are in use or not in the first instance, and shall be arranged in the same sequence on all similar items of equipment.

F. Switches shall be provided to interrupt the supply of current to the tripping mechanism of the circuit breakers and latched contactors. All such switches and mechanism shall be mounted in accessible positions clear of the operating mechanism, and shall be adequately protected.

1.53 EARTHING

A. Connections by a secondary conductor of an approved section shall be made from the earth terminal of each item of equipment to the system earth. Where necessary, or as required by KAHRAMAA, the earthing conductor shall be suitably cleated. All earthing conductors shall be made of copper.

B. No drilling of the earth conductor shall be allowed except in the jointing or terminating work unless agreed with KAHRAMAA.

C. All metal parts, other than those forming part of any electrical circuit, shall be connected to the main earth system by means of a hard drawn high conductivity copper earth bar with a cross sectional area such that the current density is not greater than 200 A/mm2 for 1 second fault durations and 115 A/mm^2 for 3 second fault durations with a minimum of 30 mm^2.

D. The substation earthing shall comply with IEEE 80.

E. If an earthing conductor is required to be installed along the same route as the cable the copper conductor shall have a cross-sectional area not less than 30 mm2. The earthing conductor shall be connected at both ends to the main system earth or shall act as the main system earth connecting transformer neutral points and various items of equipment. The earthing conductor, when installed as the main system earth shall be the same size of the main system earth and shall be able to carry any prospective fault current.

F. Earth conductors laid direct in the ground shall be lead covered, with a minimum thickness 2 mm. The trench for these conductors shall be lined and backfilled with fine top soil or clay.

G. Joints shall have a resistance not exceeding that of the equivalent length of the conductor, and

H. KAHRAMAA may require any joint to be tested to prove compliance with this requirement as well as the jointing technique adopted to seal the lead covering.

I. No flat earthing conductor shall be drilled with a hole larger than 13 mm diameter clear for attachment to the apparatus earth terminal; where holes larger than this are required a

suitable tab shall be fitted to the end of the conductor. At any other point no hole larger than 6 mm diameter shall be drifted in any earth strip.

J. Connections shall be protected where necessary against electrolytic action and shall be made between clean surfaces and under sufficient pressure to prevent burning caused by fault currents. Joints shall preferably be made by low temperature bracing or crimping. Where bolted joints are used in copper connections they shall have the joint faces tinned.

K. All main members of structural steelwork shall be earthed by copper connections bonded to the steelwork at two locations and the lower arcing horns of outdoor type cable terminations shall be directly bonded to the main earthing system.

L. Connection to apparatus and structures shall be made clear of ground level, preferably to a vertical face and protected as appropriate against electrolytic corrosion. They shall be made between clean surfaces of sufficient size and pressure to carry the rated short circuit current without damage.

M. Power terminal studs rated for full system fault rating shall be provided at a convenient height (at the base of structure) to permit the attachment of portable earth connections for maintenance purposes.

N. The terminal studs shall be connected to the main earthing system via lead sheathed bond of approved design.

O. All large equipment shall be double earthed at two opposite locations. Wherever number of panels is installed together, appropriately sized grounding conductor shall run through the panels to connect earth point of each panel with the grounding conductor and both ends of grounding conductor shall be directly connected with indoor grounding grid. In case number of panels installed together is eight (8) or more than from every sixth (6) panel the earth bar shall have one additional connection to the indoor grounding grid.

P. All non-current carrying metal parts of electrical equipment shall be bonded to an earth terminal or terminals mounted on the equipment and readily accessible and shall be connected to the main earthing system.

Q. All equipment terminals, provided for an external earth connection, shall be identified by indelible means unless such terminals are directly and visibly mounted on metallic equipment frames or earth bars, when such marking may be omitted.

R. Identification marks for earth terminals shall comprise the colours green/yellow in combination or a reproduction of the symbol no. 5019 in IEC 60417.

S. The size of the copper earth bar in control panels, control desks or similar enclosures containing low voltage apparatus, shall be such as to comply with the specified requirements for withstanding prospective short-circuit currents. The size of this bar shall, in no cases, be less than 100 sq. mm. cross-sectional area, providing that sufficient mechanical integrity is provided by adequate supports and terminals, and also, providing this size is not less than the size of the largest incoming power supply conductor.

T. The body of all relays shall be earthed using braided copper. Special consideration shall be given to the electronic earthing of static and numerical relays. The earth wires used for body earthing of panel mounted equipment shall be colour-coded (green and yellow).

7.4.2 26 0509 - Fire Barriers and Cable Transitions – Deleted from here, moved to Appendix7.1, Item 7.1.19

7.4.3 26 0513 - Conductors and Cables

GENERAL

1.1 SUMMARY

A. Section includes conductors, related splices, terminations, and accessories for:
   1. Power Cables used throughout electrical distribution system
   2. Control and Signaling Cables

B. Related Sections:
   1. Section 26 0500 – Common Work Results for Electrical
   2. Section 26 0526 – Grounding and Bonding of Electrical Systems
   3. Section 26 0533 – Raceway and Boxes for Electrical Systems
   4. Section 26 0536 – Cable Trays for Electrical Systems
   5. Section 26 0553 – Identification for Electrical Systems

1.2 DEFINITIONS

A. HOFR: Heat and Oil Resistant, Flame Retardant

B. LSOH: Low Smoke Zero Halogen

C. PVC: Poly Vinyl Chloride

D. SWA: Steel Wire Armored

E. XLPE: Cross-linked Polyethylene

1.3 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BASEC - British Approval Service for Cables.

D. BS 4579-1:1970 - Specification for performance of mechanical and compression joints in electric cable and wire connectors. Compression joints in copper conductors.

E. BS 5467:1997+A3:2008 - Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V.

F. BS 6004:2000 - Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring.

G. BS 6007:2006 - Electric cables. Single core unsheathed heat resisting cables for voltages up to and including 450/750 V, for internal wiring.

H. BS 6121-1:2005 - Mechanical cable glands. Armour glands. Requirements and test methods.

I. BS 6141:1991 - Specification for insulated cables and flexible cords for use in high temperature zones.

J. BS 6207:1991 - Specification for mineral-insulated copper-sheathed cables with copper conductors.

K. BS 6231:2006 - Electric cables. Single core PVC insulated flexible cables of rated voltage 600/1000 V for switchgear and controlgear wiring.

L. BS 6346:1997 - Electric cables. PVC insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V.

M. BS 6500:2000 - Electric cables. Flexible cords rated up to 300/500 V, for use with appliances and equipment intended for domestic, office and similar environments.

N. BS 6622:2007 - Electric cables. Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV. Requirements and test methods.

O. BS 6724:1997+A3:2008 - Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low emission of smoke and corrosive gases when affected by fire.

P. BS 6910-2:1989 - Cold pour resin compound and heat-shrink cable joints in the voltage range up to 1000 V a.c. and 1500 V d.c. Code of practice for on-site installation.

Q. BS 6977:1991 - Specification for insulated flexible cables for lifts and for other flexible connections.

R. BS 7211:1998 - Electric cables. Thermosetting insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring, and having low emission of smoke and corrosive gases when affected by fire.

S. BS 7629-1:2008 - Electric cables. Specification for 300/500 V fire resistant screened cables having low emission of smoke and corrosive gases when affected by fire. Multicore and multipair cables.

T. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

U. BS 7835:2000 - Specification for armoured cables with extruded cross-linked polyethylene or ethylene propylene rubber insulation for rated voltages from 3.8/6.6 kV up to 19/33 kV having low emission of smoke and corrosive gases when affected by fire.

V. BS 7846:2009 - Electric cables. Thermosetting insulated, armoured, fire-resistant cables of rated voltage 600/1000 V, having low emission of smoke and corrosive gases when affected by fire. Specification.

W. BS 7889:1997 - Electric cables. Thermosetting insulated, unarmoured cables for a voltage of 600/1000 V.

X. BS 7919:2001 - Electric cables. Flexible cables rated up to 450/750V, for use with appliances and equipment intended for industrial and similar environments.

1.4 BS 8519:2010 - SELECTION AND INSTALLATION OF FIRE-RESISTANT POWER AND CONTROL CABLE SYSTEMS FOR LIFE SAFETY AND FIRE-FIGHTING APPLICATIONS. CODE OF PRACTICE.

1.5 SUBMITTALS

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

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

C. Qualification Data: For Installer and testing agency.

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

E. Certification of approval by Local Authority where applicable.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Shop and Construction Drawings: submit drawings for approval including, but not limited to the following:

1. Exact routing layouts, sections and profiles of trays, feeder, sub-feeder cables and branch circuits, with indication of any equipment to show and verify coordination between various trades.
2. Details of supports and fixings for buses, trays and cables.
3. Details of connections to transformers, switchboards, panelboards etc.
4. Details of terminations, splices and tapings where permitted, glands and bushings at enclosures.

5. Number and size of conductors in conduit for all branch circuits in accordance with final conduit routing.
6. Cable sizing calculations.
7. Cable schedule.
8. Cable termination schedule.

I. Point-wise compliance statement to the specifications duly signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

J. The Contractor shall follow to the submittal procedures outlined in the "General Requirements and Scope of Works".

1.6 QUALITY ASSURANCE

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

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

C. Testing: Ensure all testing of cabling is undertaken in accordance with BS 7671 and any applicable Local Authority code or regulatory requirement and compile results to be submitted with the O&M information.

1.7 COORDINATION

1.8 SET SLEEVES IN CAST-IN-PLACE CONCRETE, MASONRY WALLS, AND OTHER STRUCTURAL COMPONENTS AS THEY ARE CONSTRUCTED.

A. Ensure routing of multiple cable runs along main containment routes are planned and installed correctly, ensuring that cabling lies flat on the containment and does not twist and obstruct the ability to install, remove, access or maintain any other cable.

PRODUCTS

1.9 SYSTEM CONDITIONS FOR LOW VOLTAGE

A. Rated Voltage: 240/415 ± 6%, 3 Phase, 4 Wire.

B. Neutral: Solidly Earthed.

C. Fault Level: 31 MVA at 415 V.

D. The nominal mains frequency is 50 Hz. Under normal operating conditions there may be a variation of ± 0.1 Hz. Industrial conditions in the state may occasionally result in a short term variation of ± 0.15 Hz. for duration of only a few seconds.

E. In emergency overload conditions, the frequency would be allowed to drop to 48.8 Hz. At which point load shedding would take place. The nominal voltage is 415/240. It is KAHRAMAA practice to maintain the voltage level at a value not exceeding ±6% variation from the nominal value.

1.10 SYSTEM CONDITIONS FOR MEDIUM VOLTAGE

A. The 11kV system has three phase and earth. 11kV side neutral is earthed through earthing transformer at primary sub-stations.

B. Nominal Voltage: 11kV.

C. Maximum Voltage: 12kV.

D. Maximum Symmetrical fault level: 31.5/40kA based on location in network.

E. Limited earth fault current through earthing transformer: 4.5 kA.

F. Frequency: 50 Hz.

G. Impulse: 75 kV.

1.11 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.12 GENERAL REQUIREMENTS FOR POWER CABLES

A. Use new cables, delivered to site with seals intact, manufactured not more than one year prior to delivery, labelled with manufacturer's name, size, description, BS number, classification, length, grade and date of manufacture.

B. All cables used shall be BASEC approved bearing marks of conformity.

C. All cables to have copper conductors, unless otherwise stated as special requirement.

D. All cables shall be XLPE and where run internally have an LSF (low smoke fume) sheath. PVC cables shall not be used without the permission of the Consultant.

E. XLPE armoured cables shall be used only in the positions indicated on the attached drawings and or Specification Sections and each cable shall fully comply with the following requirements.

F. All lighting and power wiring using single core cables shall be single core LSF cables

1.13 11KV CABLING

A. General:

1. The 11kV, 33kV, 66kV &132KV single core cables shall comprise a circular stranded copper conductor (of milliken type construction if 1000mm² or greater) insulated by a continuous vulcanization, triple extrusion process, simultaneously applying a semiconducting conductor screen, a thermosetting insulating dielectric and a semiconducting core screen. The extruded core shall be cured using a dry curing process and the byproducts of crosslinking removed by a prolonged degassing process. The core shall be sheathed overall with an extruded lead sheath and protected with a continuously extruded polymeric over sheath. A thin layer of graphite or semi-conducting polymer shall be applied overall and firmly bonded to permit testing of the cable over sheath.
2. 11kV XLPE insulated cables shall comply with the requirements of IEC 60502 & IEC 60840 plus any additional requirements specified hereafter.
3. The cable shall be designed for a reliable service life of at least 40 years.

B. Conductors:

1. Conductors shall be stranded, annealed, high conductivity copper, or aluminium of at least 99.5 per cent purity. The copper wire before shaping shall be smooth, uniform in quality, free from scale, inequalities, spills, splits and other defects and should comply with the requirements of international specification IEC 60228.
2. The term 'annealed' signifies that the wire before stranding is capable of at least 15 per cent elongation without fracture, the test piece being not less than 150 mm and not more than 300 mm long.
3. When made up from shaped wires the conductor shall be clean and uniform in size and shape and its surface shall be free from sharp edges and unless otherwise approved shall be taped with a layer of conducting or semi-conducting material.
4. Not more than two joints shall be allowed in any of the single wires forming each length of conductor and no joint shall be within 300 mm of any other joint in the same layer. The jointing of wires shall be by brazing, silver soldering cold welding or electrical welding. No joint shall be made in the wire after it has been formed up into the required length.
5. The conductor will be waterblocked to meet the requirements of IEC 60502 & IEC 60840, using waterblocking tapes around each layer of conductor wires to form a

water barrier to prevent water penetration along the conductor in case the cable damaged. A radial water barrier over the conductor alone is not acceptable. The use of waterblocking powder on its own is not permitted.

C. Conductor Screens:

1. A conductor screen shall be used to provide a smooth interface between the conductor and the cable insulation. A suitable semi-conducting binder tape will be applied over the conductor to prevent the extruded screen falling between the interstices of the conductor strands.
2. The semi-conducting screen will have a spot minimum thickness of 1.0mm.
3. The conductor screen will be made from semiconducting crosslinked polyethylene (XLPE) using carbon black material and will be applied as part of a triple extrusion process.
4. The conductor screen shall be extruded and consist of a black, semi-conducting thermoset material fully compatible with the conductor and extruded insulation. The outer surface of the semi-conducting screen shall be super smooth, cylindrical and firmly bonded to the overlying insulation.
5. A smoothness assessment should be conducted on extruded tape samples of the semiconducting screen material. The contact surface between the screen and the insulation shall be cylindrical, smooth and free from protrusions and irregularities that extend more than 0.125mm into the insulation.

D. Insulation:

1. The insulation shall be an extruded crosslinked polyethylene (XLPE) material forming a concentric dielectric surrounding the conductor.
2. The use of insulation based on pure LDPE is preferred to the use of insulation based on Copolymer.
3. The materials for the manufacture of HV cables shall be delivered in clean bulk containers.
4. The preferred manufacturing process is the vertical continuous vulcanisation (VCV) line however cable manufactured with MDCV or CCV lines will also be considered.
5. Every effort is to be made by the manufacturer to ensure the purity of the insulation extruded on the cable core. Frequent sampling during compound manufacture should take place.
6. A contamination check of extruded tape samples of the insulation should be laser checked for contamination prior to manufacture. The contamination level shall be:
   a. Not more than 5 contaminant >100um/100g.
   b. Not more than 2 contaminants 90um<X<110um/100g.
7. 2kg per tonne of material should be checked.
8. Suitable sieves are to be employed to remove particulate contamination from the extruded material that may affect the electrical performance of the cable insulation.
9. The thickness of the insulation shall be specified as the minimum average value measured according to IEC Publication 60840.
10. The insulation thickness shall be based on the maximum conductor screen stress. The maximum conductor screen stress used will be clearly stated and justification for its selection will be provided in the form of Type Test reports and Experience lists.
11. Evidence is required of Weibull Life Prediction from endurance and voltage ramp testing and of your calculations to predict cable service life.
12. Any information supplied pertaining to XLPE insulation should be related to a unique compound identification number that can be cross-referenced to Type Test reports etc.

13. The Cable Manufacturer shall demonstrate their system of incoming material control, manufacturing process control, and cable quality control.
14. Manufacturing processes that utilize advanced monitoring systems including i) Ultrasense online ultrasonic core inspection equipment and ii) Pellet Checking equipment are considered desirable.

E. Insulation Screen

1. The insulation screen shall be extruded and consist of a black, semiconducting thermoset material fully compatible with the extruded insulation. The interface between the insulation and the semiconducting screen shall be super smooth, cylindrical and firmly bonded.
2. Testing of the material should be as for the conductor screen.
3. To reduce the methane content of XLPE at a heat treatment after curing shall be carried out.
4. The extruded conductor screen, insulation and insulation screen shall be manufactured to the highest standards of concentricity, diameter roundness and longitudinal diameter stability. The Bidder/Contractor shall provide a detailed description on the extrusion, curing, cooling and heat treatment after curing processes

F. Cushioning/Waterblocking Layer

1. The core shall be taped overall with semiconducting cushioning tapes to prevent possible mechanical damage of the cable core caused by thermal expansion during normal operation of the cable.
2. Provision should be made to prevent the longitudinal penetration of water along the interface between the cable core and the metallic sheath by the application of suitable water swellable tapes applied over the cable core.

G. Metallic Sheath

1. The sheath is required to fulfill the following requirements:
   a. Provide a radial watertight barrier to the ingress of moisture into the extruded cable core,
   b. Provide a low resistance path for cable charging current,
   c. Provide protection against minor accidental damage caused by third party interference with cable during installation and service.
   d. Be capable of sustaining the specified earth fault currents for the time stipulated by the user.
2. The water impervious sheath shall consist of a seamless and continuously extruded tube of lead alloy. The lead alloy used for the sheath shall be alloy 1/2C or equivalent. A thin layer of bitumen shall be applied over the sheath.
3. Lead alloy sheath of best quality metal, shall meet the requirements of BS EN 12548 and BS 3908 recommendations, free from pinhole flaws and other imperfections shall be tightly extruded over the water blocking layer.
4. The minimum thickness at any point shall not fall below the specified nominal thickness by more than 0.1mm or 5% of the nominal thickness.
5. For the purpose of increasing the total short circuit current rating of the cable, a copper wire screen of suitable cross sectional area may be applied between the core bedding layer and the lead sheath. A copper tape shall be applied directly over the copper wires in an opposite lay to the lay of the copper wires, to ensure equal current sharing in the copper wire screen.
6. A suitable binder tape shall be applied over the copper wire screen.

H. Over sheath

1. The cable serving shall be robust enough to prevent unnecessary damage during installation and shall insulate the cable from earth.
2. The outer covering shall be of a high density polyethylene material. (HDPE) shore D not less than 58%.
3. The minimum average thickness and minimum thickness at a point shall comply with Clause 10.6 of IEC 60840 and not less than the value stated in the schedule.
4. An outer conductive coating (graphite coating or extruded layer) shall be applied to the covering to serve as an electrode for the voltage test on the outer covering.
5. Where sabka (marsh) areas are found on the site, the Contractor shall use lead-sheathed cables where installed externally.

I. Anti-Termite Protection

1. An approved chemical additive shall be added to the cable over sheath compound to protect it from termite attack.

J. Fire Resistance

1. All cable sections installed within buildings on the substation sites shall be painted with an intumescent paint to give a fire performance that conforms to the requirements of,
   a. IEC 60332-1 (Fire).
   b. IEC 60332-3A (Fire).
   c. IEC 60754 (Minimal Halogen)
2. Ideally, over sheath materials will also have an oxygen index of less than 30% and a
3. temperature index of greater than 260□C.

K. Markings

1. The following information will be clearly printed with indelible ink on the semiconducting XLPE
2. screen of every cable;
   a. '11KV or 33kV or 66kV or 132KV XLPE Cable – KAHRAMAA – Cable No.XXXXX - Date'.
3. The oversheath should be legibly embossed along its length with the following information:
   a. '11000V or 33000V or 66000V or 132000V Electric Cable, (Cable size), (Manufacturer), (Year of Manufacture) PROPERTY OF KAHRAMAA' (sequential length marking at every meter interval starting from 000).
4. The embossed letters and figures shall be raised and consist of upright block characters along two or more lines, approximately equally spaced around the circumference of the cable.
5. For both the semiconducting XLPE screen and the over sheath, the maximum size of the characters shall be 13 mm and the minimum size not less than 15 per cent of the nominal or specified external diameter of the cable or 3 mm, whichever is the greater.
6. For both the semiconducting XLPE screen and the over sheath, the spacing between the end of one set of embossed characters and the beginning of the next on the legend shall not exceed 150 mm. Any additional information embossed on the sheath (e.g. the Manufacturer's name) shall not affect the spacing between repetitions of the legend.

L. Dispatch

1. Both ends of the cable shall be rendered fully watertight by fitting a metallic end cap and a pulling eye that are plumbed to the cable metallic sheath. The pulling eye shall be directly connected to the conductor and be capable of withstanding a tensile load of 100N/mm² of conductor area up to a maximum of 6 tones. When requested by the user, pulling eyes shall be fitted to both ends of the cable.
2. The cable shall be dispatched on a drum of suitable construction of minimum hub diameter 20D (where D is the overall diameter of the cable). The drum shall be fully enclosed by either adjacent fitting wooden battens or

1.14 PVC AND XLPE/SWA CABLES

A. Generally the type of load to be served by these cables:

1. Sub main distribution panels.
2. Distribution boards.
3. External feeder pillars.

B. Indoor / outdoor: Indoor and outdoor.

C. Armoured cables shall comprise stranded copper conductors of equal section laid up in sector shape, the cores being XLPE insulated, as specified, further insulated with overall LSF bedding, single wire armoured and XLPE/LSF sheathed overall.

D. LSF / XLPE insulated cables shall have fire-retardant low smoke and halogen-free (LSOH) inner-sheath and out-sheath instead of PVC compounds. XLPE cables used for high voltage distribution systems shall incorporate semi-conducting screening tapes and copper tape.

E. XLPE armoured cables rated at 600/1000 Volts shall comply with BS.5467 and those rated at 6.35kV/12kV, 12.7kW/24kV and 19kV/36kV Volts shall comply with BS 6622 and BS 7835. Cable sheaths shall be red for HV and black for LV cables.

F. Where permitted by the Consultant, PVC armoured cables shall be rated at 600/1000 Volts in accordance with BS.6346.

G. Duplicate copies of the test certificates for each length of cable, together with 300mm of stepped sample cut from the cable length, shall be forwarded by the manufacturers direct to the Consultant before the cable is despatched to the site.

H. In accordance with Local Authority requirements armouring of cables to BS.6346 and BS.5467 shall not be used as the sole circuit protective conductor. A separate CPC shall be provided for all circuits unless otherwise noted.

I. Power circuits constructed to BS 7846 for emergency, essential or life safety equipment wired in XLPE/SWA cables shall include a Mica/glass fire-resistant insulation covered by an extruded cross-linked insulation complying with BS 7655, suitable for operating temperature of 90deg.C. It shall meet the requirements of IEC 60331 and BS 6387 categories CWZ for fire resistance/low smoke, IEC 60332-3, BS EN 50265, BS EN 50266 for flame propagation.

J. Submit manufacturer's catalogue information and technical data for review by the Consultant.

1.15 PVC AND PVC/PVC CABLES

A. Generally the type of load to be served by these cables:

1. Final circuits.

B. Indoor / outdoor: Indoor.

C. Shall be selected in accordance with the following:

1. Where used as final sub-circuits for lighting and power and with conductor sizes not exceeding 2.5 mm2, they shall be of 440 volt/250 volt insulation grade to BS 6004.
2. Where used as mains circuits or where conductor sizes exceed 25 mm2, they shall be 600 volt/1000 volt insulation grade to BS 6346.
3. They shall have insulation suitable for 70 Degree C conductor temperature and comply to BS 6746 and 7655.

1.16 PVC ARMOURED CABLES

A. Generally the type of load to be served by these cables:
   1. Sub main distribution panels.
   2. Distribution boards.
   3. External feeder pillars.

B. Indoor / outdoor: Indoor and outdoor.

C. Shall be selected in accordance with the following:
   1. They shall be of 600 volt/1000 volt grade to BS 6346 and suitable for 70 degree C conductor temperature with insulation complying to BS 6746 and 7655.
   2. Unless otherwise specified, the armouring shall be constructed of single layer of galvanised steel wires complying with BS EN 10257-1.
   3. They shall be multi-core type

1.17 FLEXIBLE CORDS & CABLES

A. Generally the type of load to be served by these cables:
   1. Final connections to equipment.

B. Indoor / outdoor: Indoor and outdoor.

C. Flexible cords or cables shall be manufactured in accordance with the attached drawings and/or specification sections. No cord or cable less than 1.0mm sq. shall be used and selected in accordance with BS 7671 (514-07).

D. Flexible cords or cables, except those used at the final connection to lighting fittings, shall be circular 2 or 3 core as required and each conductor shall be insulated with butyl rubber or EP rubber with cores twisted together, filled with sheathing compound, textile or the like, so as to form an assembly of practically circular cross-section with HOFR sheathing in accordance with BS EN 50525.

E. Flexible cords used for the final connection to all luminaires and other equipment incorporating heat producing devices shall be 150deg.C rubber insulated, 60deg.C LSOH sheathed flexible cords to , circular twin or 3-core as required, in accordance with BS EN 50525. Flexible cords shall be identified as indicated in BS 7671.

1.18 HEAT RESISTANT CABLES

A. Generally the type of load to be served by these cables:
   1. Final circuits in high temperature areas.

B. Indoor / outdoor: Indoor.

C. Heat resisting cables shall be used as only as agreed with the Consultant and shall be of the butyl rubber insulated type or approved equal.

D. Butyl rubber insulated cables shall be manufactured to BS.6007 and rated 450/750 Volts.

E. No cables less than 1.5mm sq shall be used.

1.19 FIRE RATED CABLES

A. Generally the type of load to be served by these cables:
   1. Life safety systems (fire water pumps, fire alarm system etc.).

B. Indoor / outdoor: Indoor and outdoor.

C. Shall be selected in accordance with the following:-

1. Unless otherwise specified, according to BS 6387, C, W, Z, mica glass tape, nominal rating 600/1000V with LPCB certification.
2. Where used in final sub-circuit for lighting and power with conductor size of 100 mm^2 and less, they shall be of 440 volt insulation grade.
3. Where used as mains circuits or where conductor sizes exceed 100 mm^2, they shall be of 660 volt insulation grade.
4. Terminations, unless otherwise specified shall be rated for 105 degree C.

1.20 CONTROL CABLES

A. Generally the type of load to be served by these cables:

1. Control systems..

B. Indoor / outdoor: Indoor and outdoor.

C. Control cables shall be designed according to BS EN 50525 and BS EN 50288 and shall be rated 600 Volt.

D. Control cable shall be as follows:

1. Conductors: Quantity and size shown on drawing are all copper.
2. Identification: Colour coded
3. Insulation: LSF
4. Armour: Steel
5. Jacket: Flame retardant LSF

E. Provide control cables as shown on drawings and as specified.

F. Control cable shall be installed in cable tray, unless otherwise shown.

G. Terminate control cables in associated equipment with suitable connectors.

1.21 CABLE CERTIFICATION MARKING

A. Cables shall bear CENELEC mark or if included in British Approvals Service for Cables (BASEC) in accordance with BASEC regulations.

1.22 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

1.23 CABLE SLEEVES:

A. Supply and hand to others for installation non ferrous cable sleeves for incorporation into the structure where cables pass through fire compartment floors and walls.

B. Packing material

C. Weak mix mortar; intumescent, plaster or mastic; solid intumescent material; or intumescent granule filled bag. These locations be marked on the contractors working/shop/as installed drawings

1.24 CABLE COVERS AND MARKERS

A. Material - Recovered plastic, integral tape.

1. Marking - Electric

B. Plastic marker tape

1. Yellow, marked electric.

EXECUTION

1.25 GENERAL

A. Use and install cables only as directed in the appropriate standard or as directed by the manufacturer in writing. Lay cables in one length unless otherwise indicated. Obtain permission from supervising officer for all through joints, and where overall length requirement exceeds practical drum size.

B. Install cables when temperature is 5 degrees C or greater, using cables stored at or above this temperature for not less than 24 hours.

C. Use drum stands, drum axles, fair leads, rollers, cable stockings and other equipment as recommended by the cable manufacturer and as appropriate to the method of installation.

1.26 INSTALLATION OF INSULATED CABLES

A. Straighten and dress cables using methods and tools recommended by cable manufacturer.

B. Use thermoplastic or LSF sheathed cables in location indicated, and where cables may come into direct contact with any material that may be corrosive to copper.

C. Do not allow extra length on installed cables to allow for cutting back of moisture affected ends. Store mineral insulated cables in the form as supplied by manufacturer.

1.27 CLEARANCES

A. Unless otherwise stated, the minimum clearance between cables shall be as follows:

TYPE OF CABLE	LADDER RACK	CABLE TRAY
Multi-core SWA or MICS	1d	2d
Single core cables	1d	2d (Trefoil)
Where d = horizontal clearance between cables equal to largest cable diameter.		

B. Multiple banking of cables is not permitted unless approved. (A minimum clearance of 4d is required between cables to ensure no de-rating applies).

C. All single core cables shall be terminated to minimise eddy currents i.e. onto a substantial non-ferrous plate.

D. All cables shall be installed in accordance with the manufacturers' recommendations and to comply with the IEE Regulations and Local Authority Requirements.

E. Each run of cable shall be manufactured in one length. No through joints shall be allowed on any new cables unless authorised by the Consultant. The Contractor shall include for phase identification of cable conductors from the main switchboard. Terminals at each end of the feeders shall be correspondingly marked.

F. The Contractor shall include for measuring and cutting the exact lengths required for the run. There shall be no additional cost to the Client for waste cable lengths.

G. PVC or LSF served cables shall not be installed in direct contact with any form of polystyrene.

H. Where PVC or XLPE armoured cables are to be installed together they shall be fixed to a common cable tray, the cables being secured to the cable tray by means of suitable cleats, or other approved means.

1.28 INSTALLATION OF UNARMOURED CABLES:

A. Install and use un-armoured cable in accordance with BS 7540-1, BS 7540-2, BS 7540-3 or the manufacturer's written instructions.

1.29 INSTALLATION OF ARMOURED CABLES

A. In no case shall the radius of any armoured cable bend be lower than eight times the overall diameter of cable for PVC armoured cable and twelve times the diameter for XLPE armoured cables.

B. The cables shall be terminated in approved type compression glands to BS 6121 complete with shroud and propriety earthing plate/tag, from which an earth bond shall be made to the panel earth bar.

C. Resin only shall be used as a flux. Cable jointing kits shall accord with BS 6910.

1. Compound shall be to BS 1858 Class 2 unless otherwise stated.
2. The design, control of work and actual jointing procedures shall be undertaken in accordance BS 6910-2:1989 "Cold pour resin compound and heat-shrink cable joints in the voltage range up to 1000 V a.c. and 1500 V d.c. Code of practice for on-site installation".

D. Except where the gland is screwed into a screwed entry of an enclosure, allow for the provision of a gland earth tag washer (or earth ring) together with brass bolt, nuts and washers irrespective of whether the enclosure is metallic or non-metallic.

E. Where an enclosure is non-metallic and a protective conductor is required for the armouring (e.g. to continue the protective conductor through the enclosure), allow for the earth tag and the protective conductor lug to be clamped between two locknuts within the enclosure, so obviating the risk of the degradation of the joint by creepage of the non-metallic enclosure material.

F. Spacing of cable supports shall be within the maximum distances specified in BS 7671 Wiring Regulations, according to the cable diameter, with a maximum spacing of 600 mm horizontally and 750 mm vertically for cables having an overall diameter exceeding 40 mm. Cleats shall be of the correct size type and spacing to suit the particular cable. Cleats shall be plastic or silicon aluminium type, cable tie wraps shall not be permitted.

G. Where cables pass through non-fire rated floors or through walls, they shall be protected by a short length of heavy gauge pipe bushed with hardwood or lead at each end. When rising through a floor the protecting barrel shall project to a height of approximately 1.20 m.

H. Where PVC or XLPE armoured cables are to be laid direct in the ground, they shall be buried at a depth of not less than 900 mm below ground level for 600/1000 Volt grade cables and a minimum depth of 900 mm for 11 kV cables. The bottom of the trench shall be covered with a 75 mm minimum layer of sand before the cable is laid and a further covering a 90 mm depth of sand shall be provided over the cable and the whole identified by means of heavy gauge polyethylene strip with printed warning of cable below. The tape shall be coloured YELLOW for an electric cable and GREEN for a telephone service connection and laid 225 mm below finished ground level.

1.30 ARMOURED CABLES SCHEDULED TO CROSS ROADS, PATHS, CAR PARKS, STRUCTURAL CONCRETE OR PAVEMENTS, EXCEEDING 1.80 M WIDE, SHALL BE INSTALLED IN ADEQUATE CROSS-SECTIONAL AREA EARTHENWARE DUCTS OR APPROVED AND EQUAL TYPE. CABLES TO BE INSTALLED ADJACENT TO PAVEMENTS SHALL BE LOCATED BELOW THE OUTER EDGE OF THE PAVEMENT, WITH CABLE PROTECTION COVERS OR TAPE.

A. Where more than one cable is to be installed in a common trench or route, they shall be spaced at the following minimum dimensions:

USAGE	MV	LV	COMMS

MV	150 mm	300 mm	800 mm
LV	300 mm	80 mm	800 mm

B. Rollers shall be used during the installation of underground cables to prevent them being pulled through the base of the trench.

C. No cable crossing shall be permitted except at branches off the main trench. Where the cables enter draw-in points adequate slack cable shall be left. All cables shall be kept clear of other service pipes and cables by not less than 50 mm, preferably below hot water pipes. Where it is found necessary to cross service pipes and cables and the required clearance cannot be obtained, hardwood blocks shall be inserted between and securely fixed in position.

D. Where cables enter buildings, they shall pass through buried ducts laid to fall. The ducts shall be complete with suitable puddle flanges and after the installation of the cables the Contractor shall include for the ducts to be plugged to ensure that a complete watertight seal is provided around and within the duct.

1.31 SEGREGATION

A. Where an installation comprises of circuits for telecommunication, fire alarms or emergency lighting systems as well as circuits operating at low voltage and connected to a mains supply system; precautions must be taken to prevent electrical contact (and for fire alarm circuits and emergency lighting physical contact) between the cables of the various types of circuits.

B. Segregation must be achieved as indicated in BS.7671 and in accordance with local authority requirements.

C. When fixing the covers for cable trays put spacer between tray and cover to ensure the tray cover does not touching the cables.

D. In addition to the above specific requirements and manufacturers recommendations must be obtained in respect to telecommunications cables which may require additional shielding for segregation. In the case of Telephone cables, the relevant authority or supplier must be contacted.

E. For guidance generally arrangements for enclosing cables to the above regulations are detailed below:

1. Category 1: A circuit operating at low voltage and supplied directly from a mains supply system.
2. Category 2: Telecommunications circuits e.g. radio, telephone, sound, intruder alarm, bell and call and data transmission circuit.
3. Category 3: Fire alarm and emergency lighting.

F. The following installation methods may be considered:

1. Method "A": All three categories installed in trunking must be individual segregated by fire resistant partitions between each category.
2. Method "B": Independent conduit system for each category.
3. Method "C": All three categories installed in the same enclosure, provided that category 3 circuits are mineral insulated and category 2 are insulated to same standard as category 1.
4. Method "D": Category 3 circuits separately enclosed, Category 2 insulated to same standard as Category 1 when installed in same enclosure.

G. When Category 1 and 2 circuits terminate at boxes for the connections of accessories or controls, the two categories of circuit must be partitioned by means of rigidly fixed screen or barriers.

H. In all cases the relevant sections of the specific Specification shall supersede the above clauses.

I. Notwithstanding the above, LV and ELV cables shall not be permitted to run in the same enclosure or cores of the same multi-core cable.

1.32 CABLE INSTALLATION IN LOW TEMPERATURES

A. Install cables at lower installation temperatures when authorised by manufacturer in a written statement.

1.33 INSTALLATION OF LSF CABLE

A. Install LSF cables in accordance with manufacturer's instructions.

B. Ensure temperature rating of cable is above 50 degrees

C. Ensure over-sheaths are not damaged by abrasion or scuffing.

1.34 INSTALLATION OF CABLES IN TRUNKING & CONDUITS:

A. Install cables so that they are orderly and capable of being withdrawn.

B. Arrange single core wiring generally using the loop-in method.

C. Trunking: in vertical trunking provide pin racks at 3m intervals. Use ties at 2m intervals for all wires of the same circuit reference. Mark ties with circuit reference number at 10m intervals.

D. Conduit: Provide cable clamps in conduit boxes at 10m intervals in vertical conduit.

E. Allow for full range of movement at building construction movement joints. Make all joints to wiring at terminal blocks in conduit boxes.

1.35 CABLE TRENCHES

A. Preparation & Planning:

1. Ensure that trenches for cables and cable ducts are prepared, backfilled and reinstated.
2. Supervise all work to cable trenches by others.
3. Carry out walk over survey of trench route, dig trial hole in any area considered to be potentially difficult. Establish location of any other underground service adjacent to cable route.
4. Re-plan cable routes after survey and trial holes.
5. Submit report of survey and trial holes.
6. Carry out any instructed work to adjacent services. Set out cable trenches, excavate trench carefully setting aside any materials required for backfilling or reinstatement.
7. Minimum cover in cable trenches

B. Grade:

1. Grade trench bottom to a maximum slope of 1:12, unless otherwise specifically noted.
2. Clear trench bottom of loose stones and place bedding to full width of trench.

C. Bedding:

1. Riddled earth 6 mm grid for cables; riddled earth 12 mm grid for ducts; imported soft sand; or pea shingle, for ducts.
2. Bedding thickness – 75 mm; or 100 mm for ducts.
3. Install cables or ducts. Haunch cables or ducts in bedding material to a minimum depth of 75 mm above highest cable or duct.

D. Cable or Duct Identification:
   1. Warning tape - Yellow with black legend.

E. Backfill:
   1. Backfill trench using two layers 100 mm thick hand rammed. Complete backfilling in layers and reinstate trench.
   2. Backfill material - as excavated from trench.

F. Cable Installation in Trenches:
   1. Lay cables on newly prepared bedding. Ensure multiple layers of cable are separated vertically by a 50 mm layer of hard rammed bedding material.
   2. When using a power winch ensure tension on the cable is taken by element of the cable designed for that purpose that is armour or conductor cores as appropriate and not plastic sheath, metal sheath or core insulation.
   3. When hand pulling cable ensure no kinks are formed and that flaking, when used, is done in the correct direction.
   4. Do not allow cable to twist during installation. Use swivels to connect pulling bond to cable stocking or equivalent fitting.
   5. Check drum is suitable for jacking before commencing installation. If drum or reel is unsuitable for jacking, flake cable in correct direction in maximum size turns from drum or reel before commencing installation. Use skilled labour to supervise all unreeling, flaking or running of cable from a drum.
   6. Lay cables in the formation shown; ensure spacing is not reduced below that indicated.
   7. Bind trefoil groups at 1m intervals. Bind any associated earth or protective conductor to its cable or trefoil group at 1m intervals.
   8. Ensure installation radii and permanent bending radii are not less than those recommended by the manufacturer.
   9. Do not lay cables to without integral mechanical protection direct in the ground.
   10. The cables shall be looped (min. 360°) around the inside surface of all manholes, pull boxes and gutters to provide extra cable for expansion and contraction and for possible future splicing.
   11. Provide one 120 sq. mm. bare copper ground in each conduit parallel to cables.
   12. All cables shall be tagged.

1.36 CABLE DUCTS

A. Duct Work:
   1. Where ducts are laid by another subcontractor, main contractor shall supervise its laying and installation.
   2. Lay ducts on to newly prepared bedding as shown on the drawings.
   3. Duct joints shall be made in accordance with the manufacturer's instructions.
   4. Ensure that ducts slope no more than 1:60 vertically or 1:30 horizontally.
   5. Ensure that pre-formed duct bends used at ends of duct routes meet the requirements of the cable manufacturer for bending radii.

B. Manholes:
   1. Construct manholes, draw pits and jointing chambers as shown on the drawings.
   2. Where required use standard Local Authority approved manhole types.
   3. Verify alignment of completed duct run by drawing through a mandrel 7 mm diameter less than nominal duct bore for minimum length 250 mm.
   4. Clean completed duct run by drawing through a circular wire brush 12 mm diameter more than nominal duct bore.

C. Draw Wires:
   1. Install a draw wire of corrosion resistant material and minimum breaking strength 550N in each empty duct.
   2. Plug and seal all ducts with proprietary duct plugs, on completion.

1.37 CABLE JOINTS AND TERMINATIONS

A. Ensure all joints and terminations are made by appropriately qualified cable jointers, using jointing materials, components and workmanship recommended by the cable manufacturer and the jointing accessory manufacturer. Install cable glands in accordance with BS 6121-5.

B. Cold pour resin and heat shrink joints per joint or splice manufacturer's instruction.

C. Cut all cable ends immediately prior to jointing or terminating. Cables left unconnected for more than 24 hours shall be sealed with approved cable cap to prevent the ingress of moisture.
   1. Seal plastic sheathed cables using proprietary shrink on end caps.
   2. Seal lead sheathed cables by a plumbed dressed lead cap with airspace to allow conductor movement.

D. Strip cables to bring out the cores and expose conductors, for the minimum length required for connection, to leave no exposed length of conductor after termination.
   1. Ensure that strands are not damaged when stripping cable cores. Twist strands together.
   2. Do not reduce number of strands. Secure all strands at terminations.

E. Clean armour thoroughly prior to jointing or terminating.

F. At connections to equipment and switchgear without integral cable clamping terminals, use compression or solder type lugs for bolted terminal connections, of correct bore.

G. Form all compression connections to components using tools that cannot be released unless the correct degree of compression has been achieved.

H. Install and inspect compression and mechanical connectors on conductors in accordance with BS EN 60228 and BS 7609.

I. Bolt core terminations with lugs to equipment using washers or proprietary shake proof devices.

J. Do not bunch more than three cores at clamping terminals or bolted connections.

K. Mark cable conductor phasing, or other core identification, at each end of all cables, and at all joints, maintaining consistency of marking with any existing system.

L. Connect all cores, including multicore cable spare cores, at all joints and terminations.
   1. Bond any unused cores or multicore cables to earth at both ends, unless otherwise indicated.

1.38 CABLE SLEEVES

A. Pack sleeves with fire resistant material after cable installation.

1.39 ARC AND FIRE-PROOFING

A. Tape Manufacturers shall be Bishop Model 43A or 3M Model 700 or equivalent approved material.

B. Fireproof cables in manholes using fireproofing tape in half-lapped wrapping.

C. Extend fireproofing 2.54 mm into duct.

D. Spiral wrap fireproofing tape with glass tape 3M number 27.

1.40 CABLE IDENTIFICATION

A. Provide identification in accordance with Specification Section 26 0553.

B. Provide all cables, other than final sub-circuit wiring enclosed in conduits or trunking, with labels fixed at each end of cable either side of wall and floor penetrations at approximately 12m intervals at convenient inspection points by means of non-releasable plastic straps, minimum width 4 mm.

C. Ensure labels show the reference number of cable consistent with what is indicated on the drawing.

D. Terminal Marking and Conductor Identification:

1. Provide for switchgear and control gear elements whose terminals are marked in accordance with BS 5472 (EN 50005) and BS 6272 (EN 50042).

   a. Use a unique reference to identify each element in the switchgear or control gear.
   b. Mark on or adjacent to each element its reference.
   c. Identify each terminal for connection to external wiring or cabling using a reference system complying with BS EN 60445 based on the element reference and the appropriate element terminal reference.

2. Use lettered or numbered ferrules or sleeves to BS 3858 to mark each auxiliary conductor or control cable core with the identity of the terminal to which it is connected and the reference of plant or equipment to which it is connected and the identity of the terminal at the remote end.

   a. Contractor shall submit to the CONSULTANT method of ferrule marking or submit a ferrule list of review.
   b. Numbering system must be indicative of the cable run its origin and termination point.

3. Ensure that main circuit conductors are identified in accordance with BS 7671 (IEE Wiring Regulations) paragraph 514. Ensure that all identification of terminals and conductors is recorded and included on record drawings and in operation and maintenance documentation.

E. Underground Cable Identification:

1. Identify external underground cable routes by means of approved markers along their length at distances not exceeding 50m and where a change of direction occurs on such routes.

   a. Provide cables markers with a brass plate or impress concrete to clearly indicate the reference of group of cables or reference number of cable and operating voltage of cable.
   b. Provide key to any reference system used at switchgear.
   c. Mark and protect direct buried cables with plastic tape yellow printed black "DANGER ELECTRIC CABLES".

1.41 CABLE CONDUCTOR COLOUR CODING

A. Identify cable conductors in accordance with Section 26 0553.

1.42 CONDUCTOR ARRANGEMENT

A. Arrange circuit polarity so that phases read in phase rotation order followed by the neutral, if any, from top to bottom in horizontal conductor layouts and left to right in vertical conductor layouts.

1. Ensure flat horizontal arrays have leading phase to the left and neutral to the right from left to right when viewed from supply point.

2. Arrange phase or live pole of two wire apparatus at top or left hand and neutral and earth both at bottom or right hand side.
3. In all cases, ensure conductor arrangements defined are when viewed from front face of all equipment and terminating facilities.
4. Apply identification markers in accordance with BS 7671 (IEE Wiring Regulations), Clause 514 to all conductor termination points.

1.43 TERMINATING MINERAL INSULATED CABLES

A. Use terminations in accordance with BS EN 60702-2 and components and materials recommended or supplied by cable manufacturer.

B. Use seals with maximum temperature rating indicated, stub caps to the largest size available, and drilled caps and headed sleeves for larger sizes.

C. Use glands of type indicated. At terminations to accessory boxes within a plaster or render finish, cable clamps fixed to accessory box and firmly gripping cable sheath may be used. Use earth tail seals with sheath grip type accessory boxes.

D. Equipment not provided with threaded entries secure glands using lock washers and locknuts or brass conduit bush. Use gland shrouds when plastic covered MI cables are used.

E. Using PVC, PIB or LSF material tape to BS 3924 or BS EN 60454 to match sheath, tape overall gland any bare copper sheath and form seal to cable sheath under all shrouds.

F. Mark core sleeve with appropriate identification.

G. Install voltage surge suppressors in accordance with manufacturer's recommendations and surge supprassors to BS 7671, Section 331-01-01

1.44 JOINTING MINERAL INSULATED CABLES

A. Joint mineral insulated cables using methods and materials recommended by cable manufacturers. Terminate cables in externally threaded glands using seals with temperature rating indicated.

B. Insulate connectors using PVC tape to BS 3924 or BS EN 60454, ensuring good seal to conductor sleeve. Make off glands into either end of internally threaded brass sleeve of correct size. Protect brass sleeve using heat shrink sleeve

1.45 FLEXIBLE CORDS & CABLES

A. Where luminaires are suspended from flexible cords the maximum weight supported must not exceed the value indicated in BS 7671 or the manufacturer's guidance.

1.46 RECORD INFORMATION

A. Identify the type and route of all main and sub-main cables routes on the as-installed record drawings. This shall include all changes in direction and entry / exit from risers.

B. Include manufacturers published data of all cables within the O&M Manual.

TESTING

1.47 TYPE TESTS

A. The appropriate type tests specified in this clause shall be made before the manufacturer supplies on a general commercial basis the type of cable described in this specification in order to demonstrate satisfactory performance requirements.

B. These tests excepting those which are also required as additional regular tests need not be repeated once they have been performed successfully, unless alterations are made to cable design or materials which might affect the performance.

C. The accessory manufacturer must demonstrate by type test approval tests on the specific cable that any joint or termination that it is intended for use with the cable supplied for a specific contract is compatible with that cable.

D. Tests are required to demonstrate satisfactory performance characteristics of the basic accessory design.

E. Designs suitably tested may be used for applications where the electrical design stresses are the same or lower than those tested.

F. Type Testing will be in full accordance with IEC60502 for 11KV cable.

G. Cable installation at site will not be started till successful completion of type test.

H. In case of type test failure, repetition of type test will be allowed only one time, after full investigation for type test failure, witnessed and endorsed by accepted third party.

I. In case of type test failure for second time KAHRAMAA reserve their rights to reject the cable manufacturer and select another one from the preferable vendor list.

1.48 SCHEDULE OF TYPE TESTS

A. The type tests shall comprise electrical tests on complete cable and the appropriate tests on cable components.

B. The electrical tests shall be carried out in sequence on one sample of cable. The bending test shall be included in this sequence of tests to check that the electrical properties of the cable after bending are satisfactory.

1.49 ELECTRICAL TESTS

A. The normal sequence of tests shall be:

1. Bending test followed by partial discharge test (IEC Publication 60840).
2. Tan delta measurement (IEC Publication 60840).
3. Heating cycle voltage test, followed by partial discharge measurement (IEC Publication 60840).
4. Impulse withstand test followed by power frequency voltage test (IEC Publication 60840).
5. Megger test.
6. Phase rotation test.
7. Resistance test.
8. Sheath test.
9. And all other tests as necessary and required by Kahramaa.

1.50 TESTS ON CABLE COMPONENTS

A. The following tests should be completed on the cable components:

1. Check of cable construction
2. Measurement of thickness of insulation
3. Measurement of insulation concentricity
4. Measurement of insulation purity
5. Measurement of moisture content in extruded insulation and screens
6. Hot set test for XLPE insulation
7. Shrinkage test
8. Measurement of resistivity of semiconducting screens
9. Measurement of screen protrusions
10. Tests for determining the mechanical properties of the insulation before and after ageing (IEC Publication 60840)
11. Tests for determining the mechanical properties of the non-metallic sheaths before and after ageing (IEC Publication 60840)
12. Ageing tests on pieces of complete cable to check compatibility of materials (IEC Publication 60840)
13. Impact test on metallic sheath
14. Pressure test at high temperature on sheaths
15. Measurement of density of HDPE insulation

16. Measurement of carbon black content of black PE sheaths
17. XLPE Material Characterisation
18. shrinkage test for PE, HDPE and XLPE insulations
19. Water penetration test (IEC Publication 60840)

B. For 11KV cables relevant clauses of IEC 60502 shall be applicable.

7.4.4 26 0526 - Grounding and Bonding for Electrical Systems

GENERAL

1.1 SUMMARY

A. This section specifies the general grounding and bonding requirements for the electrical and telecommunication installations for personnel safety and equipment operations. This includes the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 27 0500 – Common Work Results for Communications

1.2 DEFINITIONS

A. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.

B. "Grounding electrode system" refers to all electrodes required by Local Authority, BS, ANSI and IEEE, as well as including supplementary, lightning protection system and telecommunications system grounding electrodes whether they are shown or not on the drawings.

1.3 REFERENCES

A. BS 7430:2011 - Code of practice for protective earthing of electrical installations.

B. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

C. BS 951:2009 - Electrical earthing. Clamps for earthing and bonding. Specification.

D. BS EN 12163:2011 - Copper and copper alloys. Rod for general purposes.

E. BS EN 50525-1:2011 - Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U). General requirements.

F. BS EN 62305:2006 (series) – Protection against lightning.

G. IEEE 80 Guide for safety in AC Substation Grounding.

H. IEEE 81 Guide for Measuring Earth Resistivity, Ground Impedance and Earth.

I. Surface potentials for Ground system.

J. IEC 60364-5-54 Earthing arrangements and protective conductors for indoor installations up to 1000 V a.c. and 1500 V d.c.

K. NFPA 780 Lightning Protection Code.

L. BS EN 62305 Protection of against Lightning.

M. BS 7430 Code of Practice for Earthing.

1.4 QUALITY ASSURANCE

A. The Contractor shall be responsible for the design, supply, testing and commissioning of all Lightning Protection, Earthing and Bonding systems in accordance with BS 7671, BS EN 62305 and local power supply authority regulations.

1.5 SUBMITTALS

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

B. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.
5. Grounding for sensitive electronic equipment.
6. Overall earthing schematic indicating cross sectional area of all earthing, protective and bonding conductors.
7. Overall earthing layout indicating earthing provisions at substations, switchgear, distribution panel boards etc., identifying fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts, and exact location of earth pits, rods and details of installation and connections, and exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.

C. Field Quality-Control Test Reports: Submit certified, numbered, written test reports to include the following:

1. Test procedures used and test conditions.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

E. The Contractor shall follow to the submittal procedures outlined in the "General Requirements and Scope of Works".

1.6 SPARES

A. Contractor shall provide a list of spares required for each type of equipment installed as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.7 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.8 MATERIALS

A. Use materials and installations methods in accordance with BS EN 62305, BS 7671, BS 7430, Electricity Safety, Quality and Continuity Regulations and Local Electricity Supply Authority Requirements as appropriate.

B. Use materials only after having been approved by the Consultant, resulting from material submittals complying with the "General Requirements and Scope of Works" and Section 26 0500 – Common Work Results for Electrical.

1.9 LIGHTNING PROTECTION

A. Lightning protection shall be provided for all buildings and shall be in accordance with BS EN 62305.

B. The main components of a lightning protection system are as follows:

1. Air terminations,
2. Down conductors,
3. Earth terminations,
4. Joints, bonds, test joints, etc.

C. The buildings have large flat roof. Air termination network mesh of approximately 10 m x 20 m shall be used. Down conductors, one for each 20 m of the building perimeter shall be used. Each down conductor should be provided with a test joint.

D. The ring around a building installed as a part of main earth electrode system shall be used for air termination network.

E. Nuts and bolts at the test joint or other joints, which are to remain detachable, shall be made of coppernickel-silicon-bronze.

F. Down conductors are to be connected to the earthing ring around the buildings. The connection points should be stripped of the lead sheath. The connection points are to be bitumen protected against corrosion.

1.10 GROUNDING GRID

A. Lead-sheathed stranded copper conductor not less than 240 mm² shall be used for main grid conductors and down leads connected to them.

B. The lead sheath shall be at least 2 mm thick.

C. The cross-section of ground grid conductors shall be confirmed by calculation in accordance with the main technical data, but shall not be less than 400mm² for the down leads and 240mm² for the grounding grid electrodes. All down leads shall be with redundant connections.

D. The size of lead-sheathed stranded copper conductors shall be uniform throughout the area under the Contract. The current density for lead sheathed stranded copper conductor shall not be greater than 140 A/mm² for 1 sec. duration.

1.11 INDOOR GROUNDING CONDUCTORS

A. Bare copper tape shall be used for the ring inside the building on the walls at each operational level. The cross-sectional area shall be a minimum 150mm2 (30mm x 5mm); the size required is to be confirmed by the contractor.

B. PVC sheathed stranded copper conductor or bare copper tape shall be used for connection of the equipment to the ring inside building.

C. Lead-sheathed stranded copper conductor not less than 400 mm² cross-sectional area shall be used for all connections of the ring inside the building to outdoor ground electrode system.

D. Each connection between the equipment and the earthing system (spur connection) shall carry the total fault current, but the cross-section area of branch connections may be reduced to 60 percent of corresponding single conductor to provide for the current distribution in two or more conductors.

E. The current density for copper earthing conductors shall not be greater than 190 A/mm² for 1 sec. duration.

1.12 GROUND LEADS

A. All equipment within the station area shall be connected to the main grid including but not limited to the following: steel structures, hoist and motors, 33kV SWG, 11kV SWG, transformers neutral points, transformer tanks, fences, cables armour, cable trays and conduits, AC switchboards, DC switchboards, control panels, control desks, relay panels, motor frames, lighting fixtures, lighting poles, housing of small equipment, ladders, steel reinforcing bars where it is applicable or where it is used in ground slabs for equi-potential grading, etc.

B. Branch connections of the non-current carrying metal parts of equipment shall have a minimum size as follows:

1. Relay and control panels, AC and DC switchboards, distribution boards, etc.: 70 mm^2
2. From metallic enclosure of LV electrical equipment having a supply cable above 35 mm^2: 70 mm^2
3. From metallic enclosure of LV electrical equipment having a supply cable with a size between 6 mm^2 and 35 mm^2: 25 mm^2
4. From metallic enclosure of LV electrical equipment having a supply cable size below 6 mm^2: 6 mm^2
5. To structures and to plant equipment and other non-electrical equipment: 6/25/70 mm^2
6. Earth continuity conductor of Cable trays shall be flexible braided copper of minimum 35 sq.mm (at both sides).

C. The above conductor sizes are minimum. Each conductor shall be designed to carry maximum earth fault current for the fault clearance time or 1 sec. whichever is the longer time.

D. All branch connections shall be made by means of compression type devices or exothermic welding (typically Cadweld) methods, approved by KAHRAMAA may be applied.

E. All joints and connection welding shall be of by exothermic welding (Cadweld).

F. All bare parts of underground grounding conductors shall be suitably protected against direct contact with the soil to prevent electrolytic corrosion of plant equipment.

G. The Contractor shall record the route of all ground electrodes with dimensions marked on the drawings to adequately define the position of the runs.

H. Earth bonds shall be used to bond all steel platforms operating floors, ladders, hand rails, cable tray, structural steel work, etc. which does not have a solidly welded path to the main structure/or grounding grid.

I. Particular attention shall be paid to the effectiveness of bonds onto frames of electrical equipment, and at all points where the earth conductor is bolted.

J. Whenever dissimilar materials are to be joined the necessary bi-metallic plates shall be inserted as required to ensure that electrolytic action is avoided.

K. All electrical equipment shall be equipped with earthing hooks of sufficient size and shall be grounded at the grounding system by means of heavy-duty tinned copper compression lugs.

L. All grounding copper conductors for indoor installation shall be PVC sheathed, coloured green and yellow.

M. Lead sheathed copper grounding conductors emerging from the ground shall be protected against mechanical damage by steel pipes up to 150 mm above grade level. The pipes shall be sealed with a non-setting non-flammable compound.

1.13 EARTH ELECTRODES FOR SYSTEM EARTHING

A. Form: Rod with female thread each end.

B. Dimensions:

1. Rod Diameter - 15 mm - nominal.
2. Rod Length - Driven to a depth of 2m into the summer water table.

C. Material:

1. Copper clad / bond – utilized for general purpose earthing systems in ground where there are minimal salt content and the rod is not immersed in water in normal conditions.
2. Stainless Steel – utilized for general purpose earthing systems in ground where high levels of salt, acidity or other aggressive substances are found.

1.14 EARTH ELECTRODE COUPLINGS:

A. Use high strength driving cap in contact with driven rod and couplings of compatible material fully enclosing the rod threads.

1. Earth Busbars: Manufacture earth busbars from hard drawn, tinned, high conductivity copper bar.

B. Test Links:

1. Provide two test links, in connections between main earth conductors and earth busbar.
2. Fabricate each from two additional sections of earth busbar.
3. Mount one section on stand-off insulators matching earth busbar; use remaining section as removable test link.
4. Secure 12 mm high tensile brass studs to fixed sections of busbar and drill corresponding clearance holes in test links and provide brass washers, nuts and locking devices to secure frame/neutral earthing and test links.

1.15 ACCESSORIES

A. Rod to tape clamp:

1. Sized to suit earth rod and connector.

B. Lugs/Tags:

1. Provide lugs or tags to enable connection of bonding conductors to equipment earth terminals.

C. Protective Cable Terminations:

1. For bolted connections use crimp type lugs compressed by automatic tool to achieve correct pressure and crimp depth.

D. Protective Conductor Warning Notices/Labels:

1. Provide a permanent label durably marked in letters 4.75mm minimum height "SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE", in visible position, at each bonding conductor connection to extraneous conductive parts.

E. Main Earth Conductor - Warning Tapes:

1. Provide green/yellow PVC tapes labelled "EARTHING CONDUCTOR" over complete external lengths of main earth conductors at 300mm depth below finished ground.

F. Earth Bar Label:

1. Label earth bar "SAFETY ELECTRICAL BONDING - DO NOT REMOVE" with wall mounted laminated plastic tablet engraved in 10mm high red letters on white ground.

G. Earth Pit:
1. Provide earth pit as detailed elsewhere in the design.
2. Ensure load rating and construction of the pit is suitable to the type of traffic expected in the area of installation.
3. Provide internal earth bar, adequately sized as required,

1.16 TRANSFORMER/REACTOR NEUTRAL CONNECTIONS

A. Redundant connections from the main grounding grid shall be provided for the transformer/reactor neutral earthing. Dedicated ground rods with min. 15 mm diameter, extendible type of solid copper or stainless steel construction driven directly into the ground to a minimum depth of 2.0 meters into the summer water table without excavation or drilling shall be provided for grounding each neutral terminal of transformers/reactors.

B. The connections from ground rods to the main ground grid shall be made in a concrete inspection pit outside the transformer room with cover, using bolted clamps. Clamping arrangements and terminations shall be submitted for review and approval.

C. Apart from this earth pit, there shall be a pit inside the transformer/reactor room for terminating the cable from the neutral bushing and the spur connections from the outside earth pit using a common bare copper bus bar. Size of the bus bar shall be a minimum of 70x10mm. Length, clamping arrangement and connections shall be adequate enough to withstand the forces due mechanical and electrical stresses in the neutral path during fault conditions. Mounting arrangement shall be submitted for review and approval. All materials shall be protected against corrosion.

1.17 LIGHTNING PROTECTION MATERIAL

A. The following lightning protection material shall be used: lead sheathed copper tape at least 50 mm² for roof conductor and down conductor, copper or stainless steel earth rod 6 m long.

1.18 PERFORMANCE GUARANTEES

A. Where corrosion due to atmospheric, chemical, electrolytic or other causes is likely to impair any part of the grounding system and lightning protection system, suitable precautions shall be taken to prevent:
1. Electrolytic corrosion between dissimilar metals.
2. Chemical corrosion of copper.

B. Fittings and joints shall be resistant to the corrosive agents or otherwise suitably protected with bitumen or embedded in plastic compound according to to the local conditions.

EXECUTION

1.19 GENERAL

A. Provide a fully functional earthing system to protect life and property in accordance with BS7671, BS EN 62305 and local power supply authority regulations.

1.20 SOIL SURVEY AND CALCULATIONS

A. The Contractor shall carry out an earth resistivity survey on each site and report in writing to the Engineer in accordance with the approved program. The report shall detail the methods and instruments used and the results of the surveys. Based on the results the Contractor shall include in the report his proposals for the resistivity to be used in the design of the earthing system.

B. The value of resistivity to be used in the design of the earthing system shall be subject to the Engineer's approval.

C. The surveys shall show the variation of resistivity across the site and with the depth below the site. The Contractor shall consider if there is a need to model the resistivity in two layers and if there is any advantage in the use of long rods. The surveys shall also determine the depth and nature of any underlying rock, which may limit the depth for driving earth rods or if boring will be necessary for installing earth rods.

D. The weather conditions prior to and at the time of the surveys shall be recorded in the report and an assessment made of the seasonal variations in resistivity based on meteorological data for the area. The program for the project should, as far as possible, time the resistivity surveys to take place during a dry season.

E. The report should also state if there are any indications that the ground is corrosive to copper or if there is any risk of galvanic corrosion on other metal structures in the neighbourhood.

F. The report shall be approved by the Engineer before proceeding with the design of the earthing system.

G. The calculations shall be submitted for approval prior to commencing the design of the earthing systems

1.21 EARTH ELECTRODE SYSTEM

A. System Design and Calculations:

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

B. Earth Electrodes:

1. Copper clad / bond – utilized for general purpose earthing systems in ground where there are minimal salt content and the rod is not immersed in water in normal conditions.
2. Stainless Steel – utilized for general purpose earthing systems in ground where high levels of salt, acidity or other aggressive substances are found.

C. Locations:

1. Locate electrodes not less than 2 m distant from building/structure protected, and away from telecommunication and pilot cables and metallic fences.

D. Depth of rod:
   1. Driven to a depth of 2m into the summer water table.

E. Depth of Electrode heads:
   1. Locate electrode heads just below ground level or as shown on drawings.

F. Spacing:
   1. Where electrodes are installed in a group ensure minimum distance between electrodes is twice depth of rods.
      a. Where rods for clean earth are installed ensure distance from any other system rods is six (6) times depth of clean rods unless otherwise noted.
      b. Dimensions between earth rods of the same service and earth rods of differing services shall comply with BS 7430 and the requirements of the Local Utility providers.

G. Main earth Conductor Connection:
   1. Connect main earth conductor to first electrode using heavy duty purpose made silicon aluminium bronze body conductor clamp and high tensile phosphor bronze bolt.
   2. Material, minimum size as BS 7430 Table 4 - Copper.

H. Earth Electrode Clamps:
   1. Connect tape to electrode head using heavy duty purpose made silicon aluminium bronze body connector clamps or leaded gunmetal body connector clamps, and high tensile phosphor bronze bolts to BS EN 12163.

I. Earthing Clamps:
   1. Use clamps complying with BS 951, for bonding pipes and lead Sheathed Cables.
   2. Earth Electrode Inspection Facilities:
      a. Provide enclosure for each connection between earth conductor and associated earth electrode system. Install so that top is flush with finished ground or floor level. Ensure enclosure provides adequate access for testing purposes. Provide pit details for builders work.

1.22 BUILDING OR STRUCTURAL ELEMENT EARTH ELECTRODES

A. Standard: BS 7430.

B. Form: Building or structural element.

1.23 EARTH ELECTRODES IN DRAW PITS:

A. Provide concrete cover, permanently labelled, for electrodes installed through cable draw pit bases.

B. Connect groups of electrodes to main earth conductor via bolted link in inspection pit as BS 7430 for test purposes.

C. Ensure the installation of cabling through the draw pit does not restrict access to the rod for testing purposes.

1.24 EQUIPOTENTIAL BONDS

A. Main:
   1. Provide main equipotential bonds in accordance with BS 7430 and BS 7671.
   2. Material - Insulated cable, single core to BS 6004.
   3. Use no joints in main equipotential bonds.

B. Supplementary:

1. Provide supplementary equipotential bonds to BS 7430 and BS 7671. Joints not allowed in these bonds.
2. Material - Insulated cable, single core to BS 6004.

1.25 CLEAN EARTH DISTRIBUTION

1. Install clean earth distribution in double insulated cables from earth electrodes to equipment points.
2. Mount all busbars with insulators and separate from other earthing systems.

1.26 CIRCUIT PROTECTIVE CONDUCTORS:

A. Material:

1. Insulated cable, single core to BS 6004 as indicated or integral conductor of multi-core cable.

B. Provide protective conductors sized in accordance with BS 7671 (IEE Regulations) 543-01-03 and Tables 54B, 54C, 54D, 54E and 54F or provide protective conductors sized in accordance with BS 7671 (IEE Regulations) 543-01-04 and Table 54G.

1.27 OTHER INSTALLATION REQUIREMENTS

A. Dissimilar Metals:

1. Ensure, where dissimilar metals are used for system, that purpose made jointing materials are used such that corrosion and deterioration of the electrical connection are not caused.
2. Ensure bonding connections to other metal parts of building are electrolytically compatible with those metal parts.
3. Use the guidance given in BS 7430 Table 8 when bonding dissimilar materials.

B. Copper Tape Joints:

1. Provide waterproof protection at joints subject to moisture.
2. Joint copper tapes by brazing, using zinc-free brazing metal with melting point at least 600 degrees C or exothermic welding.

C. Aluminium Tape Joints:

1. Provide waterproof protection at joints subject to moisture.
2. Joint aluminium tapes by welding to BS EN 1011-4.

D. Stranded Conductor Joints:

1. Provide waterproof protection at joints subject to moisture.
2. Joint copper stranded conductors with compression joints to BS EN 61284.

E. Protective Cable Terminations:

1. For bolted connections use crimp type lugs compressed by automatic tool to achieve correct pressure and crimp depth.
2. Make connections between tape and equipment using high tensile grade brass bolts with brass nuts, washers and locking devices. Use phosphor bronze bolts, nuts and washers where connections are liable to corrosion.

F. Building Structural Reinforcing

1. Provide bonding to earthing system.

G. Common Earthing System

1. Common earthing system to be used.
2. Earthing system of multiple facilities to be interconnected with a redundant cable pair, min diameter 185mm^2.

1.28 TESTS

A. Prior to backfilling or casting concrete to the earthing /grounding system network and associated conductors record the test results to demonstrate compliance with the required resistance.

B. Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.

C. All tests on material and equipment shall be made in accordance with IEC Standards if not otherwise specified.

D. The testing of grounding system shall be in accordance with IEEE 81.

E. Upon completion of grounding system, the following measurement shall be effected:
   1. 1. Measurement of resistance to earth,
   2. 2. Measurement of touch voltage inside and outside perimeter fence
   3. 3. Measurement of step voltage inside and outside perimeter fence,
   4. 4. Determination of Grid Potential Rise.
   5. 5. Contact resistance measurement to check the Integrity of welded/bolted joints in the internal as well as external grounding system.

7.4.5 26 0529 - Hangers and Support for Electrical Systems

GENERAL

1.1 SUMMARY

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

B. Related Sections:
   1. Section 26 0500 – Common Work Results for Electrical
   2. Section 26 0536 – Cable Trays for Electrical Systems.
   3. Section 26 0533 – Raceway and Boxes for Electrical Systems
   4. Section 26 0539 – Underfloor Raceways for Electrical Systems
   5. Section 26 0548 – Vibration and Seismic Controls for Electrical Systems.
   6. Section 26 2500 – Enclosed Bus Assemblies

1.2 REFERENCES

A. BS 4429:1987 - Specification for rigging screws and turnbuckles for general engineering, lifting purposes and pipe hanger applications.

B. BS 5950-1:2000 - Structural use of steelwork in building. Code of practice for design. Rolled and welded sections

C. BS 6946:1988 - Specification for metal channel cable support systems for electrical installations.

D. BS 7668:2004 - Weldable structural steels. Hot finished structural hollow sections in weather resistant steels. Specification.

E. BS EN 10143:2006. Continuously hot-dip coated steel sheet and strip. Tolerances on dimensions and shape.

F. BS EN 1090-1:2009+A1:2011 - Execution of steel structures and aluminium structures. Requirements for conformity assessment of structural components.

G. BS EN ISO 1461:2009 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.

H. BS EN ISO 2081:2008. Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel.

I. Local Electricity Supply Authority Regulations.

1.3 SUBMITTALS

A. Contractor to provide the following information as part of a complete and comprehensive technical submittal:
   1. Rated capacities
   2. Detailed assembly drawings
   3. Dimensions
   4. Weights
   5. Method of field assembly
   6. Components

B. Product Data: Catalogue sheets, specifications and installation instructions.

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

D. The Contractor shall follow to the submittal procedures outlined in the "General Requirements and Scope of Works".

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Company specializing in manufacturing Products specified in this Section with minimum three years experience.
   2. Manufacturer is ISO 9001:2000 certified.

B. Undertake installation and procure materials in accordance to BS 6946.

1.5 COORDINATION

A. Provide steel supports, anchor bolts, inserts, etc., for all equipment specified under this section of the specifications.

B. Floor-mounted electrical equipment shall be installed on a minimum of 100 mm (concrete housekeeping pads with a minimum of 100 mm equipment inset on all sides unless the item of equipment has an integral plinth. Concrete shall be in accordance with referenced concrete specification section.

C. Provide formed steel support channels extending from and solidly anchored to the floor and ceiling slabs and mount the designated equipment thereto.

D. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

E. Provide steel support channels for
   1. Communication and special systems cabinets.
   2. Disconnect switches.
   3. Fire alarm system cabinets.
   4. Individual motor starters.
   5. Individual circuit breakers.
   6. Panelboards.
   7. Wall mounted transformers.

1.6 DELIVERY, STORAGE AND HANDLING

A. Material delivered to jobsite shall be stored in original packaging per manufacturer's requirements.

PRODUCTS

1.7 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.8 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems:

1. Comply with BS 6946:1988 - Specification for metal channel cable support systems for electrical installations
2. Minimum material channel yield strength shall be 170N/mm.sq unless otherwise stated.
3. Brackets, support hardware and accessories shall have a minimum yield strength of 170N/mm.sq unless otherwise stated.
4. Maximum length of channel shall be no greater than 6m.
5. Minimum material thickness on all components shall be no less than 2.5mm.
6. Channel dimensions shall be selected in accordance with manufacturers guidance and be suitable for the applicable load criteria.

B. Nonmetallic Slotted Support Systems:

1. Structural-grade, factory-formed, glass-fiber-resin channels and angles with (14-mm diameter holes at a maximum of 200 mm, in at least 1 surface.
2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
4. Channel dimensions shall be selected in accordance with manufacturers guidance and be suitable for the applicable load criteria.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units (sometimes known as wedge nuts).
4. Clamps for Attachment to Steel Structural Elements: varying types including purlin clips, beam clamps, pipe clamps and flange clamps etc, suitable for attached structural element.

F. Through Bolts or rod connectors: Structural type, hex head, and high strength.

G. Toggle Bolts: All-steel springhead type.

H. Hanger Rods: Threaded steel, minimum dimension to be M6.

I. Cut ends of channel systems shall be provided with plastic channel end caps.

1.9 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 5 Section "Metal Fabrications" for steel shapes and plates.

1.10 COATINGS

A. Supports and Channels

1. Support channels system steelwork shall be constructed of steel with coatings complying with:

a. BS EN 10143:2006 - Continuously hot-dip coated steel sheet and strip. Tolerances on dimensions and shape.

b. BS EN ISO 1461:2009 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.

B. Support Hardware and Accessories

1. All supplementary bracketry and support components shall be constructed of steel with coatings complying with:

a. BS EN ISO 2081:2008 - Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel

C. Fasteners, fixings, bolts and washers

1. All sundries and associated materials shall be constructed of steel with coatings complying with:

a. BS EN ISO 2081:2008 - Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel.

b. BS 7371-12:2008 - Coatings on metal fasteners. Requirements for imperial fasteners

D. Products for use outdoors shall be hot-dip galvanized unless otherwise stated.

E. Where specified elsewhere in the design documentation, channels and support hardware and accessories may be treated with alternate finishes or coatings including:

1. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating.

2. Painted Coatings: Manufacturer's standard painted/powder coating.

EXECUTION

1.11 APPLICATION

A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for conduits, cable trays, cable basket and cable ladder in accordance with the manufacturers recommendations and loading tables and generally as required for the loading requirements.

B. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits. Secure cable containment systems to these supports proprietary clamps / fixings.

C. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel and system components.

D. Dry Locations: Steel materials.

E. Corrosive Environments: Stainless Steel or non-metallic U-channel and system components.

1.12 SUPPORT INSTALLATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 90 kG.

B. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. As an alternative to expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 100mm thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 100mm thick.
6. To Steel: Proprietary beam clamps.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
9. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
10. Holes cut to depth of more than 38mm in reinforced concrete beams or to depth of more than 19mm in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
11. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration and shock- resistant fasteners for attachments to concrete slabs.
12. Support trunking in accordance with the manufacturers requirements and/or Guidance Note 1 Selection and Erection published by the IEE Regulations.
13. Support conduit in accordance with Appendix I of Guidance Note I Selection and Erection published by the IEE (now IET).
14. Ensure conduit is not under mechanical stress. Fix conduit boxes independently of conduit.

C. All cable tray and tray supports cutting edges to be painted with galvanized paint.

D. Use proper length bolts for tray and supports avoid extended bolts on tray and Supports.

1.13 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, all types of cable containment and other devices unless components are mounted directly to structural elements of adequate strength.

B. Comply with installation requirements generally identified in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

C. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

D. Components shall be welded where appropriate to ensure structural strength.

1.14 REVIEWED AND MODIFIED

A. Construct concrete bases of dimensions indicated but not less than 100mm larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified generally in Division 03 Section.

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

1.15 PAINTING

A. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting.

B. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

C. Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint.

7.4.6 26 0533 - Raceway and Boxes for Electrical Systems

GENERAL

1.1 SUMMARY

A. This Section includes metal conduits, raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0529 - Hangers and Support for Electrical Systems
3. Section 26 0553 – Identification for Electrical Systems

1.2 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Civil Defence Department requirements.

C. Qatar Construction Specification 2010.

D. BS 31 - Steel Conduit and Fittings for Electrical Wiring.

E. BS 4607-1 - Non-metallic conduits and fittings for electrical installations. Specification for fittings and components of insulating material.

F. BS 4662 - Boxes for flush mounting of electrical accessories – Requirements and test methods and dimensions.

G. BS EN 50085-1 - Cable trunking systems and cable ducting systems for electrical installations. General requirements.

H. BS EN 50085-2-1 - Cable trunking systems and cable ducting systems for electrical installations. Cable trunking systems and cable ducting systems intended for mounting on walls and ceilings.

I. BS EN 50085-2-2 - Cable trunking systems and cable ducting systems for electrical installations. Particular requirements for cable trunking systems and cable ducting systems intended for mounting underfloor, flushfloor, or onfloor.

J. BS EN 50085-2-3 - Cable trunking systems and cable ducting systems for electrical installations. Particular requirements for slotted cable trunking systems intended for installation in cabinets.

K. BS EN 61386-1 - Conduit systems for cable management. General requirements.

L. BS EN 61386-21 - Conduit systems for cable management. Particular requirements. Rigid conduit systems.

M. BS EN 61386-22 - Conduit systems for cable management. Particular requirements. Pliable conduit systems.

N. BS EN 61386-23 - Conduit systems for cable management. Particular requirements. Flexible conduit systems.

O. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

1.3 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

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

D. Structural members in the paths of conduit groups with common supports.

E. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

F. Point-wise compliance statement to the specifications duly signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

G. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works". Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

1.4 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.5 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.6 RIGID STEEL CONDUIT

A. Conduit shall be rigid heavy wall galvanized, threaded type, minimum size shall be 20mm diameter, nominal for controls and 25mm) diameter, nominal for power.

B. Fittings and Conduit bodies shall be as follows:

1. Couplings to be zinc-plated, malleable iron.
2. Hubs to be zinc-plated, malleable iron with insulated throat
3. Locknuts shall be steel. Die cast locknuts shall not be used.
4. Insulated bushings shall be zinc-plated, malleably iron, with 150 deg. C rating, moulded on phenolic thermosetting insulation. Use nylon insulated metallic bushings for sizes 25 and larger.
5. Insulated grounding bushings, shall be same as above except provided with tin plated copper saddle for grounding conductor.
6. Expansion fittings, up to 50mm (2 inches), shall be three-piece type, complete with bonding jumper.
7. Conduit bodies shall be zinc-plated, malleable iron with tapered threaded hubs.

1.7 INTERMEDIATE METALLIC CONDUIT

A. Conduit shall be light weight rigid steel. Fittings shall be as specified under Rigid Steel Conduit above.

1.8 ELECTRICAL METALLIC TUBING AND FITTINGS

A. To be used only for special purposes and, or when specifically indicated on the drawings. Only on special permission shall this material be used in wiring.

B. Conduit shall be continuous, seamless tubing, galvanized or sheradized on the exterior, coated on the interior with a smooth hard finish of lacquer, varnish, or enamel.

C. 20mm in size and smaller, shall be steel set-screw type fittings; 63mm size and larger must employ steel compression gland fittings; Outdoor shall be rain-tight steel compression gland fittings. Indent type fittings shall not be used.

D. All connectors shall have insulated throat and where installed in slab or concrete work, provide approved concrete tight fittings.

1.9 FLEXIBLE STEEL CONDUIT

A. Single strip, continuous, flexible interlocked, double-wrapped steel, galvanized inside and outside, forming smooth internal wiring channel, Maximum length: 1.8M.

1. Each section of raceway must contain an equipment grounding wire bonded at each end and sized as required.
2. Provide connectors with insulating bushings.
3. Steel squeeze-type or steel set screw type fittings.

1.10 LIQUID TIGHT FLEXIBLE ELECTRICAL CONDUIT

A. Same as flexible steel conduit except with tough, insert water-tight plastic outer jacket.

1. Cast malleable iron body and gland nut, cadmium plated with one-piece brass grounding bushings which thread to interior of conduit.
2. Spiral moulded vinyl sealing ring between gland nut and bushing and nylon insulated throat.

1.11 NON-METALLIC CONDUIT

A. Shall be composed of polyvinyl chloride suitable for the relevant application, and listed for exposed and direct burial application.

1. Fittings and adhesives must be produced by the same manufacturer who must have had a minimum of ten (10) years experience in manufacturing the products.
2. Materials must have a tensile strength of 7,000-7,200 psi at 23 degrees C (73.4 degrees F.), flexural strength of 12,000 psi and compressive strength of 9,000 psi.

3. All joints shall be solvent cemented in accordance with the recommendations of the manufacturer.

1.12 ALUMINIUM & STAINLESS STEEL CONDUIT / FITTINGS

A. To be used only for special purposes and, or when specifically indicated on the drawings.

1.13 METAL WIREWAYS (TRUNKING)

A. Shall be constructed from folder sheet steel, galvanized to protect from corrosion and be constructed in accordance with the requirements of BS EN 50085-1 and BS EN 50085-2-1.

B. As indicated on the drawings, elsewhere in the specification or as required to provide segregation between categories of wiring / systems; containment may be single or multi-compartment as required.

C. Fittings and Accessories shall include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with trunking sections as required for complete system.

D. Wireway covers, unless otherwise indicated, shall be available with a return edge to ensure a minimum IP30 protection and shall include for the following fixing options:

1. Screw fix
2. Tamperproof
3. Die-cast turn buckle

E. Wireway covers, where indicated as weatherproof or in any areas considered open to the elements shall be provided with IP 54 rated covers and fixings.

F. Finishes:

1. Manufacturer's standard enamel finish.
2. Manufacturer's standard galvanized finish.

1.14 NON-METALLIC WIREWAYS (TRUNKING)

A. Shall be constructed of the following materials as detailed elsewhere:

1. Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.
2. PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

C. As indicated on the drawings, elsewhere in the specification or as required to provide segregation between categories of wiring / systems; containment may be single or multi-compartment as required.

1.15 OUTLET, JUNCTION, AND PULL BOXES

A. Cast Type Conduit Boxes, Outlet Bodies and Fittings

B. Provide surface mounted outlet and junction boxes, in indoor locations, where exposed to moisture and in outdoor locations.

1. Use Ferrous Alloy boxes and conduit bodies with Rigid Steel or IMC. Use Ferrous Alloy or cast aluminium boxes and conduit bodies with Electrical Metallic Tubing.
2. Covers shall be cast or sheet metal unless otherwise required. Threads for hubs shall be tapered.

C. Galvanized Pressed Steel Outlet Boxes:

1. Pressed steel, galvanized or cadmium-plated, minimum of 100mm, octagonal or square, with galvanized cover or extension ring as required.

1.16 SWITCH AND OUTLET BOX, INDOORS

A. Nominal 75x75mm (single) or 75x135mm (twin) boxes shall be used as required, depths of flush or surface boxes to be 25mm minimum or deeper to accommodate cabling.

B. Where multiple switches or bespoke receptacle requirements are indicated on the drawings multigang or bespoke boxes may be used.

1.17 LIGHTING FIXTURE BOX

A. Suitably (rigidly) fixed conduit box of the same manufacturer and material specification as the main conduit system may be used as a suitable for light fixtures to be supported and secured from.

B. In the case of light fixtures in excess of 2kg independent suspensions / fixing systems shall be provided which may include direct fixture to building fabric, channel support systems, wire or chain suspensions.

C. All un-used conduit entries into conduit boxes shall be blanked off with proprietary plug.

1.18 SHEET STEEL BOXES INDOORS

A. Shall be 1.5 mm min thick sheet steel for boxes with maximum side less than 500mm and maximum area not exceeding 0.25 sq.m;

1. Riveted or welded 20mm flanges at exterior corners.
2. 20mm minimum size of knockouts.
3. Either galvanised or epoxy enamel coated

B. Covers:

1. Same gauge steel as box.
2. Machine bolts / machine screws threaded into tapped holes; maximum spacing twelve 500 mm.
3. Provide gasket to box lid where required.

C. Paint:

1. Rust inhibiting primer; with black epoxy enamel coated exterior.
2. Any damage to painted coating occurring during construction shall be treated on site to prevent corrosion.

1.19 PLASTIC BOXES INDOORS / OUTDOORS

A. Shall be 3.0 mm min thick PVC-U moulded enclosures with maximum side less than 500mm and maximum area not exceeding 0.25 sq.m;

1. Suitable for drilling or cutting however also complete with 20mm minimum size of knockouts.
2. Degree of protection IP65 minimum.
3. Optional insulated accessory mounting plate
4. Raised pads in base of box to allow accessory mounting nuts to be recessed
5. Silicon rubber lid seal.
6. Brass inserts M3.5 with stainless countersunk fixing screws

B. Covers:

1. Same material as box.
2. Machine bolts / machine screws threaded into brass inserts; maximum spacing twelve 500 mm.
3. Provide gasket to box lid where required.

1.20 PULL AND SPLICE BOXES, OUTDOORS

A. Aluminium reinforced, with removable covers secured by brass machine screws.

B. Where size of box is not indicated, size to permit pulling, racking, and splicing of the cables. Braze a ground connector suitable for copper cables to the inside of the box.

1.21 JUNCTION BOX, SIDEWALK TYPE

A. Cast iron, hot-dipped galvanized with threaded conduit entrance hubs, flanged, reinforced checkered cover, gasketed with pry bar slots and countersunk stainless steel screws.

1.22 FLOOR BOXES

A. Floor boxes, where used in conjunction with a conduit system, shall be of the in-screed / cast in type. Constructed of galvanized sheet steel and be complete with riveted or welded seems.

B. Floor boxes shall be constructed in accordance with the requirements of BS EN 50085, pt 1 and 2.

C. General:

1. Box shall be a minimum of 60mm deep.
2. Box shall be fixed directly to the slab prior to screeding or where depth of screed requires adjust a suitable base shall be provided for the box in order to raise the box to the desired final floor level.
3. Multiple box size options including partitioning of internal accessory zone from 1, 2, 3 and 4 compartments.

D. Floor Box Covers:

1. Rugged construction, impervious to cleaning detergents compatible with floor covering.
2. Self-closing and in accordance with BS EN / IEC 61534-22.
3. Box cover to be provided suitable for the location and capable of accepting the depth of floor finish materials.
4. Optional lockable cover.
5. Cable grommet openings shall be complete with anti-trap
6. Floor box cover material shall be:

   a. Finishes within carpeted areas for floor box trims (unless identified elsewhere) shall be polypropylene, ABS or Polymide and finished grey and reinforced with steel.
   b. Finishes within wood or tiled floor areas for floor box trims (unless identified elsewhere) shall be bronze, brass or stainless steel.

E. The finished assembly shall achieve:

1. IP 2X in standard areas.
2. IP 65 where floors are likely to be cleaned using a wet method such a ceramic / marble or stone flooring.

F. Modular fittings compatible with preset inserts and shall include covers; provisions for service outlets, connectors; and associated device plates for indicated systems. Provide for internally mounted outlets and communication-jack and connector assemblies complying with requirements in Division 26 Sections section 26 27 26 Wiring Devices as a minimum shown below:

1. Single / twin or triplex power outlets.
2. Single / twin / triplex or quad telephone-data outlets to the appropriate category as defined elsewhere.
3. Duplex receptacle and duplex telephone-data jacks.
4. Fiber-optic cable connector.

5. TV, Radio, BNC

EXECUTION

1.23 APPLICATION OF RACEWAYS

A. The following applications must be adhered to except as otherwise required by Code. Raceways not conforming to this listing must be removed by this Contractor and replaced with the specified material at this Contractors expense.

1. Rigid Steel - Application:
   a. Use in every instance where exposed or concealed in wall or ceiling voids, except where another material is specified elsewhere.
2. Intermediate Metal Conduits(I.M.C.)
   a. Same as standard threaded rigid steel conduit.
3. Electrical Metallic Tubing (E.M.T.) and Aluminium:
   a. Use only on special permission or where specified on drawing. These shall not be used underground or in slab on grade.
4. Flexible Steel:
   a. a. Use in dry areas for connections to lighting fixtures in hung Ceilings, connections to equipment installed in removable panels of hung ceilings and generally at equipment raceway connections where sound and vibration isolation is required.
   b. Provide proprietary couplings for the terminations at each end.
5. Liquid-Tight Flexible Conduit:
   a. Use in areas subject to moisture where Flexible steel is unacceptable and at connections to all motors, and all raised floor areas.
   b. Provide proprietary couplings for the terminations at each end.
6. Non-Metallic Conduit:
   a. The use of plastic conduit shall be limited to cast in / flush installations either in walls or floor slabs and screed systems.
   b. Suitable fixings shall be provided to secure conduit prior to casting / screeding etc.
7. Stainless Steel
   a. Provide stainless steel conduit where indicated elsewhere in the specifications.
   b. Generally required for all areas of highly corrosive environments or clean areas installations.

B. Support raceways at intervals no greater than 2000mm and with one support within 600mm of each coupling, box, fitting, or outlet box. Provide one support within 600mm of each elbow or bend.

C. Unless otherwise stated elsewhere within the design documentation all cable containment located within air conditioned environments shall be pre-galvanized type. Externally routed cable tray shall be hot dipped galvanized post fabrication type.

1.24 RACEWAY SYSTEMS IN GENERAL

A. All Wiring Systems:

1. Provide raceways for all wiring systems, including security, data transmission, paging, low voltage etc., 240/415 volt wiring shall be kept independent of ELV systems wiring.
2. Where non-metallic raceways are utilized, provide sizes as required with the grounding conductor considered as an insulated additional conductor.
3. Caps and bushings shall be installed as soon as installed and remove only when wires are pulled.
4. Securely tie embedded raceway in place prior to embedment.
5. Lay out the work in advance to avoid excessive concentrations of multiple raceway runs.
6. Draw up couplings and fittings fully and ensure connections are tight.

B. Above-grade raceways to comply with the following:

1. Install raceways concealed except at surface cabinets and for motor and equipment connection in electrical and mechanical rooms.
   a. Install a minimum of six 150mm from flues, steam pipes, or other heated lines. Provide flashing and counter-flashing for waterproofing of raceways, outlets, fittings, etc., which penetrate the roof.
2. In no case will installation of raceways be permitted to interfere with the proper placement of principal reinforcement.
3. Raceways running parallel to slab supports, such as beams, columns, and structural walls, shall be installed not less than twelve 300 mm from such supporting elements.
4. To prevent displacement during concrete pour of lift slab, saddle supports for conduit, outlet boxes, junction boxes, inserts, etc., shall be secured with suitable adhesives / fixings.

C. Non-metallic raceway installation shall conform to the following:

1. All joints are to be made by the solvent cementing method using the material recommended by the raceway manufacturer. To insure good joints, components shall be cleaned prior to assembly.
2. Raceway cut-offs shall be square and made by handsaw or other approved means which does not deform the conduit. Raceway shall be reamed prior to solvent cementing to couplings, adapters, or fittings.
3. Electrical devices which are served by PVC raceways shall be grounded by means of a ground wire pulled in the raceway.
4. Install raceway on steel construction with approved clamps which do not depend on friction or set screw pressure alone.
5. Conduit cleaning shall be done with ball mandrel (diameter approximately 85 percent of conduit inside diameter) followed by close fitting wire brush and wad of felt, or similar material. This assembly may be pulled in together with, but ahead of, the cable being installed. All empty raceways shall be similarly cleaned. Clear any raceway which rejects ball mandrel.
6. Support raceways at intervals no greater than 1000mm and with one support within 300mm of each coupling, box, fitting, or outlet box. Provide one support within 300mm of each elbow or bend.

D. Use following methods of fixing conduit:

1. Floor screeds: Saddles or crampets
2. Buried in plaster or render: Crampets or saddles
3. Above false ceilings: Saddles or proprietary hangers.
4. Surface: Saddles

1.25 OUTLET, JUNCTION, AND PULLBOXES

A. Sizing:

1. Provide outlet, junction, and pullboxes as indicated on the drawings or as required for the complete installation of the various electrical systems, and to facilitate proper pulling of wires and cables.
2. Pull-boxes shall be sized per electrical code minimum.
3. Boxes on empty conduit systems shall be sized as if containing conductors of 25 sq.mm.

B. Orientation:

1. Install boxes and covers for wiring devices so that the wiring devices will be installed with a vertical orientation unless otherwise noted on the drawings.

C. Exact Location:

1. The exact location of outlets and equipment is governed by structural conditions and obstructions, or other equipment items.
2. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to the room layout and will not interfere with other work or equipment.
3. Verify final location of outlets, panels, equipment, etc., with the consultant.
4. Where ptoject requirements are detailed by other parties such as an interior designer, Contractor shall follow setting out requirements as indicated on those drawings.

D. Back-to-back outlets in the same wall, or "thru-wall" type boxes:

1. This shall not be permitted.
2. Provide 300mm minimum spacing for outlets shown on opposite sides of a common wall to minimize sound transmission.
3. Provide 600mm minimum horizontal spacing for outlets shown on opposite sides of a fire rated wall to maintain fire rating.

E. Outlet boxes in finished ceilings or walls:

1. Fit outlet boxes in finished ceilings or walls with appropriate covers, set flush with the finished surface.
   a. Where more than one switch or device is located at one point, use gang boxes and covers unless otherwise indicated.
   b. Sectional switch boxes or utility boxes will not be permitted.
   c. Where drywall material is utilized, provide plaster ring. Provide outlet boxes of the type and size suitable for the specific application.
   d. Where outlet boxes contain two (2) or more 240 volt devices, or where devices occur of different applied voltages, or where normal and emergency devices occur in same box, provide suitable phase barrier.

F. Pull Box Spacing:

1. Provide pull boxes so no individual conduit run contains more than the equivalent of four (4) quarter bends (360 degrees total).

G. Conduit Sizes 32 mm and Larger:

1. Provide boxes to prevent cable or wire from being excessively twisted, stretched, or flexed during installation.
2. Provide support racks/rails for boxes with multiple sets of conductors do not rest on any metal work inside box.

H. Conduit Sizes one 25mm and smaller, low voltage wire and cable (maximum distances):
   1. 60m straight runs.
   2. 45m runs with one 90 degree bend or equivalent.
   3. 38m runs with two 90 degree bends or equivalent.
   4. 30m runs with three or four 90 degree bends or equivalent.

I. Floor Boxes
   1. Prior to Concrete Pour:
      a. Firmly support boxes.
      b. Adjust levelling screws to insure box covers are flush with finished floor.
      c. Plug unused opening with proper fittings and seal joints with compound for exclusion of concrete and moisture.
   2. After Concrete Pour
      a. As soon as traffic is permitted on slab, remove any accumulation of water and foreign matter to avoid corrosion and rust.
      b. Provide temporary protection until such time as final connections / finishing is required.
      c. Ensure covers are flush with finished floor.
      d. Install cover plates and accessories after floor finishing materials have been installed.

7.4.7 26 0536 - Cable Trays for Electrical Systems

GENERAL

1.1 SUMMARY

A. This Section includes steel cable trays, cable ladders and accessories.

B. Related Sections:
   1. Section 26 0500 – Basic Electrical Materials and Methods
   2. Section 26 0526 – Grounding and Bonding for Electrical Systems
   3. Section 26 0529 – Hangers and Support for Electrical Systems
   4. Section 26 0509 – Fire Barriers and Cable Transitions

1.2 REFERENCES

A. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

B. BS EN 10088-2 - Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.

C. BS EN 10130 - Cold rolled low carbon steel flat products for cold forming. Technical delivery conditions.

D. BS EN 10346:2009 - Continuously hot-dip coated steel flat products. Technical delivery conditions.

E. BS EN 61537 - Cable management. Cable tray systems and cable ladder systems.

F. BS EN ISO 1461 - Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.

G. Local Electricity Supply Authority Regulations.

1.3 SUBMITTALS

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

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

1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Seismic-Restraint Details signed and sealed by the manufacturer, supplier or Engineer who is responsible for their preparation including:
   a. Design Calculations: Calculate requirements for selecting seismic restraints.
   b. Detail fabrication, including anchorages and attachments to structure and to supported cable trays or ladders.
   c. Manufacturer's data for restraints.

C. As Built Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray and ladder layouts and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:

1. Vertical and horizontal offsets and transitions.
2. Clearances for access above and to side of cable trays / ladders.
3. Vertical elevation of cable trays / ladders above the floor or bottom of ceiling structure.

D. Field quality-control reports.

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

F. Point-wise compliance statement to the specifications duly signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

G. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.4 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of cable trays, ladders and fittings of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. Source Limitations: Obtain each type of material (tray or ladder) components through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labelled, certifying products in accordance with the relevant standards with supporting documentation supporting accreditation to BS, CE, UL standards by recognized independent laboratories / testing facilities acceptable to the Consultant and where necessary the authorities having jurisdiction, and marked for intended location and application.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver cable tray or ladder systems and components carefully to avoid breakage, denting and scoring finishes. Do not install damaged equipment.

B. Store cable trays or ladder components and accessories in original cartons, raised off the floor and maintained in a flat position and in clean dry space. Protect from weather and construction traffic. Wet materials should be unpacked and dried before storage.

PRODUCTS

1.6 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.7 CABLE TRAY MATERIALS AND FINISHES

A. All cable trays and associated equipment / material shall comply with BS EN 61537.

B. Metallic cable tray steel shall comply with the requirements of:

1. BS EN 10130 and BS EN 10346 for pre-galvanized cable tray and associated components.
2. BS EN 10130 and BS EN 1461 for hot dip galvanized cable tray and associated components.
3. BS EN 10088-2 for stainless steel cable tray and associated components.

C. Metallic cable tray selections shall be as follows:

1. Heavy duty consistent with the following features:

a. Size ranging from 75mm – 900mm.
b. Return flange, minimum edge dimension to be 25mm or greater.
c. Metal gauge of not less than:

1) 0.8mm up to 150mm wide.
2) 1.2mm from 151mm to 600mm wide.
3) 1.5mm from 601mm to 900mm wide.

D. Bends, tees, joints, crossovers and reducers shall be from the same manufacturer as the cable trays, material specifications may alter based on the manufacturers standard construction.

1.8 CABLE LADDER MATERIALS AND FINISHES

A. All cable ladders and associated equipment / material shall comply with BS EN 61537.

B. Metallic cable ladder steel shall comply with the requirements of:

1. BS EN 10025 and BS EN 10346 for pre-galvanized cable tray and associated components.
2. BS EN 10025 and BS EN 1461 for hot dip galvanized cable tray and associated components.
3. BS EN 10088-2 for stainless steel cable tray and associated components.

1.9 CABLE TRAY / LADDER ACCESSORIES

A. Fittings: Tees, splice plates, crosses, risers, elbows, end plates, barrier strips and other fittings as indicated, of same materials and finishes as cable tray / ladder. All fittings shall be factory made and no site construction shall be permitted.

B. Covers: Solid or Louvered type of same materials and finishes as cable tray / ladder shall be provided for ALL cable trays and ladders installed externally and exposed to sunlight.

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

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

1.10 WARNING SIGNS

A. Lettering: 40mm high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Materials and fastening are specified in Division 26 Section "Identification for Electrical Systems."

EXECUTION

1.11 GENERAL

A. Install cable trays as indicated:

1. Installation shall be in accordance with equipment manufacturer's instructions, and with recognized industry practices to ensure that cable tray equipment comply with requirements of BS and Local Supply Authority Standards.

B. Coordinate cable tray with other MEPF works as necessary to properly integrate installation of cable tray work with other work.

C. All cable tray and tray supports cutting edges to be painted with galvanized paint.

D. Use proper length bolts for tray and supports avoid extended bolts on tray and Supports.

E. Provide sufficient space encompassing cable trays to permit pulling and maintaining cables.

F. All preformed bends shall be of a sufficient radius to accommodate the minimum binding radius of the cables installed upon it.

G. Unless otherwise stated elsewhere within the design documentation all cable containment located within air conditioned environments shall be pre-galvanized type. Externally routed cable tray shall be hot dipped galvanized post fabrication type.

H. Light duty cable tray shall be limited to telecommunication and other low current systems usage. All LV / MV cabling shall use medium duty as a minimum.

I. Comply with manufacturer requirements for selections of cable tray and associated supports and hangers taking full account of the anticipated load, inclusive of a 25% safety factor.

1.12 CABLE TRAY AND LADDER INSTALLATION

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

B. Remove burrs and sharp edges from cable trays.

C. Fasten cable tray supports to building structure and install seismic restraints.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
2. Place supports so that spans do not exceed maximum spans on schedules.
3. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
4. Support the complete assembly to prevent twisting from eccentric loading.

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

E. Install expansion connectors where cable tray crosses building expansion joint. Space connectors and set gaps according to applicable standard.

F. Make changes in direction and elevation using standard fittings.

G. Make cable tray connections using standard fittings.

H. Seal penetrations through fire and smoke barriers according to Section "Fire Barriers and Cable Transitions"

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

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

K. Install barriers to separate cables of different systems and insulation levels.

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

1.13 CABLE INSTALLATION

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

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

C. On vertical runs, fasten cables to tray every 450 mm. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

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

E. Install covers after installation of cable is completed.

1.14 EARTH CONNECTIONS

A. Ground cable trays according to manufacturer's written instructions and the requirements of BS 7671, BS 7430 and the requirements of the Local Electricity Wiring Regulations.

1.15 FIELD QUALITY CONTROL

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

1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by BS-7671. Verify that communication or data-processing circuits are separated from power circuits by barriers.
3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
5. Visually inspect each cable containment joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
7. Perform visual and mechanical checks for adequacy of cable containment grounding; verify that all takeoff raceways are bonded to cable tray.

B. Report results in writing.

1.16 PROTECTION

A. Protect installed cable trays.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and

cable tray can be constructed of wood or metal materials until the risk of damage is over.

7.4.8 26 0553 - Identification for Electrical Systems

GENERAL

1.1 SUMMARY

A. Section includes identification labels and notices to be applied to all electrical cables, plant, equipment and systems including, but not limited to:

1. Identification of protective devices.
2. Warning notices, voltages in excess of 250 volts.
3. Periodic inspection and test notices.
4. Residual current device notices.
5. Earth electrode safety electrical connection label.
6. Bonding conductor connector point to extraneous conductive parts label.
7. Earth free local equipotential bonding areas warning notice.
8. Electrical separation areas warning notice.
9. Outdoor equipment socket outlet notice.
10. Components of mechanical systems.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical

1.2 REFERENCES

A. BS 5499-5:2002. Graphical symbols and signs. Safety signs, including fire safety signs. Signs with specific safety meanings.

B. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

C. BS EN 60073:2002 - Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators.

D. BS EN ISO 7010:2012 - Graphical symbols. Safety colours and safety signs. Registered safety signs

E. BS ISO 3864-1:2011 - Graphical symbols. Safety colours and safety signs. Design principles for safety signs and safety markings.

F. BS ISO 3864-3:2012 - Graphical symbols. Safety colours and safety signs. Design principles for graphical symbols for use in safety signs.

G. Local Electricity Supply Authority Regulations.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type of label and sign to illustrate size, colours, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

D. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

E. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

F. All labeling shall be subject to the review and approval by Kahramaa.

1.4 QUALITY ASSURANCE

A. Obtain approval prior to manufacture, with regard to style, colour, lettering, size and position of all labels and notices.

B. Ensure that all lettering and symbols comply with the requirements laid out in BS 7671 (IEE Wiring Regulations), paragraph 514 and BS ISO 3864-1.

C. Coordinate identification names, abbreviations, colours, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes and standards Use consistent designations throughout Project.

D. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

E. Coordinate installation of identifying devices with location of access panels and doors.

F. Install identifying devices before installing acoustical ceilings and similar concealment.

PRODUCTS

1.5 GENERAL

A. Lettering and size of labels and notices:

1. Ensure labels and notices of adequate size for the lettering required, and allow a minimum margin around all lettering of one line space vertically and two letter spacing horizontally.
2. Use materials for labels and notices with a predicted life equal to or greater than the design life of the electrical cables, plant, equipment or installation to which it refers.

B. Size: according to BS ISO 3864-1 or 5mm minimum high letters.

C. Lettering: White.

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

E. Engraved accessory plates:

1. Engrave switchplates, spur units, pushes and special plates for equipment, call systems, fire alarms, etc.
2. Use 6mm high letters with engraving coloured red.

1.6 MATERIALS

A. Use materials for labels and notices with a predicted life equal to or greater than the design life of the electrical cables, plant, equipment or installation to which it refers.

B. External:

1. Sign written, or stencil in paint compatible with surface.
2. Colour - Background, plant standard finish.
3. Lettering - white.

C. Internal:

1. Engraved thermosetting plastic laminate.
2. Colour - Background, white or red.
3. Lettering - red or white.

1.7 NAMEPLATES:

A. Unless otherwise noted, nameplates shall be black lamacoid plates with white engraved upper case letters enclosed by white border on bevelled edge.

B. Nameplates for equipment, supplied by the emergency system, shall be red lamacoid with white lettering.

C. All nameplates shall be engraved and must be secured with rivets, brass or cadmium plate screws. The use of Dymo tape or the like is unacceptable.

D. Nameplate inscriptions shall bear the name and number of equipment to which they are attached as indicated on the Drawings. The Consultant reserves the right to make modifications in the inscriptions as necessary.

E. Cable tags and wire identification labels.

F. Cable tags shall be flameproof secured with nylon ties.

G. Wire markers shall be pre-printed cloth tape type or approved equivalent.

H. Plasticized Cloth:

1. Non-conductive.
2. Waterproof.
3. Capable of withstanding continuous temperatures of 113 degrees C (235 degrees F) and intermittent temperatures to 149 degrees C (300 degrees F).
4. Over-coating for protection against oil, solvents, chemicals, moisture, abrasion and dirt.
5. Heavy, thermo-resistant industrial grade adhesive, for adhesion of label to any surface without curling, peeling or falling off.
6. Label Designations, Nominal System Voltages Applied to the covers of all medium and low voltage pull, splice and junction boxes.
7. Machine printed.

1.8 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Colour and Printing:

1. Yellow tape with Black text.
2. Inscriptions for Tapes: DANGER ELECTRIC CABLES, DANGER HIGH VOLTAGE CBALES (or similar to Authority requirements).
3. Inscriptions for Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

EXECUTION

1.9 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Aluminium Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: Plenum rated.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 150 to 200 mm below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 400 mm overall.

I. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

1.10 IDENTIFICATION SCHEDULE

A. Switchboards:
   1. Furnish and install a master nameplate for each switchboard, engraved with the equipment identification indicated on the Drawings. Mount at top of incoming section.
   2. Provide on each main switch an identifying nameplate. Where multiple mains are employed each switch shall be numbered. Inscription shall be "main switch" or "main switch no. 1" etc...

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

C. Panelboards and Load Centres:
   1. Furnish and install a nameplate for each panelboard and load centre engraved with the identification indicated on the Drawings. Mount at top of panel.
   2. After installations are complete, provide and mount under sturdy transparent shield in the directory frame of each panel door, a neat, accurate, and carefully typed directory properly identifying the lighting, receptacles, outlets, and equipment each overcurrent device controls.
   3. Include on directory the panel or load centre identification, the cable and raceway size of panel feeder, and the feeder origination point.
   4. Fit labels on switchgear as required by BS 7671 and BS EN 60439 to indicate duty of unit, its voltage, phase and current rating, protective device rating size of conductor involved, and all other necessary details.

D. Disconnect Switches:
   1. Furnish and install a nameplate for each disconnect switch engraved with the equipment designation which the disconnect serves.

E. Motor Control Centers:
   1. Furnish and install a nameplate for each motor controller or combination motor controller for both individual motor controllers and those in a motor control center. Engraving must indicate the motor served and the type of service (e.g., AC-8 -1st floor supply, EF-2 electric closet exhaust).

F. Motors and starters labels:
   1. Fit identification labels to all motors, starters and starter panels.

2. Ensure positive identification of respective motors and starters. Provide motors with non-corrodible labels attached adjacent to each bearing giving details of the lubricant to be used.
3. Mark direction of normal rotation on motor casing. Provide labels to identify motor equipment fitted with surge suppressors and thermistors stating that insulation test voltages must not be applied to thermistors and thermistor control units.
4. Ensure labelling is compatible with schematic and wiring diagrams, and complies with BS EN 60034-8.

G. Feeder Switches:
1. Furnish and install two (2) nameplates for each feeder switch including, but not limited to those in switchboards, switch and fuse panelboards, take-offs at bus ducts, motor control centres, multiple meter centres, etc., as follows:
   a. The first nameplate must be white background with red lettering. Engrave with the words "REPLACE ONLY WITH FUSE". Engrave with proper fuse trade name and ampere rating (i.e. Bussman LPS-R 100).
   b. The second nameplate shall indicate the load served, the size and type of cable and raceway,

H. Remote Smoke Detector Lamps and Test Stations:
1. Furnish and install a nameplate on each remote smoke detector lamp and/or test station.
2. Engraving must indicate the location of the device to which the lamp is connected, as approved by the Consultant.

I. Switches:
1. Furnish and install an engraved nameplate for each switch, controlling loads that are not local to the switch.
2. Engraving shall be as directed by the Consultant.

J. Pullboxes, Raceways, Enclosures, and Cable Terminations.
1. Circuits rated over 40 Amp and all cables over 600V:
2. Provide identification label with circuit numbers on enclosure cover.
3. Furnish and install cable tags on each cable that enters a pull box, enclosure, switchboard, and at terminations. Mark tags with type written inscription noting the load served, type and size of cable, and the over-current device protecting the cable.

K. Conduit and trunking colour coding:
1. In areas of mechanical plant or voids accommodating mechanical services, or where otherwise indicated, identify electrical conduits and ducts in accordance with BS 1710.
2. Apply colour orange to BS 4800 by painting on service as a band over 150mm or applying an adhesive tape type wrap around services over a length of 150mm.

L. Sub Circuits:
1. Provide identification label with panel and circuit numbers on enclosure cover.
2. Identify each circuit with wire markers when enclosure label and wire colours do not provide enough information to identify each circuit without tracing.
3. Square box covers hidden above lay-in ceilings may be marked with indelible ink marker in lieu of using printed labels.

M. Fire Alarm Terminal Cabinets:

1. Furnish and install an approved nameplate on each fire alarm terminal cabinet.
2. Nameplates shall indicate floor and where multiple terminal cabinets are installed a prime designation for each cabinet (e.g. FATC-1A, FATC-1B).
3. Terminals shall be permanently identified in an approved manner.
4. Label all wiring.

N. Telecommunications System:

1. Each horizontal cable from a termination block or patch panel to a telecommunications outlet shall be libelled at both ends.
   a. Tags shall be consecutively numbered so that no two (2) cables have the same identification.
   b. In addition cable tag shall note the room number in which the data transmission outlet is located.
2. Each backbone cable shall have a flameproof tag attached at both ends of the tag.
   a. Tags shall be consecutively numbered so that no two (2) cables have the same identification.
   b. Additional inscriptions shall be provided as directed by the Owner.
3. Patch panel ports shall be consecutively numbered so that no two (2) ports have the same number.

O. Generator Control Panel:

1. Furnish and install a red nameplate for each generator control panel. Engraving shall indicate the generator controlled by the panel.
2. At each switch board that is served from a generator supply shall be furnished with a label "DANGER SERVED FROM AUTOMATIC GENERATOR"

P. UPS & Computer Power Centres:

1. Furnish and install a black with lettering nameplate for each unit.
2. Provide identification labels for all low voltage and medium voltage pull, splice and junction boxes in main feeder and sub-feeder runs, indicating nominal system voltage.
3. Apply labels after painting of boxes, conduits, and surrounding areas have been completed.
4. Clean surfaces before applying labels; clean aluminium surfaces with solvent wipe.
5. Apply labels on cover and minimum of one (1) fixed side; one (1) label visible from floor where boxes are installed exposed.

Q. Provide identification for all equipment, boxes, enclosures and devices according to the following table:

1. Type Identification material Information/example:
   a. Equipment Cabinet Nameplate Equipment identification /"Outdoor lighting control"
   b. Major Equipment Nameplate Equipment identification /"Panel MDP"
   c. Minor Equipment Identification Label Equipment identification / "Fire alarm relay R-2" J-box, enclosure (screw cover).
   d. Identification Label, indelible ink marker above lay-in ceilings.
   e. System type and circuit numbers / "Fire Alarm zone 3"
   f. Receptacle Identification Label Circuit identification / "PNL A2-CKT18"
   g. Fire alarm device Identification Label Device id number & zone /"SD3-4"
   h. Security device Identification Label Device identification /"Camera-4"

R. Cables

1. Cable Conductor Colour Coding:

   a. Identify cable conductors in accordance with BS 7671 (IEE Wiring Regulations) paragraph 514, note that a lighting sub-circuit switch wire is a phase conductor in a single phase circuit.
   b. Provide all cables, other than final sub-circuit wiring enclosed in conduits or trunking, with labels fixed at each end of cable either side of wall and floor penetrations at approximately 12 meters intervals at convenient inspection points by means of non-releasable plastic straps, minimum width 4 mm.
   c. Ensure labels show the reference number of cable.
   d. All single phase final sub-circuit phase wiring coded RED.
   e. Terminal marking and conductor identification:

      1) Provide for switchgear and control gear elements whose terminals are marked in accordance with BS 5472 (EN 50005) and BS 6272 (EN 50042).
      2) Use a unique reference to identify each element in the switchgear or control gear.
      3) Mark on or adjacent to each element its reference. Identify each terminal for connection to external wiring or cabling using a reference system complying with BS EN 60445 based on the element reference and the appropriate element terminal reference.

   f. Adjacent to terminals.

      4) Use lettered or numbered ferrules or sleeves to BS 3858 to mark each auxiliary conductor or control cable core with the identity of the terminal to which it is connected and the reference of plant or equipment to which it is connected and the identity of the terminal at the remote end.
      5) Ensure that main circuit conductors are identified in accordance with BS 7671 (IEE Wiring Regulations) paragraph 514.
      6) Ensure that all identification of terminals and conductors is recorded and included on record drawings and in operation and maintenance documentation.

   g. Underground cable identification:

      7) Identify external underground cable routes by means of approved markers along their length at distances not exceeding 50m and where a change of direction occurs on such routes.
      8) Provide cables markers with a brass plate or impress concrete to clearly indicate the reference of group of cables or reference number of cable and operating voltage of cable.
      9) Provide key to any reference system used at switchgear.
      10) Mark and protect direct buried cables with plastic tape yellow printed black "DANGER ELECTRIC CABLES" elsewhere.

S. Additional Safety Signs:

1. Provide safety signs in accordance with BS ISO 3864-1 and BS ISO 3864-3.
2. Supplementary wording:

   a. Main Switchrooms and Plantroom Doors: "AUTHORISED PERSONS ONLY".
   b. Permit to work systems: "DO NOT OPERATE. WORK IN PROGRESS".
   c. Emergency stop buttons: "EMERGENCY STOP PUSH-BUTTON".

3. Plant and equipment labels:
   a. Fit labels on all items of plant, equipment, switches, etc., include the following information: service controlled, circuit reference, voltage, type of supply and phase etc., circuit protection type and rating.
4. Maintenance notices:
   a. Equipment - Fix notices giving warning of, and instructions on, any special maintenance procedures to plant and equipment.
5. Colour corrected light fittings:
   a. Fix a warning or identification disc to light fittings containing colour corrected fluorescent tubes or other colour corrected light sources to ensure that maintenance staff install the correct lamps.
   b. Indicator lamps and push buttons for power systems:
      11) Use indicator lamp and push button colours in accordance with BS EN 60073.
      12) Red, danger or alarm; yellow, caution; green, safety.
      13) Red, emergency action Push buttons; red, stop or off; yellow, intervention; green, start or on.
      14) Illuminated push buttons - Type A.

T. Safety signs.
1. Details of supplementary or text signs to BS 5499-5 as indicated on drawing.
2. Label all electrical plant and equipment using safety sign 8.A.0044 of BS 5499-5 where voltages above ELV exist.
3. Provide supplementary or text signs complying with BS 5499-5 with each safety sign 8.A.0044 as indicated.
4. Label all electrical plant and equipment with the labels specified in the appropriate British Standards for that plant or equipment.
5. Identify each substation and main switchroom with safety sign 8.A.0044 to BS 5499-5 with supplementary signs to BS 5499-5, notices and signs required by BS 5499-5 for any fire extinguishing system and notice giving details of,
6. Name of the Substation or switchroom
7. The presence of High and Low Voltages.
8. Administrative instructions for access.
9. Location and method of contacting the controlling authority.
10. Actions to be taken in an emergency.

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

V. Place identification colours at bulkheads, wall penetrations and any other place where identification is necessary.

7.4.9 26 0573 - Overcurrent Protective Device Coordination

GENERAL

1.1 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

B. Related Sections:
   1. Section 26 0513 – Conductors and Cables
   2. Section 26 0526 – Grounding and Bonding of Electrical Systems
   3. Section 26 2813 – Fuses
   4. Section 26 2816 – Enclosed Switches and Circuit Breakers

C. Protection systems are not limited to the ones mentioned in this specification. The Contractor is obligated to amend as required and found necessary by the client.

1.2 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

D. BS EN 60898-1:2003+A13:2012 - Electrical accessories ± Circuit breakers for overcurrent protection for household and similar installations. Circuit-breakers for a.c. operation.

E. BS EN 60898-2:2006 - Electrical accessories. Circuit-breakers for overcurrent protection for household and similar installations. Circuit-breakers for a.c and d.c. operation.

F. BS EN 60909-0:2001 / IEC 60909-0:2001 - Short-circuit currents in three-phase a.c. systems. Calculation of currents.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Calculations: Submitted calculations shall be signed and stamped by an MMUP Grade A electrical engineer employed by the Contractor.

C. Product Certificates: For coordination-study and fault-current-study computer software programs, capable of undertaking calculations in compliance with BS 7671 for Low Voltage, and BS EN 60909-0 / IEC 60909-0 for High Voltage.

D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital form inclusive of the PDF and soft copy of the calculation.
   1. Coordination-study input data, including completed computer program input data sheets.
   2. Study and Equipment Evaluation Reports.
   3. Coordination-Study Report.

E. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

1.4 DOCUMENTATION WITH TENDER

A. The Tender shall contain at least the following information and documents:
   1. Protection and indication single line diagrams of the substation(s).
   2. General arrangement drawings of the protection and indication panels.
   3. Manufacturing specification of the protection and indication equipment.
   4. Catalogues, literature and reference lists of proposed equipment: A comprehensive set of documentation shall be provided for all protection relays covering, as a minimum, the following topics :

a. Detailed description of protection relay including coverage of self-monitoring facilities, if applicable.
b. Range of features provided as standard.
c. Range of optional features.
d. Range of settings provided for all features, both standard and optional.
e. Details of all of the operating time characteristics for the protection relay.
f. Statement of performance under reference conditions.
g. Variation of performance with departure from reference conditions.
h. Effects of interruptions to dc auxiliary power supply.
i. Current transformer requirements.
j. Voltage transformer requirements.

5. Pre-energisation and commissioning: Details of all necessary pre- energisation and commissioning tests shall be submitted for approval prior to the tests being performed, together with any supporting explanatory documentation such as "Installation, Operation and Maintenance manuals". An opportunity shall be provided for CLIENT and KAHRAMAA to witness site tests.
6. Type test certificates from an independent testing authority or independently witnessed: A type test certificate shall be provided for each relay type, which should confirm compliance of the protection relay with the requirements of the relevant sections of IEC 60255. Any areas of non-compliance shall specifically be identified. It shall be stated whether the protection relay has been approved by any independent approval bodies or users.
7. Quality Management System Manual and ISO Certificate of the equipment manufacturer.

1.5 DOCUMENTATION AFTER AWARD OF CONTRACT

A. All documents required for CLIENT's approval shall be submitted by the Contractor in accordance with Section General Requirements.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed internationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

PRODUCTS

1.7 GENERAL REQUIREMENTS FOR PROTECTION RELAYS

A. This section contains the general requirements applicable to all protection relays.

B. Each element of the main plant, transmission and distribution systems shall be provided with high-speed discriminative protection (main protection), capable of detecting all "credible" faults and issuing tripping commands to the associated circuit breakers within the prescribed time. "Credible" faults shall include all faults whether phase/phase or phase/earth irrespective of whether maximum or minimum plant is connected, account being taken of the fault impedance. "Noncredible" faults are those involving a second order plant failure, for example, a broken conductor lying on high resistance ground and for which extended fault clearance time may be acceptable.

C. There shall be two sets of main protection for systems at 66 kV and above such that the loss of one set or the failure of one set to clear a fault will not result in time delayed tripping for an electrical fault. Redundant auxiliary supplies shall be used and there shall be redundant tripping systems.

D. High-speed discriminative protection systems shall be engineered as complete schemes, with due account being taken of current and/or voltage transformer performance. Attention shall be paid to the total performance including the behaviour pattern in the presence of system transients for faults "in zone", faults "out-of-zone", and during the period immediately following a switching operation irrespective of whether that operation is to eliminate a network short-circuit or is to energise or to de-energise any part of the network.

E. In the event of an uncleared external fault or any other abnormal operating condition which may cause damage to plant, time delayed tripping shall be initiated as a back-up action to prevent plant damage.

F. With reference to the above the protection systems must therefore be designed, manufactured, applied, set and commissioned to offer the highest level of security against incorrect operation for faults beyond the protected circuit or during disturbances or temporary overload conditions from which the power system should recover.

1.8 PROTECTION TECHNOLOGY

A. All relays performing a measuring function shall be of numerical design with continuous self-monitoring. Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication function may be based on standard attracted armature or other electromechanical techniques.

B. In order to maximise the cost-benefit of the protection in all groups and to reduce lifetime costs, all protection relays shall be of numerical design wherever practical. The main numerical relays should offer instrumentation, disturbance recording and event logging functions in addition to providing protection. Routine test requirements shall be limited to basic function testing only, through the provision of comprehensive, continuous self-monitoring with alarm and diagnostic functions.

C. Numerical relays and schemes provided shall all be suitable for connection to a local communications network (either interfaced directly to the substation LAN or to the local BCU) to allow the complete relay scheme to be interfaced to a central computer work station. The communications bus, necessary modems and interface units and all associated software shall be provided as part of the contract. With the resulting system it shall be possible to interrogate all numerical relays and schemes to monitor and extract recorded data (including settings, measurement parameters, disturbance records). It shall also be possible to enable remote adjustment of relay settings if required.

D. Numerical relays shall also be provided with a local communications port to allow direct interfacing to a lap-top PC, to facilitate local interrogation, setting-up and recorded data extraction. Individual protection units shall be provided with an integral user interface to facilitate setting changes and observation of indications without the use of remote communications.

E. Protection relays shall be from approved suppliers and they shall be type-tested according to relevant sections of the current IEC 60255 standards and copies of type test certificates should be provided. Relays shall be CЄ-marked in accordance with European Union requirements related to Electromagnetic Compatibility and Low Voltage Equipment safety. Equipment complying with other national standards may be accepted at KAHRAMAA's discretion and where the vendor provides copies of the relevant standards.

F. Protection relays shall have a minimum of two year's satisfactory service history in similar applications with at least 5 utilities. The history is to be supported by reference lists.

G. Relays must be offered on the basis of a minimum service life of 15 years.

H. Statements must be obtained from the relay manufacturer(s) to this effect, with confirmation that a spares and repairs service will be available for the stated minimum service life.

1.9 PROTECTION DISCRIMINATION

A. On the occurrence of an electrical fault on the 220kV, 66kV and 11kV power systems, the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted plant or circuit from the network.

B. Protection equipment associated with adjacent plant or circuits may detect the fault, but there must be discrimination between this protection and that of the faulted plant or circuit. Time delayed tripping is not permitted except where main protection has failed to clear a fault or where plant damage would otherwise occur.

C. All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the electrical system.

1.10 PROTECTION SETTINGS

A. A protection setting study shall be performed as part of the contract and a list of the settings to be applied to all protection equipment, together with all associated calculations and relay co-ordination curves on log paper, shall be provided for review and approval not less than 3 months prior to the first programme date for commissioning. Any limitations imposed on the power system operation as a result of the settings proposed shall be explicitly stated. In the absence of system data required for calculation purposes, assumptions may be made, providing these are clearly identified as such in the relevant calculations.

1.11 CONSTRUCTIONAL REQUIREMENTS

A. General

1. For modular protection systems, means shall be provided to positively lock each withdrawable module or unit in the "service" position. It shall not be possible to remove any module without first short-circuiting all associated current transformer circuits. All other main protection relays shall be accommodated within withdrawable cases. Means shall be provided to ensure that current transformer connections are short circuited prior to being disconnected when the relay is withdrawn from its case.
2. All relay cases shall be earthed except where insulated cases are provided for special requirements.

B. Equipment Accommodation

1. Protection and control cubicles should be of front access, swing-rack design, with glazed front door through which necessary equipment indications can be observed. At 66kV and 11kV, the protection and control equipment for up to two outgoing cable feeder circuits, on the same side of a bus section, may be accommodated within a common cubicle, but there shall be proper segregation of wiring and terminal blocks to facilitate scheme testing for one circuit without and risk of affecting scheme operation for the accompanying circuit while on load. At 11kV there should be separate cubicles for incoming circuits and for the bus section.

C. Operator Interface

1. All numerical protection systems shall be provided with an integral local user interface, to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be

an additional feature to the local user interface. No exceptions to this requirement shall be permitted.

2. Relay serial communication facilities should allow all information which is available locally at the relay front panel to be accessed remotely. It should also be possible to carry out bulk transfer of settings and fault record information using appropriate PC based software. The necessary software for communication with each relay type shall be provided as part of the contract.
3. Each protection relay shall also comply with the following requirements.

D. Identification

1. Each protection relay shall have a unique identifier that is clearly visible. The software reference and issue level shall be identified. The marking of all relays shall comply with Clause 12 of IEC 60255-6 (1988).
2. Each protection relay shall be provided with a card holder and card or LCD display facilities on which shall be shown :
   a. The current transformer ratio (if applicable), including all ratios of multiratio transformers and the ratio selected.
   b. Voltage transformer ratio (if applicable).

E. Settings

1. Each protection relay shall provide a means by which the user can easily apply the required settings, which is also secure from inadvertent operation. A display of the selected settings shall be provided on the protection relay.

F. Indications

1. Each relay or protection scheme shall be provided with an adequate number of indications to ensure that the appropriate faulted phase, zone, operated element, etc. can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover. It shall not be possible to operate the relay when resetting the indication. Unless otherwise approved, indications shall only be given by the protection(s) causing the relay to trip.
2. The record of relay indications shall be maintained following any DC auxiliary supply interruption.
3. For numerical relays, indication shall be provided for failures detected in the protection relay or communications equipment. The indications provided shall be designed to allow the defective item to be quickly identified. The status of the dc power supplies shall be permanently indicated.

G. Output Contacts.

1. All protection relays shall be provided with an adequate number of contacts of suitable rating to perform the required tripping functions, alarm indications, fault recorder functions and such supplementary signalling functions as may be necessary for initiation of automatic switching control, intertripping etc. In all cases contacts intended for tripping duty shall be designed such that :
   a. They cannot inadvertently interrupt trip coil current.
   b. They initiate the circuit breaker trip coil directly without the interposition of auxiliary relays or reinforcing contacts.

H. Test and Isolation Facilities

1. Each functional protection relay shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.

2. Adequate test facilities shall be provided within the protection scheme to enable the protection and control equipment to be tested from the front of the protection equipment panel with the primary circuit(s) in service. The test points shall be clearly identified and labelled.
3. Numerical relays shall include continuous self-monitoring and supervision of all parts of the relay hardware, firmware and software. An alarm contact shall close for any detected failure.
4. Adequate facilities shall be provided, preferably at the front of each protection equipment panel, to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station. The isolation points shall be clearly identified and labelled. The labels on the isolation points shall either describe the function or be uniquely numbered.
5. A list of all of the protection and control equipment being offered under the contract shall be provided together with a list of all of the test and ancillary equipment required for commissioning and routine testing of all protection and control equipment.

1.12 SERVICE LIFE AND SERVICE SUPPORT

A. The protection systems shall be designed for a service life of 15 years, allowing for only routine testing that is limited to basic functional testing in accordance with manufacturers recommendations.

B. The service life of the protection system equipment in relation to that of the main MV plant and apparatus shall be stated so that the cost of any replacement during the life of the substation can be assessed.

C. The period for which lifetime support will be provided for the protection system equipment shall be stated. Recommendations for the provision of spare parts are required.

D. Circuit diagrams for each protection system and the associated tripping system(s) shall be supplied. The diagrams shall provide sufficient information to enable fault finding and maintenance to be carried out and shall not consist solely of information used for equipment manufacture.

E. A service to enable any faulty item of protection equipment to be rectified or replaced within a stated period of the fault being reported shall be provided. The repair/ replacement period shall be defined.

F. Training for the purchaser's personnel in the operation and maintenance of the protection equipment shall be offered.

1.13 PROTECTION TESTING

A. Type Tests

1. A type test certificate shall be provided for each relay type, which should confirm compliance of the protection relay with the requirements of the relevant sections of IEC 60255 as detailed in this specification. Any areas of non-compliance shall specifically be identified. It shall be stated whether the protection relay has been approved by any independent approval bodies or users.
2. Should the certificates be invalid or unacceptable to KAHRAMAA, the type tests shall be performed by a recognised and KAHRAMAA approved independent laboratory.

B. Routine Tests

1. A routine testing programme shall be determined between the Engineer and the Contractor before the tests are undertaken at the premises of the equipment

supplier. Not withstanding, the routine testing shall comprise, as a minimum, of the following tests performed on one tenth of each relay type:-

a. Functional tests.
b. Dielectric Test (a.c. power frequency high voltage test) with 2 kV, 50Hz for 1min as per IEC-60255-5.
c. Electrical disturbance test (for static relays only) to IEC 60255-22.

2. The tests shall be conducted in the presence of KAHRAMAA or their representative.
3. The Contractor shall submit a report to the Engineer detailing the routine tests and the test results.
4. Inspection and taking over in the factory do not relieve the Contractor from his obligations as per the contract documents and guarantee of performance.

C. Site Tests

1. The Contractor shall perform the following site tests on the protective relays:-

a. Relay auxiliary D.C. supply checks.
b. CTs and associated secondary wiring tests.
c. VTs and associated secondary wiring tests.
d. Application of relay settings as determined in the Protection Setting Report.
e. Secondary injection testing to determine relay settings and operation within manufacturers stated parameters.
f. Primary injection tests where appropriate.
g. Checks of all alarm circuits.
h. Functional testing of all relays. This includes testing protection relays, aided by secondary as necessary, a scheme operation of relevant CBs.

2. The Contractor shall submit for approval a Commissioning Programme prior to the tests being performed. The Commissioning Programme shall include, as a minimum, the following:-

a. List of the site test for all protection systems/relays and associated power equipment (CTs/VTs etc.)
b. Procedures and methods for each commissioning test including those to be preformed on-load.
c. Testing equipment and instruments necessary for performing of each test.
d. Format of site test reports for each test.
e. Installation, operation and maintenance manuals.

3. Each site test shall be witnessed and signed off by a KAHRAMAA Engineer or their representative.
4. One month before the site tests and commissioning start the Contractor shall submit to CLIENT the approved Protection Setting Report.
5. Commissioning will be deemed complete when all relevant equipment is energised, loaded and all necessary on-load tests, measurements and checks are complete and signed for by the Engineer.

1.14 ENVIRONMENTAL REQUIREMENTS

A. Atmospheric Environment

1. Temperature:

a. The standard nominal range of ambient temperature shall be -10°C to +55°C.
b. The protection system shall operate satisfactorily when tested to the following requirements :

1) IEC Publication 60068-2-1 with severity class -10°C, 96 hours.

2) IEC Publication 60068-2-2 with severity class 55°C, 96 hours.

c. The protection system shall be able to withstand the temperature requirements for storage and transportation and shall be tested to the following requirements :

1) 1. IEC Publication 60068-2-1 with severity class -25°C, 96 hours.
2) 2. IEC Publication 60068-2-2 with severity class 70°C, 96 hours.

2. Relative humidity:

a. The protection system shall operate correctly with a relative humidity of 93 % and shall be tested to IEC Publication 60068-2-3 with severity class 56 days.

3. Enclosure:

a. The protection relay shall meet the requirements of the tests detailed in IEC Publication 60529 with classification IP50 (dust protected). If the individual enclosure of the relay is to a class less than IP50 then the tenderer shall provide a cubicle to classification IP50 to accommodate the relay.

B. Mechanical Environment

1. Vibration:

a. The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-1 with severity class 1.

2. Shock and bump:

a. The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-2 with severity class 1.

3. Seismic:

a. The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-3 with severity class 1.

C. Electrical Environment

1. DC auxiliary energising quantity:

a. The protection systems shall be capable of being energised from a DC auxiliary energising voltage of 110 V (nominal).
b. The protection system or its associated power supply for use in a 110 V (nominal) DC supply system shall operate correctly over a voltage range of 77 V to 150 V.
c. Numerical protection systems shall meet the requirements of IEC Publication 60255-11 with interruptions to the DC auxiliary energising quantity of 20 ms.

2. Frequency:

a. The rated frequency shall be 50 Hz. The nominal range of operating frequency shall be -5 % to +5 % of nominal.

3. Thermal rating:

a. Relay equipment intended to perform a current measurement function shall be capable of continuous operation at a current of not less than 2.4 times the nominal rating or 2 times the setting value, whichever is the more onerous.
b. Relay equipment intended for use in a normally quiescent mode and having a short time rating - for example, high impedance differential protection - shall

be rated in accordance with the intended function and taking account of such inherent protective devices as may be incorporated in the design.

c. The short time rating for all protection relaying schemes shall be 100 times the nominal relay rating for a duration of 1 s.

d. Voltage sensitive equipment intended for use on effectively earthed networks shall have a continuous withstand of not less than 1.2 times nominal voltage and a short duration withstand of not less than 1.5 times nominal phase-to-ground voltage for 30 s.

4. Insulation:

a. Rated Insulation Voltage: The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 250 V. All open contacts of the protection system shall withstand a voltage of 1000 V.

b. Dielectric Tests: The protection system shall comply with the dielectric test requirements of IEC Publication 60255-5. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested form Series C of Table 1 of IEC Publication 60255-5.

c. Impulse Voltage: The protection system shall comply with the impulse test requirements of IEC Publication 60255-5 with test voltage of 5 kV.

D. Electromagnetic Compatibility

1. The requirements of this section of the specification are applicable to electronic protection systems whether these are based on analogue digital or numerical design techniques. The requirements may also be applied to electromechanical relays that may radiate electromagnetic interference during their operation.

a. 1 MHz. Burst Disturbance: The protection system shall comply with the requirements of IEC Publication 60255-22-1 with severity Class III.

b. Electrostatic Discharge: The protection system shall comply with the requirements of IEC Publication 60255-22-2 with severity Class III.

c. Radiated Electromagnetic Field Disturbance: The protection system shall comply with the requirements of IEC Publication 60255-22-3 with severity Class III. The test shall be carried out by using Test Method A and by sweeping through the entire frequency range 27 MHz to 500 MHz.

d. Electromagnetic Emissions: The protection system shall comply with the requirements of IEC Publication 60255-25.

e. Fast Transient Disturbance: The protection system shall comply with the requirements of IEC Publication 60255-22-4 with severity level IV.

1.15 COMPUTER SOFTWARE DEVELOPERS

A. Computer products and services proposed by the Contractor shall be compliant with the Specification.

B. Companies offering services including software development and computer simulations shall be approved by the Engineer prior to their appointment.

1.16 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Undertaking calculations in order to satisfy BS 7671.

B. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

EXECUTION

1.17 11KV SYSTEMS

A. 11kV Protection Performance Requirements

1. A single set of protection shall be applied to each new 11kV incomer or transformer circuit. Remote back-up protection should be provided by protection relays of other circuits.
2. Incoming transformer circuits:
   a. New incoming feeder circuits shall be provided with one main protection Main protection shall be provided by either:
      1) Transformer differential and restricted earth fault protection for station transformers.
      2) MV cable and transformer differential protection, transformer biased differential and restricted earth fault for new and existing 11kV substations.
   b. Back-up protection shall be directional inverse time delayed overcurrent and earth fault protection.
3. 11kV earthing transformers
   a. The earthing transformer shall be protected by a separate protection relay that comprises:
      1) HV and LV restricted earth fault.
      2) 11kV instantaneous overcurrent.
      3) Inverse time delayed overcurrent for back-up protection.
      4) Inverse time delayed standby earth fault protection.
4. Outgoing circuits
   a. New outgoing feeder circuits shall be provided with main protection and a separate back-up protection.
   b. Main protection shall be provided by numerical cable differential protection suitable to use with fibre optic cable. The remote 11kV substations have to have air conditioning.
   c. Back-up protection shall be inverse time delayed overcurrent and earth fault protection. Additional high-set instantaneous overcurrent elements for rapid clearance of close-up faults shall also be provided and this protection shall be set where discrimination with other circuits can be assured.
5. Busbar protection
   a. Partial differential overcurrent and earth fault protection shall be applied to new 11kV substations. The busbar protection scheme shall also include a blocked overcurrent protection scheme via accelerated trip elements interlocked with outgoing feeder fault detection elements and also with independent time delayed back-up trip elements. Busbar protection shall also intertrip the HV CB.

B. 11kV Outgoing Cable Feeders from a new 11kV substation

1. Protection arrangements
   a. The proposed protection and control arrangements are illustrated in the single line schematic diagram.
2. Bay control and monitoring

a. The numerical feeder protection relays should be interfaced to the 11kV SCS to facilitate remote monitoring and control.
b. Bay control systems and protection relay communications are detailed in the SCS specification.

3. Protection functions

a. New outgoing feeder circuits to other switchboards within the distribution network shall be provided with main protection and a separate back-up protection.
b. Main protection shall be provided by numerical cable differential relays with fibre optic communication link.
c. Back-up protection shall be inverse time delayed overcurrent and earth fault protection.
d. Additional high-set instantaneous overcurrent elements for rapid clearance of close-up faults shall also be provided and this protection shall be set where discrimination with other circuits can be assured.
e. Back-up protection shall provide SOFT(Switch on to fault feature) function to circuit breaker control circuit.

4. Blocked overcurrent busbar protection

a. The outgoing feeder relays shall include instantaneous overcurrent and earth fault detector elements for the purpose of blocking the short-time busbar protection elements.

5. Automatic load-shedding

a. Each outgoing feeder shall be provided with a selector switch to determine which stage of load-shedding, if any, will trip the CB. The load-shedding signal from the under-frequency relay shall trip CB via a self-resetting interposing auxiliary trip relay. The load-shedding signal shall also be configured to trip the CB via the numerical back up protection relay.

C. 11kV Busbars and Bus Sections at a new 11kV substation

1. Protection arrangements

a. The protection and control arrangements are illustrated in the single line schematic diagram.

2. Bay control and monitoring

a. All the numerical protection relays shall be capable of connection to 11kV SCS to facilitate DCC remote monitoring.
b. Bay control systems and protection relay communications are detailed in the SCS specification.

3. Busbar protection scheme

a. Numerical overcurrent and earth fault protection relay shall be applied in a partial differential protection arrangement for each busbar to provide bus-selective protection. This shall offer no response to the back-feed to a transformer feeder fault or for a fault on the adjacent section of busbar.
b. The protection shall be wired to trip the incoming bus circuit breaker and the bus section breaker and shall be located in the bus section panel.
c. The basic partial differential protection must be set with a time delay to grade with outgoing feeder protection for a feeder faults and it should provide back-

up tripping for a feeder fault in the event of feeder breaker failure or protection failure.

d. Additional short-time delayed protection elements shall be set to provide accelerated tripping for a busbar fault. The short-time protection shall be configured for blocking by instantaneous overcurrent and earth fault detector elements of outgoing feeder protection relays for the protected section of busbar.

e. The accelerated protection shall be set with a short delay to give time for dependable blocking, in the event of a feeder fault, and to ensure stability with transient CT spill currents for an adjacent busbar fault or incoming feeder fault.

4. Bus-section protection

a. A numerical relay shall be connected to monitor the current from a set of CTs on one side of the bus section breaker.

b. The relay shall be set with thermal replica overload protection to initiate an alarm, followed by tripping, in the event of any operational bus section overload condition being set up.

5. Automatic load-shedding

a. To meet KAHRAMAA automatic load-shedding requirements, a multi-stage under-frequency relay shall be provided. This shall monitor the secondary voltage from one of the busbars.

b. A voltage selection scheme shall ensure that the live bus is monitored in the event that one section of busbar is de-energised or in the event of the preferred voltage source suffers a fault.

c. The relay shall control up to five stages of load-shedding.

1.18 SUBSTATION OPTICAL CABLES AND TERMINATION

A. The main optical fibre cables are supplied under the cable contract are to be terminated at an optical termination block (OTB). Depending on the substation, the main OTB may be housed within a termination panel or telecommunication cubicles. The substation Contractor shall supply and install the optic fibre cable between the main OTB and the OTB located in the applicable protection panel.

B. The optical characteristics of the substation optical fibres shall be the same as those specified in the telecommunications contract. Patch cords shall connect the protection relays to the panel OTB. A pair of spare optical fibres shall also be available in each substation optical fibre cable running from the OTB to the main protection panels and these shall be terminated at each end with the appropriate connectors.

1.19 19.3.4 INSTRUMENT TRANSFORMER REQUIREMENTS

A. CTs and VT ratio, class and accuracy limitation factor of the have been defined elsewhere in the substation specification. In addition, CTs and VTs are indicated on each protection single line drawing. The Contractor shall ensure that the CT and VT characteristics (VA burden or Vk) are calculated to meet at least the minimum protection and instrumentation manufacturers requirements.

1.20 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

1.21 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance as provided by the Authority or measured.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
   a. Circuit-breaker and fuse-current ratings and types.
   b. Relays and associated power and current transformer ratings and ratios.
   c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
   d. Generator kilovolt amperes, size, voltage, and source impedance.
   e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
   f. Busway ampacity and impedance.
   g. Motor horsepower.
4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Generator thermal-damage curve.
   e. Ratings, types, and settings of utility company's overcurrent protective devices.
   f. Special overcurrent protective device settings or types stipulated by utility company.
   g. Time-current-characteristic curves of devices indicated to be coordinated.
   h. Manufacturer, frame size, interrupting rating in amperes RMS symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes RMS symmetrical.

1.22 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes RMS symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Switchgear and switchboard bus.
2. Motor-control center.
3. Distribution panelboard.
4. Final circuit distribution board.

5. Lighting Control Panels.
6. ATS's.
7. PDU's.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

E. Equipment Evaluation Report:
1. For 415-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

1.23 COORDINATION STUDY

A. Provide a coordination study for the following systems:
1. Earth Fault Protection.
2. Differential Protection for Incomers.
3. Partial Busbar Protection.
4. Transformer Protection.

B. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study.
1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

C. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
   d. Fuse-current rating and type.
   e. Ground-fault relay-pickup and time-delay settings.
2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time

separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.
b. Voltage and current ratio for curves.
c. Three-phase and single-phase damage points for each transformer.
d. No damage, melting, and clearing curves for fuses.
e. Cable damage curves.
f. Transformer inrush points.
g. Maximum fault-current cutoff point.

D. Completed data sheets for setting of overcurrent protective devices.

E. Protection systems are not limited to the above. The Contractor is obligated to amend as required by the Client and found necessary.

1.24 INTERFACE WITH SCADA

A. Please refer to the SCADA specifications for details of interfaces with these systems.

1.25 INSTALLATION/DISMANTLING REQUIREMENTS

A. The Contractor shall furnish and install all specified equipment and accessories in accordance with Section General Technical Requirements.

1.26 SPECIAL EQUIPMENT AND TOOLS

A. Works to be done under this section include the delivery of special equipment and tools for erection, installation, maintenance, setting to work and other purposes. Requirements for special equipment and tools are described in Section General Technical Requirements and quantities in Schedule of Prices.

B. Specified special equipment and tools to be delivered by the Contractor are listed in Schedule of Prices. Any additional special equipment and tools recommended by the Tenderer shall be listed and priced in Schedule of Prices.

1.27 SPARE PARTS

A. Works to be done under this section include the delivery of spare parts. Requirements for spare parts are described in Section General Technical Requirements and quantities in Schedule of Prices. Specified spare parts to be delivered by the Contractor are listed in Schedule of Prices. Any additional spare parts recommended by the Tenderer shall be listed and priced in Schedule of Prices.

1.28 PACKAGING, SHIPPING AND TRANSPORT

A. Packing, shipping and transport shall be arranged according to the requirements in Section General Technical Requirements.

1.29 TRAINING

A. Works to be done under this section include training of CLIENT's personnel to operate and maintain equipment efficiently and safely. The main requirements for training are described in Section General Technical Requirements. There shall be no constraints on the number and category of CLIENT's personnel to be trained.

7.4.10 26 0800 - Commissioning of Electrical Systems

GENERAL

1.1 SUMMARY

A. Section includes the general requirements for commissioning electrical systems, components and controls including:
   1. Start-up and pre-functional equipment checklists
   2. Independent testing of electrical systems
   3. Validation of proper and thorough installation of all electrical systems and equipment
   4. Functional performance tests
   5. Documentation of tests procedures and records

B. Related Sections:
   1. Section 26 0500 – Common Work Results for Electrical
   2. Section 27 0500 – Common Work Results for Communications
   3. Section 28 0500 – Common Work Results for Electronic Safety and Security

1.2 DEFINITIONS

A. Commissioning: the process of ensuring that all building systems and components are installed in accordance with the design intent and perform to meet the operational requirements of the Owner. The process also includes providing training for the Owner's staff and the preparation of record documentation.

B. CA: Independent Testing and Commissioning Agency.

1.3 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. The installation shall comply with all standards, rules, regulations and requirements of KAHRAMAA.

D. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

E. BS EN ISO 10012:2003 - Measurement management systems. Requirements for measurement processes and measuring equipment.

F. IEEE 399-1997 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).

1.4 SUBMITTALS

A. Manufacturer's Certificates: Submit all relevant Certificates from manufacturers and specialist installers.

B. Detailed manufacturer's recommended procedures and schedules for Pre-functional Equipment Checks and Functional Performance Testing, supplemented by Contractor's specific procedures.
   1. Provide a sample pro-forma for the various commissioning records.

C. List of team members who will represent the Contractor in the Pre-functional Equipment Checks and Functional Performance Testing.

D. At the completion of the commissioning, submit completed Pre-functional Equipment Checklists and Functional Performance Test records organized by system and by sub-system. Bind information in a single package. The results of failed tests shall be included along with a description of the corrective actions taken.

E. Calibration Certificates: For all test equipment.

F. The Contractor shall provide any other submittal required to satisfy any Authority Having Jurisdiction and to obtain approval for the installation.

1.5 QUALITY ASSURANCE

A. The Contractor shall engage a qualified and a credited independent commissioning agency to carry out the full testing and commission of all systems. The contractor is to submit with his bid the specialist he is to use along with full company CV.

B. Commissioning Agency Qualifications: An entity specializing in testing and commissioning of electrical, communications, life safety and security systems with a minimum of five (5) years documented experience on projects of a similar magnitude and complexity.

C. Installation Supervision: Installation shall be under the direct supervision of a Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

D. Instrumentation and Test Equipment: Comply with BS EN ISO 10012.

1.6 MEETINGS, SEQUENCING AND SCHEDULING

A. Sequencing and Scheduling: The Start-up and Pre-functional Equipment Checklists shall be completed and submitted to the Consultant and the Commissioning Agency (CA) prior to undertaking the Functional Performance Tests.

B. The Contractor shall notify the Client, Consultant and the CA in writing that systems are complete and ready for verification and Functional Performance Testing.

PRODUCTS

1.7 TEST EQUIPMENT

A. Equipment to be utilized in the commissioning process shall meet the following requirements:

1. Provide test equipment as necessary for the equipment and systems to be commissioned.
2. Provide testing equipment and accessories that are free of defects and certified for use.
3. All testing equipment shall have current Calibration Certificates from an internationally recognised "Certification and Testing Agency".

1.8 INFRARED THERMO-GRAPHIC SCANNER

A. Infrared scanning equipment shall be an AGA (or approved equal) thermo-vision set capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of 0.2 degrees C with a liquid nitrogen reference.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified.

EXECUTION

1.9 COMMISSIONING PROCESS REQUIREMENTS

A. Commissioning of all equipment should be carried out by manufacturer trained technical personal.

B. Work to be performed prior to commissioning:

1. Complete all phases of the work so the system(s) can be started, tested, adjusted, balanced, and otherwise commissioned.
2. Start-up services required to bring each system into full operational state and ready for Functional Performance Testing:

a. Completion of pre-functional checklists.
b. Manufacturer's Authorized Representative Start-up as required

c. Contractor start-up
d. Testing
e. Motor rotation check
f. Control sequences of operation
g. Full and part load performance

3. Before energizing the various electrical systems, check all components of the system including electrical circuitry and safety features according to the manufacturer's operating instructions.
4. If modifications or corrections to the installed systems are required to bring the system(s) to acceptance levels due to Contractor's incorrect installation or defective materials, such modifications or corrections shall be made at no additional cost to the Owner.
5. Commissioning shall not start until each system is complete and the above items are completed and approval has been received by the Consultant.

C. Commissioning Procedures:

1. Refer to the "General Requirements and Scope of Works" for information on meetings, start-up plans, Pre-functional Checks, Functional Performance Testing, Operations and Maintenance data, and other commissioning activities.

D. Functional Performance Testing:

1. The Contractor shall perform all Functional Performance Tests outlined in the relevant Sections of the MEPF Specification and as required by Local Authorities.
2. Acceptance criteria for tests are indicated in the relevant sections of the MEPF Specification applicable to the systems being tested. Unless indicated otherwise, acceptance criteria will be specified with the individual system, equipment, component, or device.
3. Attendance by the Consultant during specified inspections and tests shall not reduce the Contractor's obligations or responsibilities with regards to testing and commissioning.

E. Documentation:

1. Submit schedules indicating those parts of the contract works for which inspections and tests are required to substantiate conformity with the Specification.
2. Provide method statements supported by risk assessments detailing the procedures for carrying out on-site tests.
3. Testing and commissioning records shall be maintained on-site for inspection by the Consultant and shall include the following minimum information.

a. Test number.
b. Equipment used for the test, with manufacturer and model number and date of last calibration.
c. Date and time of the test.
d. Indication of whether the record is the first commissioning test or a retest following correction of a previously identified problem or issue.
e. Identification of the system, subsystem, assembly, or equipment.
f. Conditions under which the test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of the test.
g. Systems and assemblies test results, performance and compliance with contract requirements.
h. Issue number, if any, generated as the result of the test.
i. Name and signature(s) of witnesses and the person(s) performing the test.

1.10 COORDINATION BETWEEN TESTING PARTIES

A. Factory Start Ups:

1. For many systems and equipment factory startups are required as part of the manufacturer's standard QA/QC procedures.
   a. These generally are Start Up related activities that will be reviewed and checked during Functional Performance Testing (FPT).
   b. All costs associated with the factory start ups are included with the bid unless otherwise noted.
2. In general, contractor shall make notification of when these factory start-ups will take place and coordinate these with witnessing parties.
3. TC shall witness all factory start-ups.
4. Commissioning Team members may witness these startups at their discretion.
5. Aspects of functional performance testing accomplished during the factory start up may be accomplished and approved by the TC if they judge they meet the intent of the FPT.

B. Independent Testing Agencies:

1. For systems where independent testing agencies are specified, the cost of this testing is included with the bid unless otherwise noted.
2. Much of the testing performed by these independent agencies will cover aspects required in the start ups and functional performance tests.
3. Contractor and testing agencies shall coordinate with the TC so that they can witness the testing and approve the applicable aspects of the FPT's.
4. Commissioning/Testing may in some cases independently spot check work of the testing agencies if the tests were not witnessed.
   a. However it is not the intent for the TC to accomplish testing that is specified in the construction specifications.
   b. For instance much of the testing requirements for the Electrical Testing will be performed by the independent electrical testing agency provided with under the bid.
   c. TC will witness the indicated sample of the testing and record the results in the record of functional performance testing.
   d. Independent agencies to be provided by the Division 26 contractors include, as appropriate:

C. Acceptance Criteria:

1. Acceptance criteria for tests shall be indicated in the General Commissioning Specification and in the specification sections applicable to the systems being tested.
2. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device.

1.11 SAFETY

A. Contractor is responsible to ensure that all safety measures are observed complying with the Project Safety Manual and, or as stipulated on Section 26 0500.

1.12 TEST PROCEDURES FOR ELECTRICAL DISTRIBUTION SYSTEM

A. Comply with BS 7671 Requirements for Electrical Installations (the IEE Wiring Regulations), IEE Guidance Notes Number 3 Inspection & Testing and other British Standards as appropriate.

B. Supply characteristics: Obtain all necessary information from the Local Supply Authority.

C. Incorporated equipment characteristics:
   1. Obtain and use information from manufacturers of equipment provided.
   2. Use information provided, for equipment supplied by others and incorporated into installation.

D. Prospective short circuit current:
   1. Obtain written confirmation of short circuit current (I_P) at the point of supply.
   2. Calculate the short circuit current values at all necessary points within the electrical installation to confirm correct equipment selections.

E. Initial verification: Carry out detailed inspection to verify the requirements of BS 7671, Section 712.

F. Testing: Undertake all tests as published in BS 7671, Section 713.
   1. Continuity of protective conductors:
      a. Confirm continuity.
      b. Use ac source or dc source.
   2. Earth fault loop impedance:
      a. Use 25A test current.
      b. Measure and record source impedance (Z_E).
      c. If alternative LV supply arrangements are available, measure Z_S when using supply with highest impedance.
      d. Measure Z_S with main equipotential bonding conductors connected. Do not summate values of several parts of each loop.
   3. Conductive parts:
      a. Test conductive parts simultaneously accessible with exposed conductive parts of extraneous conductive parts. Establish that they are either not an extraneous conductive part, or that they are reliably connected by metal to main equipotential bonding.
      b. Confirm conductive parts which are not extraneous conductive parts are separated from earth by impedance greater than 50,000 ohms.
      c. Confirm other conductive parts are bonded to equipotential zone earth bar by an impedance not exceeding 0.1 ohms.
   4. Phase Sequence: Check and confirm correct polarity of all conductors in all circuits.
   5. Phase Rotation: Undertake phase rotation test.
   6. High Voltage Tests: Conduct high voltage tests for equipment indicated. Comply with BS 923-1, BS EN 61180 and BS EN 60060-2. Comply with BS EN 61180.
   7. MV Buried Cables: Test continuity and insulation of buried consumables immediately after back-filling. Test continuity and insulation of buried cables prior to handover.
   8. Conduit, Trunking and Ducting: Test and confirm electrical continuity before installing cables.
   9. Final Sub-circuits: test for continuity, insulation resistance and earthing continuity particularly where wiring is installed in metallic conduits or raceways.

G. Mega-ohmmeter (Megger) Tests:
   1. Ensure that the insulation resistance is not less than one mega-ohm per 100 volts at 20 degrees C using a 500-volt megger.
   2. Megger testing of cables and distribution panels shall be undertaken after the cables are in place and just prior to final terminations.

H. Thermo-graphic Scanning:

1. Contractor shall provide thermo-graphic scanning on all switchgear and distribution boards and rising Bus Bars.
2. Scanning shall be undertaken when the equipment is energized and is operating at its normal capacity. It is intended that the Consultant's presence shall be made after the equipment has been in full operation; however the exact time of conducting the scan will be determined by the Consultant near the completion of the project.
3. All hot spots shall be marked, identified and an infrared thermo-graphic scanning report prepared and submitted to the Consultant. The report shall contain infrared photos of trouble spots with temperature readings.
4. All sources of heating problems shall be promptly reported to the Consultant, and all necessary corrective action shall be undertaken by the Electrical Contractor.

1.13 LOW AND MEDIUM VOLTAGE SWITCHGEAR

A. Start-up checklists:

1. Visually and mechanically inspect the following:
   a. Anchoring
   b. Grounding
   c. Torque of feeder and incoming bus duct connections
   d. Feeder cable and integral main bus connections
   e. Switchgear section alignments
   f. Clearances
   g. Mechanical operation of circuit breaker / fuse draw-out elements and operating mechanisms
   h. Trip function
   i. Main bus safety shutters
   j. Control system and alarm interconnections

B. Operational Tests:

1. Check calibration/setting of trip devices using system coordination study.
2. Verify calibration/setting of digital metering.
3. Check current and potential instrument transformer ratios.
4. Conduct insulation resistance and over potential tests on each type of each breaker element contacts, switchgear control wiring, breaker element control wiring and each bus section.
5. Conduct resistance test through switchgear bus joints.
6. Conduct current test using primary or secondary current injection.
7. Conduct phasing test on triple-ended switchgear.
8. Conduct contact resistance test on each type breaker element.
9. Conduct ground resistance test.
10. Conduct operational/functional tests of protective relaying. Time-current tests shall be conducted and trip points shall be set per A/E direction
11. Conduct operational/functional tests of digital metering.
12. Perform electrical and mechanical (key) interlock system operational tests on generator and service switchgear.

1.14 LOW AND MEDIUM VOLTAGE FEEDERS AND SUB-MAINS

A. Start-up checklists:

1. Visually and mechanically inspect cable terminations. Confirm correct identification and phasing arrangements.
2. Undertake continuity test of each feeder.
3. Undertake insulation resistance test of each feeder.

1.15 FINAL SUB-CIRCUITS

A. Start-up checklists:

1. Visually and mechanically inspect cable terminations. Confirm correct identification and phasing arrangements.
2. Undertake insulation resistance test of each final sub-circuit.
3. Perform random continuity test of any branch circuit.

B. Operational Tests:

1. Socket Outlet Polarity: Test every socket outlet for correct polarity and ensure that neutral and earth conductors are not inadvertently transposed.

1.16 MOTORS

A. Start-up checklists:

1. All motors shall be properly connected to protective devices and controls to give proper motor acceleration and correct motor rotation.
2. The control wiring shall be properly interconnected to all the control devices associated with a machine, a group of machines, or other device to produce the correct operation, timing, and/or sequencing of the equipment.
3. Overload elements in motor starters will be adjusted and checked for coordination with the actual installed motor characteristics.
4. Check all motor nameplates for verification of proper voltage, horsepower, speed, phase and power factor.

B. Operational Tests:

1. Verify proper alignment, installation, and rotation.
2. Measure the insulation resistance, phase balance, and resistance to ground.
3. Verify properly sized overloads are in place.
   a. Measure voltage available to all phases at time of initial connection and again after motor has been placed in operation under load measure amps and RPM.
   b. Record all motor nameplate data.
4. Motor current reading shall be taken at full load or as close to full load as the driven machine will develop.
5. If the ammeter reading is over the rated full load current or the proper current for the load at which the machine was operated, determine the reason for the discrepancy and take the necessary corrective action.
6. The cause of any motor operating above full load rating shall be removed instead of increasing the overload replay trip rating.
7. Contractor shall provide Certification that all instantaneous circuit breaker trip ratings are properly set to allow motor starting without nuisance tripping.

1.17 METALCLAD SWITCHGEAR

A. Type tests: The following type tests shall be performed:

1. Dielectric test on main circuit: Lightning impulse, Power frequency voltage withstand tests, Partial discharge and Radio interference voltage (r.i.v) tests.
2. Dielectric test on auxiliary and control circuit.
3. Temperature rise test.
4. Measurement of the resistance on the main circuit.
5. Short-time and peak withstand current tests
6. Short-circuit making and breaking, out-of-phase making and breaking, critical current and capacitive and inductive (reactor) current switching tests.

a. The circuit breaker shall be tested in accordance with IEC 62271-100. Test evidence shall be submitted to confirm that the highest over voltage during any switching duty does not exceed 2.5 p.u. by either performing the relevant tests or by submitting the relevant type test reports to the satisfaction of KAHRAMAA.

7. Internal arcing test.
8. Mechanical endurance, environmental operation tests.
9. Electromagnetic compatibility (EMC) tests.
10. Verification of the degree of protection and tightness tests.
11. Any other tests in the above standard.

B. Routine Tests (first time to be performed by the contractor): The following routine tests shall be performed:

1. Dielectric test on main circuit: Power frequency voltage withstand dry tests, Partial discharge and Radio interference voltage (r.i.v) tests.
2. Voltage withstand tests on auxiliary and control circuits.
3. Measurement of the resistance of the main circuits.
4. Mechanical operating tests.
5. Tightness test.
6. Design and visual checks.
7. Inspection of the general condition.
8. Mechanical operation tests.
9. Timing tests of the main contacts and auxiliary switches.
10. Complete electrical functioning tests.
11. Closing and opening check at reduced voltage and other necessary tests and verifications.

C. Low inductive current switching tests for metalclad switchgear:

1. A series of switching tests shall be made to IEC 62271-110 on each type of circuit breaker being supplied in order to demonstrate its performance when switching transformer magnetizing currents and reactor currents. Test evidence shall be submitted to confirm that the highest over voltage during any switching duty does not exceed 2.5 p.u. by either performing the relevant tests or by submitting the relevant type test reports to the satisfaction of KAHRAMAA.
2. In addition to the above, additional, low inductive current switching test evidence of 10, 50, 100 amp currents, in accordance with IEC 62271-110 under site conditions, to confirm that the highest over voltage during any switching duty does not exceed 2.3 p.u.

D. Internal arcing for metalclad switchgear:

1. Internal arcing tests shall be carried out in accordance with IEC 62271-200, Annexure A. The test evidence for each compartment shall confirm that the equipment satisfies the IEC test criteria that the internal arcing fault in one compartment does not affect the adjacent compartments and in particular the relay compartment.

1.18 TRANSFORMERS:

A. Carry out tests as specified in section 262200 - Low Voltage Transformers.

B. For transformers, the following routine tests shall be performed:

1. Measurement of winding resistances.
2. Measurement of voltage ratio and check of voltage vector relationship.

3. Measurement of impedance voltage (principal tapping) short-circuit impedance and load loss.
4. Measurement of no-load losses and no-load current at rated frequency and nominal voltage.
5. Induced-voltage test with partial discharge measurement.
6. Short Duration AC (ACSD).
7. Separate source voltage test.
8. Oil test and function tests.
9. Measurement of insulation of core.

C. The following type tests for transformers shall be performed:

1. Temperature Rise Test: This test shall be carried out with the transformer at tap positions giving highest losses. The temperature rise qualification of the earthing/auxiliary transformers shall be based on the sum of two factors; the first is a test in accordance with IEC 60076-2, at the auxiliary rating when the rises of the main and auxiliary windings will be measured. The second factor will be the calculated rise according to IEC 60076-5 at the 30-second duty rating. The total temperature rise will be the sum of both figures and the overall winding temperature shall be less than 250°C.
2. Lightning Impulse (LI) test: This test shall be carried out in accordance with IEC 60076-3 on the HV and neutral terminals. Tap-changers shall be in the position of minimum, principal and maximum tap as each phase is tested in turn (A-B-C).
3. In-lieu of evidence from demonstrably similar units and/or mechanical and thermal calculations shall be provided to demonstrate clear margins of short-circuit current withstand at system fault levels for all transformers. All tests and calculations shall be in accordance with IEC 60076-5.

D. The following special tests for transformers shall be performed:

1. Measurement of zero-sequence impedance: (Routine test).
2. Determination of sound levels to IEC 60076-10: (Type test).
3. Measurement of the harmonics of the no-load current: (Routine test).
4. Oil leakage test shall be carried out on each unit at oil pressure on conservator at 35kN/sq. m or 69kN/sq. m at bottom whichever is more stringent.

E. Site tests for transformers: Initial and final check lists shall be incorporated in the Site tests method statements, and submitted to KAHRAMAA approval prior the start of tests.

F. The following tests shall be performed after installation on Site:

1. Verification of correct and complete erection.
2. Verification of the soundness of porcelain surfaces and sealing.
3. Verification of correct connections to the earthing system.
4. Checking of auxiliary and control wiring and cabling and operation of all electrical LV equipment.
5. Voltage tests of all electrical LV circuits.
6. Measurement of the physical, chemical, and electrical characteristics of the oil including oxidation stability after filling. BDV, Tan delta, water content of oil samples before filling oil into the transformer according to IEC 60296. Comprehensive analysis of oil (DGA, Furan, BDV, Tan delta and water content) of oil samples from tank before and after complete electrical testing shall be carried out as per IEC standards.
7. Hot spot gradient check on winding temperature indicators at elevated temperature of 80degC (based on heat run test results).
8. Verification of turns ratio with measurement of charging current using an L.V. supply.

9. Resistance measurements of windings with records of oil & ambient temperatures.
10. Insulation resistance tests.
11. SFRA (Sweep Frequency Response Analysis) test (signature test).
12. Test on protection devices.
13. Tests on Current Transformer.
14. Measurement of CT wiring loop resistance.
15. Checking calibration of oil & winding temperature indicating devices.
16. Proving tests of Buchholz device by injecting pressurized gas/air.
17. Operation checks of accessories like pressure relief device, oil level gauge etc.
18. Oil Leakage Test for 48 hours.
19. Other necessary checks and verifications as deemed necessary by KAHRAMAA.

1.19 MOTOR CONTROL CENTRES

A. Start-up checklists: Refer to Manufacturer's checklist.

1. Visually and mechanically inspect:

a. Anchoring
b. Grounding
c. Torque of feeder and incoming connections
d. Electrical clearances
e. Starter and feeder unit draw-out mechanisms,
f. Cable terminations
g. Installation and setting of overload relays.
h. Control system interconnections.

B. Operational tests:

1. Perform test of overload relays for each size starter using primary current injection methods.
2. Conduct operational tests of starters through local/remote controls.
3. Conduct insulation resistance test on MCC bus-bars, each motor starter unit (except for variable frequency drives) and each control circuit.
4. Conduct contact resistance and insulation resistance test of moulded case main and feeder circuit breakers.

1.20 GROUNDING SYSTEMS

A. Perform three-point fall-of-potential test per IEEE Standard 81 or BS 7430 on the main grounding electrode or system.

1. Resistance shall be no greater than 10 ohms.

B. Perform the two-point method test per IEEE Standard 81 or equivalent test as per BS 7430 to determine the ground resistance between the main ground system and all major electrical equipment frames, system neutral, and/or derived neutral points.

1. Resistance shall be no greater than 10 ohms.

C. Conduct insulation resistance, short circuit, and ground tests of each equipment.

1.21 LIGHTNING PROTECTION SYSTEM

A. Start-up checklists:

1. Visually and mechanically inspect the following:

a. Wiring / tape connections and bonds (bolted and welded)
b. Bonding connections to roof mounted equipment
c. Down conductor routing and roof penetrations
d. Test Clamps
e. Earth Pits

B. Operational Tests:
1. Visually and mechanically inspect to include the following: bonding connections of roof mounted equipment, down conductors routing/roof penetrations, and grounding.
2. Conduct earth continuity and earthing resistance tests in accordance to BS EN 62305.
3. Review test certification.

1.22 LIGHTING FIXTURES AND LIGHTING CONTROL SYSTEMS

A. Start-up checklists:
1. Ensure all labelling is affixed and accurate.
2. Ensure all terminations are tight.
3. Check sensor placement is adequate for required duty.
4. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
5. Ensure all circuits for the loads are energized and ready for testing.

B. Operational Tests:
1. Test, calibrate, and set all digital and analogue sensing, and actuating devices.
2. Calibrate each instrumentation device by making a comparison between the graphic display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).
3. Record the measured value and displayed value for each device in the Start Up Report.
4. Check each digital control point by making a comparison between the control command at the control panel and the status of the controlled device.
5. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device in the Start-Up Report.
6. Check loads on all breakers to ensure that the breaker is properly sized.
7. For Operator Interfaces:
   a. Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
   b. Output all specified reports for review and approval.
   c. Verify the alarm printing and logging is functional and per requirements
   d. Validate all interfaces with other systems on a point by point basis

1.23 POWER GENERATORS

A. Start-up checklists:
1. Visually inspect the systems.
2. Ensure the terminations are tight on power and control wiring
3. Verify all ancillary equipment completely installed.
4. Ensure all overloads are in place.
5. Verify that generator is set in place.
6. Verify fuel connections
7. Verify radiator connections
8. Verify battery connection
9. Verify exhaust connections
10. Verify block or oil heater connection.

11. Check and record engine oil level, radiator water level, and battery electrolyte level.
12. Piping System Tests: Complete system test in accordance with the respective section
13. Inspect the installation and access/clearance for service and maintenance to ensure it meets the project and manufacturer's requirements
14. Check lubricating oil for lubricated-type equipment.
15. Check for proper seismic restraints.
16. Check that safety valves have correct setting; greater than compressor discharge pressure, but not greater than pressure rating of system components.
17. Check that all operating controls are set for initial safe operation

B. Operational Tests: Run the Generator at 50%, 75%, 100% and 125% load capacity using load banks with adjustable power factor.

1. The 50%, 75% and 100% load tests shall be conducted for 30 minutes. The 125% test shall be conducted for 15 minutes.
2. Record engine and alternator readings at the start of each test and at every 15 minute interval.
3. Simulate operation of all generator safeties such as high oil pressure, low oil pressure, high temperature, over speed, etc. Observe function of safeties under actual malfunction situation.
4. Check for excessive vibration and noise.

1.24 FIRE DETECTION AND ALARM SYSTEM

A. Start-up checklists:

1. Ensure all labelling is affixed and accurate
2. Ensure all terminations are tight.
3. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
4. Review that all fire alarm devices as shown on the construction drawings and shop drawings are installed.
5. Review height and locations of pull stations and visual alarms
6. Review that smoke and duct detectors are installed according to manufacturer's recommendations and in line with NFPA 72 and BS 5489 and the Local Civil Defence requirements.
7. Check that fire alarm system control panel is clear with no trouble or ground faults.
8. Sprinkler flow and tamper switches have been adjusted
9. Check wire supervision on all devices.

B. Operational Tests:

1. Check location of all sensors and switches to ensure conformance with requirements.
2. Cause activation of all device, assure alarms are initiated and resulting response is per the requirements.
3. Verify interfaces with all other inter-related systems or equipment including FMS, sound systems, security systems, HVAC systems, vertical delivery systems, etc. on a point by point basis for all points.
4. Validate all output devices (speakers and strobes) meet the code criteria (96 dBa at 3m and 117 candela at peak).
5. Activate high temperature detectors in the elevator machine room.
6. Verify all sequences including elevator shunt off, elevator recall including alternate floors when main floor is in alarm.
7. Activate all sprinkler flow switches. Validate that appropriate zone enunciates and alarms sound.

8. Verify audio aspects of the system function as required.
9. Verify paging messages can be heard throughout the building.
10. For annunciation panels, validate correct graphic and correct identification of all zones.
11. Test the action and interlocks of all override switches as appropriate.
12. For Operator Interfaces:
    a. Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
    b. Output all specified reports for review and approval.
    c. Verify the alarm printing and logging is functional and per requirements
    d. Validate all interfaces with other systems on a point by point basis

1.25 MATERIALS AND CONSUMABLES

A. All necessary facilities shall be provided to enable tests to be witnessed and inspections to be carried out including instruments and recorders to monitor systems.

B. Temporary Power and Fuel: Contractor shall provide all necessary power supplies and fuel for the Testing and Commissioning activities.

1.26 ADJUSTING

A. Systems improperly adjusted, incorrectly installed equipment or deficient Contractor performance may result in additional work being required for commissioning acceptance.
    1. Perform work required to correct installations not meeting contract requirements at no additional cost to the Owner.

B. Corrective work shall be completed in a timely manner to permit completion of the commissioning process.

1.27 SYSTEM DEMONSTRATION

A. Subsequent to the completion of all testing and commissioning to the satisfaction of the Consultant; demonstrate that all electrical systems operate properly in every respect and in accordance with the relevant sections of the MEPF Specification.

1.28 TRAINING

A. Engage factory-authorized service representatives to train the Owner's maintenance personnel to adjust, operate, and maintain the electrical systems, as stipulated in the relevant sections of the MEPF Specification and as outlined in the General Requirements and Scope of Works.

B. Train Owner's maintenance personnel on procedures related to start-up and shutdown, troubleshooting, servicing and preventative maintenance.

1.29 OTHER SYSTEMS

A. Contractor is not relieved of responsibility in providing other procedures whether or not indicated in the above listing, to ensure that all services perform and function as intended for the project.

B. Where bespoke systems are specified either refer to testing and commissioning within that series specification, provide tests as per manufacturer recommendations and refer to the "Scope of Works" specification.

7.4.11 26 0913 - Electronic Power Monitoring and Control

GENERAL

1.1 SCOPE OF THIS SPECIFICATION

A. This section details the supply (hardware and software) erection, testing and commissioning of the systems for control and monitoring of each of the new substations and interfaces to existing substation control systems (SCS).

B. Details of the equipment to be controlled and monitored at each substation site are indicated in the individual substation sections of this technical specification.

C. The tele-control protocol IEC 60870-5 shall be used for connection to control centres as follows:

1. At new Substations IEC 104 shall be used for connections to both control centres.
2. At existing Substations IEC 104 shall be used for connections to DCC. For NCC/ENCC, final selection of IEC 101 or 104 shall be specified based on the coordination with GTC/125/2006 and ph 9 telecom contractors.

1.2 ABBREVIATIONS

A. ATCC - Automatic Tap Change Control
B. BCU - Bay Controller Unit
C. DCC - Distribution Control Centre
D. DMS - Distribution Management System
E. EMS - Energy Management System
F. HMI - Human Machine Interface
G. ICCP - Inter-control Centre Communication Protocol
H. IED - Intelligent Electronic Device
I. NCC/ENCC - National Control Centre/Emergency National Control centre
J. NTS - Network Time Server
K. RTU - Remote Terminal Unit
L. SLC - Station Level Computer
M. SCS - Substation Control System
N. DTS - Distributed cable Temperature System
O. BMS - Battery Monitoring system
P. RMS - Reactor Monitoring System
Q. PDS - Partial Discharge System
R. TMS - Transformer Monitoring system
S. CMS - Conditioning Monitoring system (DTS, TMS, PDS, RMS, OR BMS)

1.3 CODES AND STANDARDS

A. European Standards (EN)
   1. EN 55022 Limits and methods of measurement of radio interference characteristics of information technology equipment.

B. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE Std 802 Standard for local and metropolitan area networks

C. International Electrotechnical Commission (IEC)
   1. IEC 60050 International Electrotechnical Vocabulary
   2. IEC 60060 High-voltage Test Technique
   3. IEC 60068 Environmental Testing
   4. IEC 60255-5 Insulation Tests
   5. IEC 60529 Degree of protection provided by Enclosure (IP Code)
   6. IEC 60825 Safety of laser products

7. IEC 60870 Tele-control equipment and systems
8. IEC 61000 Electromagnetic compatibility
9. IEC 61850 Communication networks and systems in substations
10. IEC 62351 Power systems management and associated information exchange – Data and communication security

1.4 SAFETY

A. The SCS equipment will be situated in high voltage electricity substations which are subject to rises in earth potential at times of system faults. Precautions shall be taken to prevent damage occurring to the equipment.

B. All metal parts, metal cable sheaths and equipment housings shall be bonded to earth. Details of the earthing arrangements shall be submitted to KAHRAMAA for approval.

1.5 SCOPE OF WORKS

A. The supply and services to be performed by the Contractor shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KAHRAMAA's personnel and warranty of the works.

B. The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

C. The scope of work as described in the following sections.

1.6 SUBSTATION WORKS

A. The supply and services to be performed by the Contractor shall comprise the site survey for the existing substations, design, manufacture, shop testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KAHRAMAA's personnel and warranty of the works.

B. The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

C. The overall scope of work consists of:

1. Supply new SCS systems for the new substations, incorporating all hardware and software necessary to monitor and control all the new power equipment provided in the scope of this project including switchgears, transformer connections, transformers, protection, etc. and to monitor all common substation equipment including LVAC, service equipment, fire system, telecommunication, and others as described in the following sections.
2. All necessary works for new signals mapping to NCC/ENCC & DCC including signal list and I/O mapping as per KM standard NCC/DCC signal list.
3. The modifications/extensions of existing Microsol RTU, TDB, and TMMC to incorporate the new extensions/modifications at remote end existing substations equipped with Microsol RTU.
4. The modifications/extensions of existing SCS systems at remote end existing substations by original supplier.
5. The modifications/extensions of SCS systems at remote end substations which are still under construction by original supplier and with close coordination with the substation main contractor.
6. The provided new systems shall comply with IEC 61850 and all specifications included in this section and with technical parameters in Volume 4. The connections of the new SCS systems shall comply with IEC60870-5-104 Protocol.

SCOPE OF WORK

1.7 OVERVIEW

A. The proposed distributed control systems for the above work should offer at least the following functionality:

1. Full operational control, reporting, alarm and indication facilities for the substation from the NCC/ENCC and the DCC (Supervisory level).
2. Full operational control, alarm and indication facilities for the substation from Human Machine Interface (HMI) workstations in the substation control room (Substation Level).
3. Operational control of each circuit/bay from the protection relay panel using the bay control unit LCD display (Bay level).
4. Control of each item of plant from the Local Control Cubicle (LCC) (Local Level)
5. The control facilities from each control point are to be interlocked (hardwired and software) to prevent operation of any device simultaneously from more than one control point.
6. At least one fully operational control point shall remain available in the event of a single equipment or communications failure.
7. Complete facilities must exist for the proper lockout and maintenance tagging of circuits and plant items to ensure the safety of personnel and the security of the system
8. The new control systems shall use IEC 61850 communication protocols over fiber and be readily interfaced with third part devices operating on IEC 61850 or other open protocols. The Tenderer shall describe such interfaces and provide an experience list of devices with which the offered control system has previously been interfaced.
9. Three numbers of TCP/IP Ethernet links (PROTECTED BY FIRE WALLS) for remote access of SCS for remote relay settings, communication with remote end facility for CMS from NCC and KM2 Building (O & M Section) and upload of PMR files. For providing non-SCADA applications such as fault recording and analysis, PMR downloading, uploading, relay remote parameter setting and access to conditioning monitoring systems and other functions mentioned in this section. All necessary software for remote end PCs shall be provided, installed and tested.

B. For the new substations, the contractor shall provide the following:

1. Provision of all hardware and software necessary to control and monitor the entire substation both locally and remotely from the NCC/ENCC and DCC.
2. Complete Substation Control System (SCS) based on IEC 61850.
3. Three numbers of TCP/IP Ethernet links (PROTECTED BY FIRE WALLS) for remote access of SCS for remote relay settings, communication with remote end facility for CMS from NCC and KM2 Building and upload of PMR files. All necessary software for remote end PCs shall be provided, installed and tested.
4. Integration of the following conditioning monitoring facilities (if it is applicable) with remote access from NCC and KM2 Building (O & M Section) via TCP/IP network:
   a. DTS
   b. TMS
   c. RMS
   d. BMS
   e. PDS
   f. Interface with GTC/125/2006 contractor to incorporate new substation into the SCADA/EMS System at the NCC/ENCC
   g. Interface with GTC/125/2006 contractor to incorporate the new substation into the DCC SCADA/DMS System.

SCS SPECIFICATION

1.8 INTRODUCTION

A. This specification describes standard terms and equipment typically associated with SCS. Alternate configurations may be considered so long as the overall functionality and redundancy required by this specification is maintained or improved.

B. The following requirement shall be incorporated in the SCS design:

1. All IEDs shall be connected directly by fibre to IEC 61850 LAN,
2. System shall meet all protection requirements as specified within these tender documents.
3. LAN structure shall support GOOSE messaging.
4. Availability, redundancy, and performance as described in the following sections.
5. For easy understanding of interlocks related to a device, a separate window showing all the interlock condition of each device shall be provided, with dynamic color change of conditions accessible from bay display window.
6. Dynamic coloring of LAN lines.
7. The remote feeder status (CB, ES, and DS) monitoring from BCU and substation HMI
8. Integration of TMS, RMS, PDS, DTS and all other monitoring system with SCS using IEC 61850, with remote access capability from NCC and O&M section at KM main Building.
9. Three numbers of TCP/IP Ethernet links (PROTECTED BY FIRE WALLS) for remote access to SCS for remote relay settings, communication with remote end facility for CMS from NCC and KM2 Building and upload of PMR files. All necessary software for remote end PCs shall be provided, installed and tested.

1.9 OVERVIEW

A. A computer based SCS shall be provided for monitoring and control. The SCS shall be designed to provide the following three control levels through a check sync control function.

1. Supervisory Control (NCC/ENCC & DCC for 11kV feeders only)
2. Station level through a HMI
3. Local, directly from the Local Control Cubicle (LCC) from the switchgear front panel at 11kV through a separate relay to avoid single point of failure of BCU.

B. The entire substation shall be monitored and controlled from Substation Control Room through one (two - applicable for S/S with 400kV level only) independent substation computers and associated HMI(s), while individual circuit bays shall be monitored and controlled from processor based Bay Control Units (BCU) located in the relay panels.

C. The SCS shall typically include:

1. Dedicated Bay control units (BCU) for each individual incoming or bus section circuit/bay with a LCD mimic and user interface for control and monitoring of the circuit/bay.
2. Dedicated Bay control units (BCU) for two individual outgoing circuits/bays (if possible) connected to the same bus section with a LCD mimic and user interface for monitoring of the circuits/bays.
3. Interface for protection devices that cannot directly interface with the IEC 61850 substation LAN (list of such relays and type of interface protocol used shall be provided).
4. Interface for laptop computer for maintenance, information transfer and emergency HMI

1.10 SYSTEM FUNCTIONS

A. SCS shall include the following functions:

1. Control of all switching devices

2. Tap Changer controls like Auto /Manual /Master Follower / Independent and Raise / Lower shall be available at SCS.
3. Load shedding/Restoration of 11kv feeders from NCC/ENCC/DCC.
4. Real time indication of status, alarms and devices
5. Display of measured values, high/low limit checking.
6. Indication of real and historical values
7. Data Archiving
8. Report generation facility from historical data of analog value.
9. Disturbance Monitoring and analysis
10. Transfer of PMR files (disturbance files) from SCS to NCC. PMR files shall be recorded and automatically uploaded to NCC. Transfer of PMR files to NCC shall be incorporated using FTP protocol over dedicated communication link.
11. For this purpose proprietary or 3rd party software shall be used ensuring that immediately after their generation at substation these files shall be transferred to NCC. All necessary connectivity and security equipment shall be provided at substation in order to support this functionality.
12. Trend display facilities
13. Protection device information
14. Remote access to SCS from the NCC/ENCC using TCP/IP link
15. Remote communications
16. Indication of automatic tap changer relay status
17. Manual local and remote setting of tap changer relay
18. Check sync control
19. Interlocking of primary plant
20. Substation Monitoring System functions (Parameter of digital protection relays: protection setting, service values, trip values, under frequency load shedding selection, etc.)
21. Time synchronization.
22. Operator action monitoring (in case of any inappropriate action taken, a maloperation message is displayed)
23. Self check & diagnostic: These functions are essential for system operation Safety and easy maintenance.
24. Manual data setting (can be performed by the operator) using the following functions:
    a. Device status setting
    b. Analogue data setting
    c. Control inhibit setting
    d. Alarm inhibit setting
    e. Maintenance tag setting
    f. High/Low limit setting
    g. Protection relay parameter setting, etc.
25. Bay indications, alarms and events from bay control units (BCU) using LCD mimic
26. For operation of any equipment through SCS, a window should indicate all relevant interlock status indicating status of each interlock condition for that equipment. This will reduce time troubleshooting.
27. Alarm and Trip indication / signals / events in the SCS shall be segregated to have a quick understanding in event of multiple tripping.
28. Tagging interlock with switching device should be provided and tested.
29. Remote feeder end status/indications for CB, ES, and DS at bay and HMI level.
30. Dynamic Schematic (single line diagram) of LVAC/DC system (AC/DC incomers and Bus Section).
31. Interoperability (Via Gateway)

32. AVR Control – SCS gateway to be checked.
33. Group load shedding (Load shedding from NCC/ENCC through Gateways).
34. Analogue measurements should be transferred to Control Centre without delay.

B. Also, all required signals related to the control, status indications and monitoring of the switchgear, power transformers, LV AC/DC switchgears and other relevant equipment shall be provided to the SCS.

1.11 DATA SCOPE

A. The data scope required for SCS will be determined at design phase in accordance with actually contracted equipment. 10% spare capacity, for each type of I/O module and system function shall be added after the finalization of the lists of Alarms/Signals.

B. Typical alarms/signals are presented below but the Contractor shall include all alarms, indications and measurements of each item of plant and the SCS system.

C. These alarms may then be grouped according to KAHRAMAA's requirements for signals to the NCC/ENCC and signals to the DCC. The final signals list shall be submitted by the Contractor for review and approval by KAHRAMAA.

D. All bay control units shall have direct analogue inputs for secondary CT and VT measurements. Power system measurements including real and reactive power shall be an internal calculation within the bay control unit.

1.12 INCOMING & OUTGOING FEEDERS

A. Control functions shall comprise:

1. Bay level control
2. Data acquisition
3. Bay level interlocking
4. Bay level supervision
5. Station wide interlocking between BCUs.

B. Measuring functions shall comprise:

1. Amps
2. Volts
3. MW
4. MVAr

C. Position indications and alarms shall comprise:

1. CB open indication
2. CB close indication
3. CB service position indication (11kV Switchgear)
4. CB test position (11kV Switchgear)
5. CB withdrawn (11kV Switchgear)
6. CB Under-frequency load shedding group (11kV Switchgear)
7. Maintenance earth switches close indication
8. Maintenance earth switches open indication
9. Bus Isolator open indication
10. Bus Isolator close indication
11. Line Isolator open indication
12. Line Isolator close indication
13. Fault making earth switch close indication
14. Fault making earth switch open indication
15. Status local/remote control selection indication
16. CB fault indication
17. CB drive fail indication
18. Protection operated
19. VT fail/Out of service

20. Trip circuit faulty
21. Inter-trip send and receive
22. AC aux. Supply failure
23. DC supply failure and
24. All other relevant alarms such as O/C Trip, GIS alarms etc.

1.13 BUS SECTION BAY

A. Control functions shall comprise:

1. Bay level control
2. Data acquisition
3. Bay level interlocking
4. Bay level supervision
5. Station wide interlocking between BCUs.

B. Measuring functions shall comprise:

1. Amps
2. Volts
3. MW
4. MVAr
5. Frequency

C. Position indications and alarms shall comprise:

1. CB open indication
2. CB close indication
3. CB service position indication (11kV Switchgear)
4. CB test position (11kV Switchgear)
5. CB withdrawn (11kV Switchgear)
6. Maintenance earth switches close indication
7. Maintenance earth switches open indication
8. Bus Isolator open indication
9. Bus Isolator close indication
10. Fault making earth switch close indication
11. Fault making earth switch open indication
12. Status local/remote control selection indication
13. CB fault indication
14. B drive fail indication
15. Protection operated
16. VT fail/Out of service
17. Trip circuit faulty
18. Inter-trip send and receive
19. AC aux. Supply failure
20. DC supply failure and
21. All other relevant alarms such as Cable Protection, O/C Trip, GIS alarms etc.

1.14 BUS COUPLER BAY

A. Control functions shall comprise:

1. Bay level control
2. Data acquisition
3. Bay level interlocking
4. Bay level supervision
5. Station wide interlocking between BCUs.

B. Measuring functions shall comprise:

1. Amps
2. Volts
3. MW

4. MVAr

C. Position indications and alarms shall comprise:

1. CB open indication
2. CB close indication
3. CB service position indication (11kV Switchgear)
4. CB test position (11kV Switchgear)
5. CB withdrawn (11kV Switchgear)
6. Maintenance earth switches close indication
7. Maintenance earth switches open indication
8. Bus Isolator open indication
9. Bus Isolator close indication
10. Status local/remote control selection indication
11. CB fault indication
12. CB drive fail indication
13. Protection operated
14. VT fail/Out of service
15. Trip circuit faulty
16. Inter-trip send and receive
17. AC aux. Supply failure
18. DC supply failure and
19. All other relevant alarms such as O/C Trip, GIS alarms etc.

1.15 COMMON ALARMS

A. Common alarms shall comprise:

1. All relevant alarms from 11kV Busbar protection
2. All relevant alarms from LVAC Switchgear
3. All relevant alarms from 110 V DC switchgear
4. All relevant alarms from 48V DC switchgear
5. All relevant alarms from Batteries, chargers (110V & 48V)
6. All relevant alarms from Telecom
7. All relevant alarms from UPS
8. All relevant alarms from GPS Clock
9. All relevant alarms from Fire Protection System
10. All relevant alarms from HVAC system
11. All relevant alarms from 11kV under frequency load shedding
12. All relevant alarms from the high voltage power cable distributed temperature monitoring equipment
13. All relevant alarms from SCS system (all alarms shall be grouped in one alarm for NCC)
14. All other relevant alarms.

EQUIPMENT REQUIREMENTS

1.16 GENERAL

A. The control system shall be designed for easy modification of hardware and software and for easy extension of the substation either from the substation HMI or each of the control centres. Maintenance, modification or extension of components shall not require a shutdown of the whole SCS. The control equipment shall comply with the latest revisions of the IEC publications, except where otherwise stated.

B. There shall be no single point of failure of the SCS at the substation level that will cause a loss of control and monitoring functionality of the substation. The Tenderer shall state how this is achieved.

C. Failure of any component of the SCS at bay control level shall not result in more than one feeder / circuit being out of control by the system. The Tenderer shall state how this is achieved.

D. All SCS computers shall have direct PCI connection to FO port connection without any interfacing to any PCI Ethernet RJ45.

E. All FO cables used for connection of SCS computers as well as connection of IEDs shall be enclosed in halogen free flame retardant outer sheath.

F. Maximal tensile strength of FO cables shall be:
   1. short term 800 N
   2. during operation 200 N

G. Ethernet TCP cable shall be used as CAT6 cables.

H. All Common alarm and computer panels/cubicles should be fan ventilated.

I. The main process information shall be distributed to databases in different bay terminals. The system shall include the concept of a Distributed Data Base approach for safety reasons.

1.17 ENVIRONMENTAL REQUIREMENTS

A. The Tenderer shall ensure that all equipment is fit for purpose and housed appropriately for the substation environment. The following requirements reflect the fact that the Bay Control Units are typically based on numerical protection relay devices.

B. The station level equipment (station computer, gateway, LAN) shall far as possible also meet the following requirements but may be housed in an IP50, force cooled cubicle. Failure of the cooling fan shall not result in system failure. Any deviation from the specifications shall be highlighted.

C. The operators' desk and HMI, typically housing a desktop computer shall be suitably designed to reduce the effects of dust.

1.18 ATMOSPHERIC ENVIRONMENT

A. Temperature:
   1. The standard nominal range of ambient temperature shall be -10°C to +55°C.
   2. The Bay Control Units shall operate satisfactorily when tested to the following
   3. requirements:
      a. IEC Publication 60068-2-1 with severity class -25°C, 96 hours.
      b. IEC Publication 60068-2-2 with severity class 55°C, 96 hours.
   4. The Bay Control Units shall be able to withstand the temperature requirements for storage and transportation and shall be tested to the following requirements:
      a. IEC Publication 60068-2-1 with severity class -25°C, 96 hours.
      b. IEC Publication 60068-2-2 with severity class 70°C, 96 hours.

B. Relative humidity:
   1. The Bay Control Units shall operate correctly with a relative humidity of 93 % and
   2. shall be tested to IEC Publication 60068-2-3 with severity class 56 days.

C. Enclosure:
   1. The protection relay shall meet the requirements of the tests detailed in IEC
   2. Publication 60529 with classification IP50 (dust protected). If the individual enclosure of the relay is to a class less than IP50 then the tenderer shall provide a cubicle to classification IP50 to accommodate the relay.

1.19 MECHANICAL ENVIRONMENT

A. Vibration:
   1. The Bay Control Units shall meet the requirements of the tests detailed in IEC
   2. Publication 60255-21-1 with severity class 1.

B. Shock and bump:
   1. The Bay Control Units shall meet the requirements of the tests detailed in IEC
   2. Publication 60255-21-2 with severity class 1.

C. Seismic:
   1. The Bay Control Units shall meet the requirements of the tests detailed in IEC
   2. Publication 60255-21-3 with severity class 1.

1.20 ELECTRICAL ENVIRONMENT

A. DC auxiliary energizing quantity:
   1. The Bay Control Units shall be capable of being energized from a DC auxiliary voltage of 110V (nominal).
   2. The Bay Control Units or its associated power supply for use in a 110 V (nominal) DC supply system shall operate correctly over a voltage range of 77 V to 150 V.
   3. Numerical Bay Control Units shall meet the requirements of IEC Publication 60255-11 with interruptions to the DC auxiliary energizing quantity of 20 ms.

B. Frequency:
   1. The rated frequency shall be 50 Hz. The nominal range of operating frequency shall be -5 % to +5 % of nominal.

C. Thermal rating:
   1. BCU I/O equipment intended to perform a current measurement function shall be capable of continuous operation at a current of not less than 2.4 times the nominal rating or 2 times the setting value, whichever is the more onerous.
   2. Voltage sensitive equipment intended for use on effectively earthed networks shall have a continuous withstand of not less than 1.2 times nominal voltage and a short duration withstand of not less than 1.5 times nominal phase-to-ground voltage for 30 s.

D. Insulation:
   1. Rated Insulation Voltage
      a. The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000V. All other circuits shall have an insulation voltage of 250V.
      b. All open contacts of the Bay Control Units shall withstand a voltage of 1000 V.
   2. Dielectric Tests:
      a. The Bay Control Units shall comply with the dielectric test requirements of IEC Publication 60255-5. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested form Series C of Table 1 of IEC Publication 60255-5.
   3. Impulse Voltage:
      a. The Bay Control Units shall comply with the impulse test requirements of IEC Publication 60255-5 with test voltage of 5 kV.

1.21 ELECTROMAGNETIC COMPATIBILITY

A. The requirements of this section of the specification are applicable to Bay Control Units. The requirements may also be applied to electromechanical relays that may radiate electromagnetic interference during their operation.

B. 1 MHz. Burst Disturbance:
   1. The Bay Control Units shall comply with the requirements of IEC Publication 60255-22-1 with severity Class III.

C. Electrostatic Discharge
   1. The Bay Control Units shall comply with the requirements of IEC Publication 60255-22-2 with severity Class III.

D. Radiated Electromagnetic Field Disturbance:
   1. The Bay Control Units shall comply with the requirements of IEC Publication 60255-22-3 with severity Class III. The test shall be carried out by using Test Method A and by sweeping through the entire frequency range 27 MHz to 500 MHz.

E. Electromagnetic Emissions:
   1. The Bay Control Units shall comply with the requirements of IEC Publication 60255-25.

F. Fast Transient Disturbance:
   1. The Bay Control Units shall comply with the requirements of IEC Publication 60255-22-4 with severity level IV.

1.22 SCS ARCHITECTURE

A. The National Control Centre (NCC/ENCC) is responsible for operation of the electricity system from generation through to and including the 11kV busbars at the Primary Substations. The Distribution Control Centre (DCC) is responsible for the operation of the electricity system from the outgoing 11kV feeders at Primary Substations through to the consumers.

B. The architecture of the SCS shall be such that it provides the same overall division of operational responsibility as exists between the NCC/ENCC and DCC. To this end, it is envisaged that each gateway shall have two communication channels. One for connection to the NCC/ENCC and one for connection to the DCC as follows:
   1. Gateway 1:
      a. Communication Port 1 – NCC/ENCC Main
      b. Communication Port 2 – DCC Back-up
   2. Gateway 2:
      a. Communication Port 1 – DCC Main
      b. Communication Port 2 – NCC/ENCC Back-up

C. Enforcement of the division of operational responsibility at the substation and bay levels shall be through the configuration of 'permissions' within the SCS.

D. The status indications and measurements from all the Primary Substation circuits shall be sent to both the NCC/ENCC and the DCC. Alarms relating to the 11kV feeders shall be sent to the DCC. However, this shall be configurable such that selected individual or grouped alarms may also be sent to the other control centre, if desired.

E. At Primary substations, the 11kV transformer circuits and 11kV bus section circuits shall be controlled from the NCC/ENCC. The 11kV outgoing feeder circuits shall normally be controlled from the DCC. However, the NCC/ENCC shall also be able to control the 11kV outgoing feeder circuits for load shedding purposes.

F. Load shedding is initiated by the NCC/ENCC and requires the tripping of selected 11kV feeder circuits at multiple Primary substations. It shall be possible to send the trip commands directly to the substations from the NCC/ENCC. The NCC/ENCC shall also be able to send the details of the selected feeders to be tripped to the DCC via the ICCP link between NCC/ENCC and DCC for the SCADA/DMS System at the DCC to send the tripping commands to the substations.

1.23 CONTROL FROM SUBSTATION

A. The following steps shall be required for the control of any item of plant through the SCS HMI:
   1. Operator enters password through HMI
   2. System verifies password an unlocks appropriate level of authorization
   3. The Operator selects the circuit to be operated from the Overview screen
   4. The Operator selects the plant item to be controlled from the detailed view

5. The Operator selects the required action such as Open / Close / raise / Lower etc
6. The SCS executes the control request
7. Messages shall be displayed on screen during the control steps to allow the Operator to monitor the control progress and cancel the operation at any point. The control operation shall have a time out facility to return the system to a safe state should the time be exceeded.

1.24 SYSTEM SECURITY REQUIREMENT

A. The system security requirement should include but not limited to System Hardening, Firewall, Antivirus/Malware detection, IPS (Intrusion Prevention System), IDS (Intrusion Detection System), Security based coding practice, User account management with RBAC (Role-Base Access Control) model, etc. as specified in IEC62351 standard, part 1-7. The requirement shall be detailed, discussed, and proposed with KM approval during Workshop.

B. Contractor shall propose the best-suited solution in securing the system as well as maintaining its performance.

1.25 DATABASE MANAGEMENT SYSTEM

A. Each SCS shall be provided with a database management system. The database management system shall present the information via a user interface such that any individual database is transparent to the user. The database management system shall provide a means of verifying the database in order to check consistency and completeness of the database. The SCS database shall be fully tested prior to uploading on the SCS or NCC/ENCC/DCC to ensure errors are reduced to a minimum.

B. The database modifications shall all be documented. The contents of a database shall not be lost if the power supply fails. After a power failure, the SCS shall start and load its database automatically. The SCS shall allow the user to configure the database on site or from the NCC/ENCC or DCC, respective to the associated SCS operational responsibilities. The NCC/ENCC/DCC database shall be kept updated with the current configuration data for each SCS. Tenderers shall state how this is achieved.

1.26 CONFIGURATION AND MAINTENANCE

A. The SCS shall perform continuous self-diagnostics to monitor its own operational capability. Any detected fault or abnormality which could affect the SCS performance or operational capability shall be indicated to the respective control centre, NCC/ENCC or DCC, and locally at the HMI.

B. A laptop computer based configuration and maintenance facility shall be provided along with all database and software interfaces required for the maintenance and configuration of the SCS, e.g. SCS diagnostics, database compiler, software listings, SCS configuration listings, etc.

C. The laptop computer shall have diagnostics for the BCU processor(s), memory, I/O ports, and any other functional areas of the BCU. The laptop computer shall also be used to monitor and test the BCUs operation and communication interfaces and shall be capable of emulating both the SCS and the NCC/ENCC/DCC.

1.27 PERFORMANCE REQUIREMENTS

A. Overview

1. The performance of the SCS shall be based on a standard circuit which consists of at least the following controllable items, indications and measurements:
2. Controls:
   a. 7 primary plant items, including 1 circuit breaker with synchronizing.
   b. 4 secondary plant items and associated indication.
3. Automatic tap change control:

a. 1 Transformer for every 5 circuit breakers, with each transformer having a minimum of 21 tap positions.

4. Analogues:
   a. 6 analogues
5. Single point status:
   a. At least 50 points
6. The standard circuit shall meet the following performance requirements where:
   a. Normal Activity for a standard circuit is defined as:
      One primary plant alarm every 30s
      One control action every 60s
      Different display request every 60s
      20% of analogues require processing every 1s
   b. High Activity for a standard circuit is defined as:
      One primary plant alarm every 2s
      One control action every 15s
      Different display request every 30s
      40% of analogues require processing every 1s

B. System Loading and Utilisation
1. Utilization of any processor
   a. Normal Activity: 30%
   b. High Activity: 70%
2. Utilization of any memory device
   a. Normal Activity: 30%
   b. High Activity: 70%
3. Utilization of any communication device of network bus
   a. Normal Activity: 40%
   b. High Activity: 80%

C. Response Times
1. Display appearance
   a. Normal Activity: < 1s
   b. High Activity: < 2s
2. Presentation of binary changes
   a. Normal Activity: < 1s
   b. High Activity: < 2s
3. Presentation of analogue changes
   a. Normal Activity: < 2s
   b. High Activity: < 4s
4. From order to process output
   a. Normal Activity: < 1s
   b. High Activity: < 2s
5. From order to update of display
   a. Normal Activity: < 2s
   b. High Activity: < 3s

INSPECTION AND TESTING

1.28 GENERAL

A. Test Principles
1. The principle of testing shall be that, at stages throughout the work, formal tests shall be performed and recorded against written test specifications to provide a high level of confidence to both the Contractor and KAHRAMAA that the Works meet the specified requirements such that subsequent stages of the Works may proceed.

2. The testing philosophy for the SCS shall ensure that the System hardware and software equipment functionality is thoroughly exercised and validated at the Contractor's premises before delivery and commissioning. The test methodology shall complement the design methodology and the two shall be developed in parallel.
3. This document does not constitute a Test Specification or Test Procedure for any part of the system but rather it sets out the stages at which tests are required and the subjects, locations and purpose of the testing at each stage.
4. The Contractor shall be responsible for specifying, conducting and recording all tests and the test documentation for all tests shall be written by the Contractor and submitted to KAHRAMAA for approval in accord with the requirements for document submission. The degree to which KAHRAMAA intervenes in the testing process will depend upon the level of confidence built up during the project.
5. Inspection of incoming goods and components, and subassembly testing, shall be undertaken by the Contractor in accordance with the procedures set out in the Contractor's own Quality Plan and are not described here.
6. This Specification covers the higher levels of complexity, namely:
   a. Type testing
   b. Subsystem testing
   c. System testing.
7. Type testing is required to verify that the equipment meets with the specified environmental conditions. For purpose built equipment such as BCU, station computer, terminals and connectors test certification shall be provided or tests shall be carried out to verify compliance with the required standards. However, for proprietary equipment such as printers, VDUs and keyboards, it shall suffice to provide test certification that shows the equipment is suitable for the intended environment.
8. 'Subsystems' are defined as single items or small groups of closely related equipment (including software) such as printers, workstations, operator consoles, etc., that may be installed as an organizational entity.
9. The 'System' is defined as the interconnection of all Subsystems and any other equipment that will eventually comprise all of the equipment supplied under this Contract (with the exception of spares) along with the communications and network media and interface equipment supplied by others.

B. Responsibilities: The Contractor's responsibilities shall include but not be limited to requirements to:

1. Produce written test plans, schedules, procedures, method statements, test record sheets and procedures for fault reporting, for all tests.
2. Submit all test documentation associated with any subsystem or system test for approval by KAHRAMAA within the required time scales.
3. Ensure that all test documentation associated with any testing has been approved by KAHRAMAA prior to the commencement of the corresponding testing.
4. Provide the equipment, test equipment, test software, personnel and facilities to conduct the testing.
5. Successfully carry out internal acceptance testing using the approved test procedures and correct any errors found in either the test procedures or the subsystem/system being tested prior to the commencement of the witnessed acceptance tests.
6. Provide facilities for KAHRAMAA and/or their Representatives to witness any Factory tests.
7. Produce permanent records of all test progress and results in a formal systematic manner.

8. Carry out all remedial work and re-testing necessary for the equipment to pass the tests.
9. Each of the above responsibilities shall be discharged to the satisfaction of KAHRAMAA, but approval by KAHRAMAA shall not imply any diminution of the Contractor's responsibilities. It is expressly the responsibility of the Contractor to satisfy himself that items 'supplied by others' are in a satisfactory condition for the Contractor's tests to be conducted.

C. Test Equipment and Facilities: The Contractor shall provide all equipment and services required for testing, including, but not limited to:
1. Laboratory test instruments
2. Special test equipment, emulators, simulators and test software, to permit full testing of System functions and performance
3. Other items of the System, specified elsewhere as being part of the Contractor's supply, even if not part of the Subsystem under test
4. Consumables required to prepare for and perform the tests.

D. All test instruments shall be subject to routine inspection, testing and calibration by the Contractor. All test instruments shall be subject to approval by KAHRAMAA and, if required by KAHRAMAA, shall be calibrated at the expense of the Contractor by an approved standards laboratory.

E. All test software shall be subject to formal quality assurance requirements stipulated elsewhere in the Specification.

1.29 TESTING STAGES

A. Inspection of incoming goods and components, and subassembly tests, shall be performed in accordance with the Contractor's Quality Plan. The formal stages of testing to be performed fall into the following three categories:
1. Type Tests Equipment shall pass these tests in order to be accepted for use under this Contract
2. Factory Acceptance Tests (FAT): Systems shall pass these tests before they may be shipped to site
3. Site Acceptance Tests (SAT): Systems shall pass these tests before they may be put into operation and before they are Taken Over

1.30 NOTICE & WITNESSING OF TESTS

A. The Contractor shall provide, as part of the Programme of Work documentation, a master plan showing the scheduled dates of testing and shall provide updates to this plan, when any changes are known, at least six weeks in advance of the tests.

B. The Contractor shall advise KAHRAMAA in writing of the actual date of commencement of every test, at least 10 working days before the commencement.

C. KAHRAMAA shall have the right to witness any tests whether conducted at the Contractor's premises or elsewhere. Records of every test, whether witnessed or not, shall be taken by the Contractor and copies sent to KAHRAMAA within three weeks of completion of the tests.

1.31 TEST PROCEDURES AND RESULT SHEETS

A. The Contractor shall prepare test procedures and result sheets for all tests. The Contractor shall also prepare a cross reference listing that clearly shows function by function and clause by clause, where the test for each of the respective function/requirement Functional Design Specification have been included in the tests.

B. Separate test procedures and result sheets shall be provided for factory and site acceptance tests. All test procedures will be subject to review and approval by KAHRAMAA and shall be submitted at least two months before the test. Result sheets will be subject to review and approval by KAHRAMAA also.

C. Test result sheets will be retained as part of the permanent QA record for the SCS.

1.32 CONTRACTOR'S PRIOR TESTS

A. The Contractor shall successfully complete a prior run of all tests, using the test procedures and result sheets described in these Tender Documents, before the commencement of the formal tests.

B. Any revisions to the test documents found necessary as a result of the prior tests shall be made before the commencement of formal tests.

C. Test results from the prior tests shall be made available to KAHRAMAA on request, to indicate the readiness of the equipment for tests to commence.

1.33 CONDUCT OF THE TESTS

A. The Contractor shall conduct the tests in accordance with the approved test procedures, and shall enter the results in the result sheets.

B. For each test, KAHRAMAA will determine whether the test has passed or failed. In general, the test will be considered to have failed if either:

1. The result of the test is not in accordance with the expected result described in the test procedure, or
2. The result of the test is in accordance with the expected result described in the test procedure, but some other unexpected or unexplained event occurred which KAHRAMAA considers to be a fault.
3. Full use shall be made during the tests of operator manuals and other documentation provided by the Contractor, to provide a series of tests of their accuracy.

1.34 FAILURES

A. The Contractor shall correct all faults found during testing, and shall arrange for the test to be repeated. The test shall only be repeated when the fault has been remedied and the equipment demonstrated to function correctly.

B. Where remedial measures involve significant modifications that might, in KAHRAMAA's opinion, affect the validity of earlier tests then the Contractor shall repeat the earlier tests and obtain satisfactory results before repeating the test in which the fault was first identified.

C. KAHRAMAA shall have the right to order the repeat or abandonment of any test in the event that results demonstrate that the equipment is significantly non-compliant with the Contract requirements, without in any way prejudicing his rights under this section.

D. KAHRAMAA shall have the right to suspend any test in the event that errors or failures have become unacceptable. KAHRAMAA shall also have the right to suspend any test in the event of a fault being detected by the Contractor but not reported to KAHRAMAA within 24 hours. In this event, the suspension shall remain in effect until reporting has been brought up to date to the satisfaction of KAHRAMAA.

1.35 FAULT CATEGORIES

A. KAHRAMAA will allocate a category to each fault, which shall determine the future conduct of test.

1.36 REPEAT TESTS

A. The Contractor shall correct and re-test every fault detected during the tests.

B. Time spent by KAHRAMAA and/or KAHRAMAA's representatives witnessing retests, or waiting at the Contractor's premises or the test site while corrections are made prior to re-test, shall be charged to the Contractor at the standard hourly rate for the personnel concerned. All other costs incurred by KAHRAMAA and/or KAHRAMAA's representatives

as a result of such re-tests, including accommodation, subsistence and travel charges, will be charged to the Contractor at cost.

C. If KAHRAMAA and/or KAHRAMAA's representatives is required to return to the Contractor's premises or the test site to witness such re-tests then time spent by the personnel concerned in travelling to the site of and witnessing such re-tests, and all charges incurred by them in so doing, will be charged to the Contractor.

1.37 FAULT LOG

A. The Contractor shall maintain a fault log throughout each series of tests. Every fault detected during the tests will be entered in the log, together with the actions taken to clear and re-test the fault.

B. The fault log will be retained as part of the permanent QA record for the SCADA/EMS System.

1.38 HARDWARE FAILURE REPORTS

A. For each hardware failure that occurs at any stage of testing, the Contractor shall investigate the failure and prepare a report on its cause(s) and design implications.

B. The report shall clearly show:

1. The most likely cause of the failure
2. An analysis of any stress that may have been caused to other components of the equipment being tested as a result of the failure
3. Whether the failure is a result of any component operating outside its design range
4. Whether any design changes should be made to avoid further failures.

C. All such reports will be retained as part of the permanent QA record for the SCADA/EMS System.

1.39 SOFTWARE FAILURE REPORTS

A. For each software failure that occurs, once the software has been approved for inclusion into the system and is subject to configuration control, the Contractor shall generate a software failure report. The report shall clearly show:

1. The observed symptoms
2. The likely cause
3. The fault category (from Table 1-3)
4. The report shall also clearly show the following information that shall be entered when the failure has been investigated:
5. The actual cause of the failure
6. The corrective action taken
7. All software modules affected

B. All such reports will be retained as part of the permanent QA record for the SCADA/EMS system.

1.40 TYPE TESTS

A. Full details of type tests performed on equipment identical to that being offered shall be submitted with the offer, accompanied by a proposed schedule of tests to be performed for each item of equipment. If the submitted type test results are satisfactory then the type tests specified may, at the discretion of KAHRAMAA, be waived.

B. In general, type test results shall show that the equipment being proposed for this Contract will perform in accordance with its design specification in the environments to which it will be subject in its application under this Contract. The environmental factors include climatic (temperature, humidity, wind, rain, etc.), electromagnetic (radiated and conducted), mechanical (transport vibration, handling knocks, operational ruggedness, earthquake stresses) and chemical (salt laden atmosphere).

C. Where appropriate, the type tests shall also demonstrate that the equipment does not exceed accepted standards in terms of its impact on the environment (e.g. noise, harmonic emissions into the mains, etc.).

1.41 FACTORY ACCEPTANCE TESTS

A. Subsystem FAT

1. A Subsystem Factory Acceptance Test shall include the inspection, hardware test and software test of any clearly identifiable Subsystem, prior to use as a component in a System test. The test shall prove that the Subsystem meets its particular physical, functional and performance specification. All corresponding inspection, and component and subassembly test documentation shall be complete and available for inspection prior to the commencement of a subsystem FAT. The tests shall be carried out at the Contractor's premises.

B. System FAT

1. The System FAT shall combine all Subsystems and shall include other equipment that shall represent, emulate or simulate those parts of the "System" to be eventually provided. The System FAT shall commence only if all associated subsystems have successfully completed their individual FATs to the satisfaction of KAHRAMAA. The Contractor shall have completed his own internal system integration tests prior to commencement of the System FAT.
2. The System shall be inspected to ensure that all interfaces mate correctly and that the System is complete. The System shall then be tested as a whole to prove that it meets the Specification in all aspects of function, performance, capacity, maintainability and operability.
3. It is required that the results of the test shall demonstrate System reliability and availability consistent with the values specified and those guaranteed by the Contractor. The test shall be carried out at the Contractor's premises. Upon satisfactory completion of the test, the System will be ready for delivery to site.
4. The FAT shall not commence until all documentation associated with the FAT including Test Plan, Cross-reference Document, Test Specifications, Test Procedures and Test Record Sheets have achieved Category I approval. The System equipment will not be allowed on site until the FAT has been successfully completed and the corresponding test records have been reviewed by KAHRAMAA.
5. Partial shipment may take place, by agreement with KAHRAMAA, of equipment that has been successfully factory tested (and the corresponding test records have been reviewed by KAHRAMAA) and is not required to form part of the System FAT.

C. General FAT Requirements

1. It is the responsibility of the Contractor to produce the Test Documentation for the FATs to the satisfaction of KAHRAMAA. Coverage shall include, but not be limited to, the following:
2. Order of Tests Tests shall be conducted to prove the integrated functioning of the system as a whole and shall include (but not be limited to) the following:
   a. Hardware inspection
   b. Hardware functionality including firmware and operating system level software tests on CPU, disks, I/O interfaces etc. (The extent of this testing will be dependent on the extent and nature of the subsystem tests)
   c. Integrated system tests to prove the functionality of all applications software in the context of the complete integrated system, equipment and software configuration
   d. System performance tests to demonstrate that the integrated system can achieve the guaranteed levels of response and to determine the limits of the response envelope

e. System performance in the face of various contingencies
f. Soak test to give an indication of system reliability, stability and robustness.

3. Inspection Prior to commencement of the tests, the equipment shall be inspected to ensure:
   a. Correct standards of workmanship and quality
   b. Correct identification labels, cabling, tagging, housing and mounting etc
   c. Adequate accessibility
   d. Compliance with the Specification and reviewed drawings (including compliance with fire safety and materials requirements)
   e. Verification of model numbers, quantities of items etc.
4. Test Conditions: The conditions of the tests shall be no less rigorous than:
   a. All subsystem components shall have been successfully inspected and tested, as necessary, and all corresponding documentation shall be complete and available for inspection.
   b. All necessary maintenance and adjustments shall be carried out before commencement of the test so that the tests can continue uninterrupted by routine operations.
   c. The equipment shall be complete at the start of the tests and no interchange of modules or equipment shall be allowed.
   d. All parts subject to wear, such as electromechanical peripherals, may be omitted from the tests if agreed by KAHRAMAA. The printing and recording equipment needed for conducting the test shall be run throughout the test.
   e. Each subsystem and/or each module shall be tested cyclically at least once per hour whilst all other parts are functioning normally.
   f. No repairs or adjustments shall be carried out during the test period unless agreed by both parties.
   g. The test shall run for at least 200 hours continuously. It need not be permanently manned throughout this period provided that a comprehensive log of operations tested and faults occurring is printed.
   h. Where there is redundancy in the equipment the test period shall be divided equally between the redundant parts. All modules must remain powered up for the duration of the test.
   i. Test equipment and test software shall be provided to load the equipment to a greater extent than the worst case predicted for the complete system. Online loading and all functions shall be tested under these worst case conditions. Sufficient hardware (e.g. remote terminals) and/or simulation devices shall be provided by the Contractor to ensure that the Design System Loading conditions can be achieved and System performance demonstrated to the satisfaction of KAHRAMAA.
   j. The tests shall be carried out at the prevailing ambient conditions of temperature and humidity, no special conditioning is required.
5. Computer Equipment: The Contractor shall provide all the software necessary to carry out the tests. Tests shall include:
   a. CPU tests
   b. RAM write/read tests
   c. Disc write/read tests
   d. Data highway loading tests
   e. Peripheral tests
   f. Workstation equipment test.
   g. Tests shall exercise communication ports and shall overload ports so that queuing of messages occurs. The tests shall use a simulated network, or where practical, a real network.

6. • Communications Tests shall include, where appropriate:
   a. Data integrity in the presence of noise
   b. Loss of Link procedures
   c. Demonstrate that communication systems do not interfere with each other (e.g. cross-talk) or with other systems
   d. Demonstration of network management functions
   e. Programming, control and configuration of the network.
   f. The tests shall use a simulated network or, where practical, a real network.
7. Soak Test
   a. Each subsystem soak test shall be carried out over a period of time sufficient to fully prove the correct functioning of the equipment comprising the subsystem. The initial System soak test shall have a minimum duration of 100 hours. The time shall be calculated as the number of hours continuously connected and running. All errors or problems shall be printed out. Messages shall also be output periodically indicating continuing successful operation.
   b. The equipment shall perform successfully without errors or failures that are inconsistent with the reliability and availability criteria of the System design.
8. Functional Tests
   a. During the functional tests, every function specified for the system in the Functional Design Specification shall be thoroughly tested. Both positive and negative tests shall be carried out.
   b. Before commencement of the functional tests, all software for which source code is supplied under the Contract shall be reassembled and/or recompiled from source. The resulting object code shall be re-linked and used for the tests.
   c. Similarly, all configurable databases, screen displays and reports shall be regenerated from source. All of these activities shall use compilers, assemblers, linkers and generation/startup utilities identical to any of those supplied under the Contract.
9. • Performance Tests
   a. The performance tests shall demonstrate that the performance and response times of the equipment are in accordance with the specified requirements.
10. • Unstructured Tests
   a. In addition to the structured tests described above, all factory acceptance tests shall include a 48 hour period of unstructured testing, during which KAHRAMAA and/or KAHRAMAA shall be at liberty to instruct the Contractor to carry out such additional tests as may be required to test the reliability and robustness of the system.

1.42 SITE ACCEPTANCE TESTING

A. After equipment has been erected and connected up on site, the Contractor shall carry out to the satisfaction of KAHRAMAA such tests as may be required to prove compliance with the Specification, independent of any factory tests.

B. In support of the Site testing activities, the Contractor shall prepare an overall test plan that covers all testing to be carried out on Site. The test plan shall indicate test precedence and dependencies and should be coordinated with the Contractor's general programme of work. It shall conform to the relevant requirements for test documentation. The test plan will be subject to the approval of KAHRAMAA and should be closely coordinated with KAHRAMAA in terms of the availability of plant for testing and the timely provision of the associated permits to work.

C. KAHRAMAA shall have the right, with KAHRAMAA's agreement, to waive some tests and require additional tests to be carried out if findings on Site indicate additional or alternative

tests are required to properly demonstrate that the works comply with the requirements of the Contract.

D. The general requirements for testing and factory testing set out in preceding clauses of this section are applicable to Site testing.

E. Subsystem SAT

1. A Subsystem SAT shall be conducted to prove that the Subsystem has not been damaged during packaging, delivery and installation on site. The test shall prove that the Subsystem is operating correctly and interfaces correctly to equipment and services on that site. On completion of the test, the Subsystem shall be ready for use in the System SAT.
2. The scheduling of Subsystem SATs shall be subject to coordination with the installation and testing schedules of equipment of other suppliers, to which the Subsystem is designed to interface.

F. System SAT

1. The System SAT shall be conducted on all the interconnected equipment forming the Contractor's scope of supply, together with equipment of other suppliers to which the System is designed to interface.
2. The System SAT shall be conducted after all the various elements of the System have been installed in the field and have all successfully completed their individual Subsystem SATs. The System SAT shall be performed with equipment in the locations in which they will eventually operate.
3. This test shall demonstrate that the overall design of the System meets the functional and performance requirements of the Specification in the field, using the actual communications network and including equipment supplied by others, to which the System is designed to interface.
4. The Contractor shall satisfy himself by testing and other necessary means, that the physical communication links between terminations supplied by others meets the Contractor's requirements. Any deficiencies in such equipment shall be reported fully in writing by the Contractor to KAHRAMAA upon their discovery, to allow prompt remedial action to be instigated. The correction of deficiencies in such equipment shall not be the responsibility of the Contractor, provided that the deficiencies have not resulted from inadequate definition and specification of requirements on the part of the Contractor.

G. General SAT Requirements

1. It must be emphasized that all testing that requires an interface to operational equipment must only be carried out after prior agreement with KAHRAMAA and adequate advance notice shall be given to KAHRAMAA by the Contractor of their intent to conduct testing involving operational equipment.
2. It is the responsibility of the Contractor to produce the Test Documentation for the SATs to the satisfaction of KAHRAMAA. They shall meet the appropriate requirements for the Factory Acceptance Test specified these Tender Documents. In addition, the following requirements shall be met:
   a. Commissioning: It shall be the Contractor's responsibility, within the scope of definite work, to fully commission the System in such a manner as to enable trained operators to use the System.
   b. Duration and Downtime: Each Subsystem SAT and the System SAT shall be carried out over a period of time sufficient to fully prove the correct functioning of the equipment. All errors or problems shall be printed out. Messages shall also be output periodically indicating continuing successful operation. The equipment shall perform successfully without errors or failures that are inconsistent with the reliability and availability criteria of the System design.

c. Testing to Plant: Initial setting to work and all subsequent 'live' tests will be directed by KAHRAMAA, and carried out jointly by KAHRAMAA and the Contractor. Tests shall be subject to KAHRAMAA's standard safety procedures, and all operational switching will be carried out by KAHRAMAA according to a programme that will be prepared and agreed in advance between KAHRAMAA and the Contractor.

H. Specific Site Test Requirements

1. Installation Tests: Following dispatch from the factory and arrival at site, the Contractor shall ensure that the location for the system or subsystem is fully prepared to proceed with installation. Of completion of installation the Contractor shall set the equipment working and carry out the necessary tests and diagnostic to verify that the system or subsystem is functioning according to the requirements. When completed the results of the diagnostic and verification tests shall be submitted to KAHRAMAA. Following this and subject to the tests being approved, the Installation Tests shall be conducted by the Contractor. On successful completion of these tests the EMS/SCADA system/subsystem shall be made available for the point to point testing and verification of the database.
2. Point To Point Testing: Site acceptance test procedures for the new SCS equipment shall ensure that the SCS database and displays are correctly mapped onto the BCU input output connections to the plant. The process of testing this mapping may take up to 1 month to complete. Therefore, the Contractor shall establish, to the satisfaction of KAHRAMAA, quality procedures that ensure the validity of the results of previous testing are systematically reviewed following subsequent changes in the database, displays and or the system code. These procedures should identify when previous test results may no longer be valid due to subsequent changes on the system. If test results are invalidated by subsequent actions then re-testing will be necessary. The scope of the re-testing shall be agreed with KAHRAMAA on a case by case basis.

I. Readiness to Commence Tests On Completion

1. When KAHRAMAA is satisfied that the Site acceptance testing has shown that the works as a whole comply with the specification and that:
   a. All test documentation and records are complete in order and signed off by the Contractor's test engineers;
   b. The spare parts and test equipment are complete, in working order and available for use;
   c. The initial issue of technical documentation and copies of marked as built drawings have been provided;
   d. Training has been completed as required by the Contract;
   e. And the arrangements for support during the warranty period have been agreed;
2. The Contractor may apply to commence the Tests On Completion.

1.43 SYSTEM ACCEPTANCE

A. The System will be accepted by KAHRAMAA if both:

1. The System and all items of equipment have successfully completed all the specified tests
2. All failures, problems and reservations noted during the tests have been corrected to the satisfaction of KAHRAMAA.

B. If either of these conditions has not been complied with, then the necessary corrective action shall be agreed between the Contractor and KAHRAMAA.

1.44 INSTALLATION/DISMANTLING REQUIREMENTS

A. The Contractor shall furnish and install all specified equipment and accessories in accordance with these Tender Documents.

1.45 SPECIAL EQUIPMENT AND TOOLS

A. Works to be done under this section include the delivery of special equipment and tools for erection, installation, maintenance, setting to work and other purposes.

B. Any additional special equipment and tools recommended by the Tenderer shall be

C. listed and priced in the BOQ.

1.46 SPARE PARTS

A. In order to assist in the ordering of spare parts, the Tenderer is required to recommend a spares holding to cover the first five (5) years, following the end of the Defects Liability Period, and to provide a cost breakdown. The Contractor shall not have access to spares held by KAHRAMAA during the Defects Liability Period.

B. The maintenance philosophy which will be adopted will generally be for fault-finding to card level and module replacement, with the faulty modules being either scrapped, if damaged beyond repair, or returned to the Contractor for repair, as appropriate.

C. The Contractor shall operate a module repair and replacement scheme, details of which shall be provided with the Tender, including turn around times.

D. The Tenderer shall base the list of recommended spare parts on the above maintenance philosophy. This list shall be submitted as an optional price and shall include a cost breakdown. Prices for the supply of spares shall include all associated charges and shall remain valid for orders placed within the term of the Defects Liability Period. KAHRAMAA shall be at liberty to order quantities of spare parts at variance with those listed by the Tenderer. The prices shall remain valid for any such variation of quantities, unless stated otherwise in the Tender.

E. The cost of spare parts shall not be used to calculate the cost of any variations to the Contract.

F. The spare parts recommended shall be identical functionally, electrically and mechanically, to the corresponding parts in the equipment supplied under the Contract and shall be suitably packed and clearly marked, ready for reception at KAHRAMAA's stores. Any special handling instructions shall be clearly marked on the packages.

G. The Contractor shall supply equipment lists of the recommended spare parts which include the names and addresses of the individual manufacturers of the listed items.

H. The recommended spares holding shall be quoted on a unit basis, as an option, for selection by KAHRAMAA at any time up until the end of the Defects Liability Period.

I. The availability of spare parts to KAHRAMAA, at a reasonable cost, shall be guaranteed by the Contractor as follows:

J. The Contractor shall maintain an adequate stock of spare parts for a minimum period of ten years (or until the end of the equipment's specified life) after the product has been removed from quantity production, declared obsolete or officially removed from sale

K. Where a component, which is not under the Contractor's control, has become unavailable, it is the responsibility of the Contractor to offer a compatible alternative at reasonable cost.

L. Design improvements or changes made to a product during its production run shall be carefully assessed such that component interchangeability shall not be affected.

M. This requirement shall apply to equipment manufactured by the Contractor and also to equipment purchased from other suppliers.

1.47 PACKAGING, SHIPPING AND TRANSPORT

A. Packing, shipping and transport shall be arranged according to the requirements in General Technical Requirements.

1.48 TRAINING

A. Works to be done under this section include training of KAHRAMAA's personnel to operate and maintain equipment efficiently and safely. The main requirements for training are described in General Technical Requirements. There shall be no constraints on the number and category of KAHRAMAA's personnel to be trained.

1.49 DOCUMENTATION

A. The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals and other information in accordance with General Technical Requirements.

1.50 DOCUMENTATION WITH TENDER

A. The Tender shall contain at least the following information and documents:
   1. General arrangement drawings of the SCS;
   2. Overall structure of the SCS;
   3. Detailed description of the SCS;
   4. Manufacturing specification of the SCS;
   5. Catalogues, literature and reference lists of proposed equipment;
   6. Type test certificates from an independent testing authority or independently witnessed;
   7. Quality Management System Manual and ISO Certificate of the equipment manufacturer.

B. Documentation After Award of Contract
   1. All documents required for KAHRAMAA's approval shall be submitted by the Contractor in accordance with General Requirements.

7.4.12 26 0923 - Lighting Control Devices

GENERAL

1.1 SUMMARY

A. This Section includes the following lighting control devices:
   1. Time switches.
   2. Outdoor and indoor photoelectric switches.
   3. Indoor occupancy sensors.
   4. Outdoor motion sensors.
   5. Lighting contactors.
   6. Emergency shunt relays.
   7. Power relays and contactors.

B. Related Sections:
   1. Section 26 0500 – Common Work Results for Electrical
   2. Section 26 0943 – Network Lighting Controls
   3. Section 26 2726 – Wiring Devices
   4. Section 26 5200 – General Lighting
   5. Section 26 5600 – Exterior Lighting

1.2 REFERENCES

A. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

B. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

C. IES – Illuminating Engineering Society

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

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

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

C. Interconnection diagrams showing field-installed wiring.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

F. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

G. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labelled as CE / BSI certified, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.7 SPARES

A. Contractor shall provide a list of spares required for each installed item of equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.8 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.9 TIME SWITCHES

A. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display.

1. Contact Configuration: as required to suit load.
2. Contact Rating: 30A inductive or resistive, 240-V ac.
3. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.

4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
5. Astronomic Time: All channels.
6. Battery Backup: For schedules and time clock.

1.10 OUTDOOR PHOTOELECTRIC SWITCHES

A. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input.

1. Light-Level Monitoring Range: 15 to 100 lx, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: Adjustable.
3. Surge Protection: Metal-oxide varistor.
4. Mounting: Twist lock, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

1.11 INDOOR PHOTOELECTRIC SWITCHES

A. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photo-resistors are not acceptable.

1. Sensor Output: Contacts rated to operate the associated relay. Sensor shall be powered from the relay unit.
2. Relay Unit: Dry contacts rated for 20A ballast load at 240V ac. Power supply to sensor shall be 24-V dc, 150-mA.
3. Light-Level Monitoring Range: 100 to 10,000 lx, with an adjustment for turn-on and turn-off levels within that range.
4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

B. Skylight Photoelectric Sensors: Solid-state, light-level sensor; housed in a threaded, plastic fitting for mounting under skylight, facing up at skylight; with separate relay unit, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photo-resistors are not acceptable.

1. Sensor Output: Contacts rated to operate the associated relay. Sensor shall be powered from the relay unit.
2. Relay Unit: Dry contacts rated for 20A ballast load at 240V ac. Power supply to sensor shall be 24-V dc, 150-mA.
3. Light-Level Monitoring Range: 10,000 to 100,000 lx, with an adjustment for turn-on and turn-off levels within that range.
4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

1.12 INDOOR OCCUPANCY SENSORS

A. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20 A ballast load at 240 V ac.
4. Mounting:

a. Sensor: Suitable for mounting in any position on a standard outlet box.
b. Relay: Externally mounted through a 13 mm knockout in a standard electrical enclosure.
c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 220 to 2,000 lx; keep lighting off when selected lighting level is present.

B. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

1. Detector Sensitivity: Detect occurrences of 150 mm minimum movement of any portion of a human body that presents a target of not less than 250 sq.cm.
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 100 sq.m) when mounted on a 3 m high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 30 m when mounted on a 3 m high ceiling.

C. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 300 mm in either a horizontal or a vertical manner at an approximate speed of 305 mm/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 50 sq. m when mounted on a 2400mm high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 100 sq.m) when mounted on a 3 m high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 200 sq.m when mounted on a 3 m high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 30 m when mounted on a 3 m high ceiling in a corridor not wider than 4.0 m.

D. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 150 mm minimum movement of any portion of a human body that presents a target of not less than 250 sq.cm and detect a person of average size and weight moving not less than 300 mm in either a horizontal or a vertical manner at an approximate speed of 305 mm/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 100 sq.m when mounted on a 3 m high ceiling.

1.13 OUTDOOR MOTION SENSORS (PIR)

A. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 10 to plus 60 deg C, weatherproof.

1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Mounting:

a. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
b. Relay: Internally mounted in a standard weatherproof electrical enclosure.
c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

3. Bypass Switch: Override the on function in case of sensor failure.
4. Automatic Light-Level Sensor: Adjustable from 11 to 215 lx; keep lighting off during daylight hours.

B. Detector Sensitivity: Detect occurrences of 150 mm minimum movement of any portion of a human body that presents a target of not less than 250 sq.cm.

C. Detection Coverage: Up to 30 m, with a field of view of 60 degrees.

D. Individually Mounted Sensor: Contacts rated to operate the connected relay. Sensor shall be powered from the relay unit.

1. Relay Unit: Dry contacts rated for 20 A ballast load at 240 V ac.
2. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

1.14 LIGHTING CONTACTORS

A. Description: Electrically operated and electrically held, combination type with fusible switch.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

B. BMS Interface: Provide hardware interface to enable the BMS to monitor and control lighting contactors.

1. Monitoring: On-off status
2. Control: On-off operation

1.15 EMERGENCY SHUNT RELAY

A. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts.

1. Coil Rating: 240 V.

EXECUTION

1.16 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

1.17 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

1.18 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 20 mm.

B. Wiring within Enclosures: Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

1.19 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

1.20 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

1.21 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1.22 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Sections associated with lighting and lighting control.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

7.4.13 26 1300 - Medium Voltage Switchgear

GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, Kahramaa, 2010.

C. All rules, requirements and regulations of Kahramaa shall be followed ensuring that only materials and installation methods approved by Kahramaa shall be used throughout this project.

D. Qatar Construction Specification (QCS) 2010 is the minimum standard for all aspects of this project. Where there is a conflict between QCS and this specification, the more stringent requirement shall apply.

1.2 SUMMARY

A. Section includes:

1. 11 kV switchgear for Incomers and Transformer feeders.
2. Provisions for revenue metering.

1.3 STANDARDS

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010. Where there are any discrepancies between these specifications and QCS 2010 the more stringent shall apply.

C. Kahramaa approved materials list.

D. All Kahramaa rules, regulations and requirements.

E. 11 kV Switchgear shall be provided in accordance with Kahramaa latest specifications and the International Standards referred to therein.

F. References include:

1. Kahramaa Specification EP-MS-P4/S2-082 Specification for 11kV Indoor Switchgear Panels –Vacuum Circuit Breaker Type.
2. IEC 60 694: Clauses common to High Voltage Switchgear
3. IEC 60 298: Metal Enclosed Switchgear.
4. IEC 60 056: High Voltage Alternating Current Circuit Breakers.
5. IEC 60 129: Alternating Current Disconnectors and Earthing Switches
6. IEC 60 265-1: Switch Disconnectors.
7. IEC 60 376: SF6 Gas.
8. IEC 60 470: Contactors.
9. IEC 60 044-1: Current Transformers.
10. IEC 60 044-2: Voltage Transformers.
11. IEC 62271-200: AC Metal Enclosed switchgear & Control gear for voltages up to 52kV.
12. IEC 62271-1: HV Switchgear & Control gear – Common Specifications.
13. IEC 62271-100: High Voltage AC Circuit-breakers.
14. IEC 62271-102: High Voltage AC Dis-connectors & Earthing Switches.
15. IEC 62271-103: High Voltage AC Switches for Voltages above 1kV and below 52kV.
16. IEC 60721-1: Classification of Environmental conditions – Environmental Parameters.
17. IEC 60721-3: Classification of Groups of environmental parameters and their severities
18. IEC 60529: Degrees of Protection provided by Enclosures.
19. EC 61243-5: Live Working – Voltage Detection Systems (CVD).
20. IEC 60050(441): International Electro-technical Vocabulary – Switchgear & Control-gear.
21. IEC 60068-2: Environmental testing – Tests.
22. IEC 60947-2: LV Circuit Breakers (including MCBs).
23. ISO 3864: Labels.
24. IEC 60270: Partial Discharge measurements.
25. BS 5685: Electricity Meters.
26. IEC 62053: Electricity Metering Equipment.
27. IEC 62052: Electricity Metering Equipment – Tests and Test conditions.
28. IEC 61243-5: Live Working – Voltage Detectors – Voltage Detecting system.

1.4 SUBMITTALS

A. 11 kV switchgear shall be included and submitted as one coordinated package.

B. Product Data:

1. Catalogue description of general construction, bus ratings (volts, phase, bus bracing and capacity) branch and main protective devices and their ratings (volts, RMS symmetrical amperes interrupting capacity) and special features and apparatus (e.g. metering equipment and protective relays.)
2. Protective coordination study showing coordination of the following:
3. 11 kV service incoming feeders and transformer feeders with the utility relays.
4. Short circuit study showing the following:
   a. Available short circuit (3-phase and phase –gnd) for all 11 kV switchgear.
   b. Comparison table of equipment ratings vs. available short circuit current.
5. Load calculations in KW/V/Amps for the battery charger loading shall be submitted. Ave loading as well as complete failure loading shall be submitted.

C. Tender information and drawings shall be submitted to Kahramaa through the supervising consultant. Submissions shall be in accordance with the requirements of the latest Kahramaa specifications.

D. Wiring diagram:
   1. Internal wiring of sensing and control devices.

E. Shop Drawings:
   1. Fabrication drawings with dimensions, component locations, and bus and feeder routing.

F. Test Report:
   1. The Employer shall witness test reports at the factory where the switchgear is tested. The manufacturer shall budget for witnessing of all the factory tests.
   2. Factory test certificates to be issued from place of manufacturer. Factory test certificates shall include all Routine tests based on IEC 694 standards.
   3. Acceptance test report.
   4. Report from contractor indicating measured peak inrush currents of transformers.

G. Certificate of Compliance:
   1. Copies of the Utility's written acceptance of the 11 kV service and the protective relay co-ordination study.
   2. Copies of written acceptance of the medium voltage switchgear location in the plant room.

H. Spare Parts:
   1. Provide a list of spare parts required for 2 years, together with its part number and price. Prices shall be valid for a minimum period of three (3) months and shall be included in the Tender price.
   2. Provide a list of commissioning spares. Spare prices shall be included in the Tender price.

I. Operation & Maintenance Manuals:
   1. Product Data as previously described above.
   2. Shop Drawings as previously described above.
   3. Wiring Diagrams as previously described above.
   4. Operating Instructions, Parts List and Service Organization.

J. Employer's Stock:
   1. Letter report identifying materials, quantities, date of delivery and Employer receiving.

K. Documents to be submitted shortly after receipt of the order:

1. CT/VT calculation.
2. Preliminary schematic diagrams of all the different types of circuits.
3. Preliminary wiring, termination and interconnection diagrams for HV, LV, internal (bus-wire), and external (or field) circuits.
4. Preliminary cable entry, glanding and securing detail.
5. Minimum clearances around the HV switchgear for ventilation and safety during operation and maintenance.
6. Total mass of the HV switchgear and of the individual shipping sections.
7. Inspection and test plan.
8. Auxiliary AC/DC load data.
9. Heating load / dissipation data.

L. Documents to be submitted after receipt of the order and before the FAT:

1. Instruction manuals for transportation, long term storage at site, installation, commissioning and maintenance. These documents must be specific to the equipment as purchased and not of a general nature.
2. SPIR forms.
3. Comprehensive list of commissioning spare parts.
4. Comprehensive list of spare parts for first year of operation.
5. Comprehensive list of spare parts, which will cover a period of two years operation.
6. Schematic diagrams of all different types of circuits
7. Single line diagram.
8. Switchboard arrangement layout and overall dimensions.

M. Documents to be submitted after the FAT:

1. Report of the Witnessed Routine Tests.
2. Final revisions of all of the above 'preliminary' documents (consolidated Vendor document/drawing file).
3. All documents shall show the relevant purchase order number, item and the manufacturer's references, dates and shall be distributed as specified in the requisition.

N. All documents shall show the relevant purchase order number, item and the manufacturer's references, dates and shall be distributed as specified in the requisition.

O. Information and documents to be submitted with tender:

1. Compliance statement against each sub-sub clause of this specification document.
2. Statement of technical deviations as mentioned in the tender document.
3. Details of recommended maintenance periods based upon time in service or number of trip operations in normal service and the number of trip operations under system fault conditions at full short-circuit rating.
4. 3 sets of detailed general arrangement, construction drawings with overall dimensions, showing its plan, elevation, side elevation, foundation details of each type of switchgear panel. The drawings shall be clearly legible and in A3 size
5. 3 sets of cross section drawings separately for each type of Switchgear panel, showing all dimensions, with description of all compartments, all components, cable connections, component identification legend, list of components, etc. All these drawings shall be in A3 size.
6. 3-sets of Single line Schematic diagrams of power and associated protection & controls circuits separately for each type of switchgear panel. Drawings shall be in A3 size.

7. 3-sets of Detailed protection AC/DC and control schematic diagrams, separately for each type of switchgear panel. Drawings shall be in A3 size.
8. 3-sets of manufacturing specification & Technical data-sheets including rated values and characteristics of the specific products being offered [Note: General details, which may broadly cover entire range of products being manufactured, are not acceptable].
9. 3-sets of installation, operation, maintenance, trouble shooting, safety, storage instruction Manuals of 11kV switchgear & Earthing equipment.
10. 3-sets of original product catalogues, literature.
11. 2-Sets of Copies of valid type test & special test reports as specified in this document, and issued from reputed independent laboratories.
12. 3-sets of duly filled-in 'Data-schedules' and 'Relay & Protection Data-Schedules for each type of panel' placed at the end of this document. [Note: Comments like 'noted', 'refer our catalogue', refer our.....' are not acceptable. Each data-field shall need to filled-up with offered data-values.
13. 3-copies of valid ISO 9001 certificate.
14. 3-copies of sales history specific to the product being offered. The details shall cover, Year, Voltage & short-circuit rating, quantity, application where used, client name & address.
15. 3-sets of copies of testimonials regarding its performance issued from other utilities, major industries
16. A detailed list of recommended spares required for maintenance of these panels.
17. 3-sets of details of all components & accessories fitted inside the switchgear panels.

P. Information to be provided with the order

1. Final review of the drawings and approval by KM is subjected to tender award. On awarding contracts the supplier should provide minimum six sets of KM reviewed and approved documents as mentioned below.
2. As built drawings of each type of switchgear panels covering, general arrangement drawings, cross section drawings, schematic single line drawings of power circuits with protection schemes, schematic drawings of control and protection covering all AC & DC circuits, electrical interlocks, and wiring diagrams.
3. Instructions and check-lists for the final installation inspection and pre-commissioning tests
4. Fully bound instruction Manuals in the English language for each switchgear type to be supplied. The Manuals shall include all of the installation, operation and maintenance procedures, trouble shooting guide lines, safety issues, storage instructions applicable to each switchgear panel type. The Manuals shall be specific to the items delivered. Manufacturers standard commercial literature may be included but shall not constitute the basis of the manual.
5. Technical data-sheets, operating instructions, product catalogues of all components including current transformers, Voltage transformers, capacitive voltage detectors, protection relays, Energy meters, vacuum interrupters, earth-switches, Live phase indicators, portable phase comparator instruments, spring charge motor, support insulators, LV cam switches, push-button switches, indicators, space heaters, Hygrostat, etc.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in their original packaging with legible manufacturer's identification.

B. Store materials in accordance with manufacturer's recommendations.

C. While located in unheated space, prior to energization, maintain temporary anti-condensation heat within medium voltage sections.

1.6 WARRANTY

A. All components shall be covered by a manufacturer's standard warranty subject to normal terms and conditions that apply to ensure that the systems have been installed correctly and their warranties shall be assignable.

1. Duration: 5 years.

B. The Contractor shall submit the manufacturer's standard form in which manufacturer agrees to repair or replace pumps/parts that fail in materials or workmanship within specified warranty period.

1.7 QUALITY CONTROL

A. The manufacturer shall provide proof of a stringent Quality Control (QC) Plan or Inspection Test Plan (ITP). In particular the main equipment manufacturing stages sanctioned by appropriate tests such as: incoming components inspection, discrete sub-assembly tests and complete functional checks on the final product. Final inspection and calibration operations shall be documented in a report drawn up by the supplier's Quality Inspection department.

B. The Assembly shall not leave the manufacturer's works until the works test sheets have been duly approved and stamped by the Engineer and written permission is obtained for their dispatch to site.

1.8 SEQUENCING AND SCHEDULING

A. Cutover steps appear schematically on the Drawings.

B. Complete installation of new work, to the greatest extent practicable without outages before starting the cutover.

C. Conduct specified tests before energizing any new equipment.

D. Do not attempt any alternate sequence without specific permission of the Architect.

1.9 MAINTENANCE

A. Provide the following items and turn over to the Employer before switchgear energisation.

1. Commissioning spares.
2. Fuse handling tools: One complete set of tools required to insert or remove fuse assemblies from their holders or clips and to replace refills.
3. Circuit breaker handling tools: One complete set of tools required to remove and re-install draw-out type circuit breakers.
4. Provide a list of spare parts for two years, together with order code numbers. Included in the spare parts list shall be individual prices valid for three (3) months. The spare parts list shall be approved and finalized by Kahramaa. This cost shall be included in the total tender cost.

PRODUCTS

1.10 SYSTEM CONDITIONS

A. The 11kV system has three phase and earth. 11kV side neutral is earthed through earthing transformer at primary sub-stations.

B. Nominal Voltage: 11kV.

C. Maximum Voltage: 12kV.

D. Maximum Symmetrical fault level: 31.5/40kA based on location in network.

E. Limited earth fault current through earthing transformer: 4.5 kA.

F. Frequency: 50 Hz.

G. Impulse: 75 kV.

1.11 GENERAL

A. Ingress Protection rating for indoor switchgear: IP 42.

B. The complete switchgear and control gear shall comprise an air insulated metal enclosed switchgear suitable for indoor use or a GIS switchgear and shall be constructed in accordance with IEC 62271-200 and shall be fully type-tested in accordance with IEC 62271-100, IEC 60694 and IEC 62271-110 in the independent testing laboratories not associated with the manufacturers or witnessed by an independent observer.

C. The switchgear panel shall be suitable for satisfactory continuous operation at the specified minimum rating, at the maximum site ambient temperature of +50 C.

D. The 11kV switchboard shall have a dedicated compartment in each bus-section for making these interfaces possible in the easiest manner possible. The relevant signals may be hard-wired individually or be combined in a computer based network arrangement. The manufacturer shall include in these interface panels all the necessary relays, transducers, networking modules, terminal blocks, networking plugs and sockets, memory hardware, adapters, digital converters and the like.

E. The 11kV switchboard shall be equipped with communicable and (according to IEC 61850) intelligent type relays suitable for transmitting alarm, trip, control and measurement signal to SCS/PMS or SCADA interface panel.

F. The contractor shall supply, install, test and commission 11 kV Switchgear as specified.

G. The 11 kV Switchgear complete with metering and instrumentation, special tools, accessories, test equipment, etc, shall be in compliance with Kahramaa latest standards.

H. The contractor shall be responsible for obtaining the latest version of Kahramaa specification for 11 kV Switchgear and shall be responsible for obtaining Kahramaa approval.

I. The product selected and proposed shall include manufacturer's instructions that indicate application conditions and limitations of use stipulated by the product testing agency specified under Regulatory Requirements.

J. The contractor shall provide full technical details of the proposed 11 kV Switchgear together with a copy of all relevant standards for review and comment by the Engineer, prior to submission to Kahramaa for approval.

1.12 11 KV INCOMING SWITCHGEAR

A. Medium voltage equipment shall provide isolation, protection and metering of 11 kV, 3 phase, 50 Hz, service main feeders, distribution feeders, and transformer feeders.

B. Enclosures

1. Minimum 2mm steel, free standing structures with hold-down clamps.
2. Access to operating parts shall be through hinged doors with screw or vault latch closures, hold-open mechanisms and with provisions for padlocking.
3. Switchgear enclosures shall be of the Metalclad Switchgear Type. There shall be a minimum of 4 main individual compartments in the switchgear, namely,
4. Separate compartment for the bus bar section,
5. Separate compartment for the circuit breaker section,
6. Separate compartment for the combination of Line CT's, Line VT's and power cable section,
7. Separate compartment for the low voltage section.
8. If applicable, a separate compartment shall be provided for the Bus bar VT section.
9. IP 41 protection as a minimum shall be provided.
10. Each panel shall be equipped with top pressure relieve vents to release the gasses resulting in a possible internal arc.
11. Enclosures shall be equipped with hygrostats.

12. Voltage indicator lamps shall be provided for 'Live cable' checking.
13. Cable entry (top/bottom) shall be check with reference drawings issued.
14. Enclosures shall clearly indicate switching positions, VT position and earthing position. The positions shall be pad lockable.
15. Enclosure shall include a Local / Remote selector switch which shall be pad lockable.
16. Mechanical interlock facility shall be mounted on the front of the enclosure.
17. Enclosure doors shall be pad lockable.
18. In the event of the protection relay not displaying Trip/Open/Close signals, provision for indication lights shall be included.

C. Bus Bar Section

1. Busing shall be silver or tin plated copper, ampere rated as indicated and braced for not less than 500MVA momentary.
2. Bus bars shall be of a copper grade no less than 99.9%.
3. Short circuit current shall be as per Kahramaa requirements.
4. Bus connections shall ensure minimum resistivity and temperature rise.
5. Busing in outside equipment shall be encapsulated.
6. Main busing shall be protected with metal oxide type, STATION class, surge arrestors, connected at line lugs.
7. Surge Arrestor voltage ratings shall be 1.3 - 1.5 X the system phase-to-ground volts.
8. A continuous ground bus, with ampacity equal to that of the phase busing, shall extend into each compartment of the assembly.
9. An additional earth switch shall be provided for each bus section. The earth switch shall be mounted above the bus riser and bus coupler enclosures. Alternatively an earth truck shall be provide for each bus bar section.

D. Circuit Breaker Section

1. Separate, metal clad, vertical style, draw-out, vacuum type, 630 / 1250 / 1600 / 2000 / 2500 Amp, 500MVA, mounted individually, with following features:
2. Rated Voltage shall be 12 kV (for 11KV circuit breakers) and 7,2KV (for 3.3 kV circuit breakers).
3. Power frequency withstand voltage shall be 38 kV (for 11 kV circuit breakers) and 28 kV (for 3.3 kV circuit breakers).
4. Lightning impulse withstand voltage shall be 95 kV (for 11 kV circuit breakers) and 75 kV (for 3.3 kV circuit breakers).
5. Short circuit current shall be as per Kahramaa requirements.
6. Short circuit breaking capacity shall be as per Kahramaa requirements.
7. Short circuit making capacity shall be 63 kA (peak). This shall be equivalent to x 2.5 times breaking capacity.
8. Electric motor/spring charged operators with anti-pump control and provisions to manually charge the springs and to close and trip the breaker.
9. Mechanism operated (MOC) and truck operated (TOC) auxiliary contacts for internal interlocks and remote alarms.
10. Circuit breakers shall have a manual facility to close and open the circuit breaker. The open button shall be "green" and the close button shall be "red".
11. IP2X protection as a minimum shall be provided.
12. Opening operations shall not normally produce an over-voltage in excess of 60kV peak due to current chopping or re-strike conditions within the modules. The break-time (initiation of trip to arc extinction) shall not exceed 50 milliseconds. Closing operations shall not produce an over-voltage in excess of 60kV peak due to pre-strike conditions within the modules.

13. The interrupting modules shall have a minimum shelf life of 20 years and shall incorporate adequate guidance and support for the moving contacts to enable them to be transported and handled without the possibility of sustaining damage to the bellows.
14. Off-load circuit and busbar isolation having integral earthing facilities and 3 positions – "SERVICE", "ISOLATED" and "DISCONNECTED". Through the operation of a selector device it shall be possible to lock the circuit breaker in any one of the three positions.
15. The means of isolation and earthing shall be interlocked with the vacuum / SF 6 interrupter closing mechanism so that the operation of isolating and earthing is only possible with the interrupter open. The position of the selector/isolator shall be easily visible from the front of the panel.
16. Provision for circuit testing shall be through insulated orifices, which may be the main circuit and busbar isolation orifices, accessible from the front of the panel. The cover shall have provisions for padlocking. Arrangements shall be made for positively securing all test plugs in position while in use. Test plugs shall be marked with their voltage and current ratings and equipment type reference.
17. Incomer circuit breakers and Bus Coupler Circuit breakers shall be equipped with both electrical interlock (48VDC) and mechanical interlock options.
18. 11 kV Incomer and feeder circuit breakers, as well as 3.3KV Incomer and feeder circuit breakers shall have auxiliary terminals made available in order to prevent upstream circuit breaker from closing while downstream circuit breakers are in the earth position. Indication positions to be sent back to the upstream circuit breakers are namely, OPEN-CLOSED-EARTH status.
19. In the event of loss of the Vacuum medium in the vacuum interrupter bottles, an alarm via a set of auxiliary contacts shall be triggered. This alarm shall be used for remote indication.
20. Operation counter shall be inserted in all 11 and 3.3 kV panels.
21. All future panels shall be fully equipped with circuit breaker as well as all related protection, control and metering devices.

E. Monitoring and Control:

1. The following remote monitoring and control functions shall be provided as a minimum:
   a. Circuit breaker Open / Close position (monitoring and control)
   b. Circuit breaker Trip / Healthy status (monitoring only)
   c. Position of circuit breaker – Service (monitoring only)
   d. Position of circuit breaker – Isolated (monitoring only)
   e. Position of circuit breaker – Disconnect (monitoring only)
   f. Position of circuit breaker – Earthed (monitoring only)
   g. Upstream circuit breaker interlock status (monitoring only)
   h. Electrical Interlock Healthy status (monitoring only)
   i. Local / Remote switch position status (monitoring only)
   j. Voltage supply MCB Trip / Healthy status (monitoring only)
2. All the abovementioned points shall be made available through auxiliary contacts and interface relays. All contacts/relays shall be pre-wired and terminated to a set of terminals in the low voltage control panel section. Terminals shall be clearly labelled.
3. Included in the monitoring, all available protection relay and multifunction meter parameters shall be remotely signalled via Profinet / Modbus TCP/IP Communication Protocol.

F. Control Power Supply

1. Protection relay : 48Vdc.
2. Metering relay : 48Vdc.
3. Indication lights : 48Vdc.
4. Voltage transformers : 110VAC.
5. Charging circuit breaker spring : 240VAC.
6. Space heaters : 240VAC.
7. Electrical Interlock : 48Vdc.
8. Voltage Indicator lamps : TBA
9. Provide individual circuit breakers for each control circuit. Individual circuit breakers shall be rated at 15KA (IEC).

G. Current Transformers

1. Current transformers shall be mounted on the cable side of the circuit breaker.
2. Current transformer secondary ratio shall be 1 (one).
3. Current transformers shall consist of a 2-core CT, namely:
4. 5P20 - Protection Core.
5. Class 0,5 - Metering Core.
6. Current transformers shall include capacitive voltage taps for 'Cable Live' indication.
7. Current transformer burden values shall be preferably 10 VA. If more than 10 VA is required, then the burden values are to safely exceed relay impedance values.
8. Unless otherwise indicated, primary cast resin current transformers shall withstand the short time current values equal to the rating of the switchgear for a minimum of 3 seconds.
9. All connections shall be labelled. Secondary windings shall be connected to terminal boards for testing purposes in the low voltage control panels where each set of transformers shall be earthed. Shorting terminals shall be provided with input and output terminals which are to be clearly labelled.
10. Core balance current transformers shall be provided for earth fault protection.
11. Additional current transformer nameplates shall be permanently mounted within the low voltage auxiliary panel for easy reference. Ideally, these nameplates should be mounted on the side of the low voltage panel.

H. Voltage Transformers

1. The voltage transformers shall have class 0.5 accuracy, rated burden in accordance with the requirements of the associated metering and protection, and ratio to suit the system voltage as indicated.
2. Voltage transformers shall be installed on the cable side of Incomer circuit breakers to provide a voltage reference.
3. Voltage transformers, shall be fixed type or withdrawable type. The circuit protection shall include either low voltage adjustable circuit breakers or 2 Amp fuses,
4. Voltage transformers shall be of a three (3) phase type. The star point of the voltage transformer shall be earthed at one point only in the low voltage control panel. The adjustable circuit breakers shall be labelled to indicate their phase colour.
5. Additional voltage transformer nameplates shall be permanently mounted within the low voltage auxiliary panel for easy reference. Ideally, these nameplates should be mounted on the side of the low voltage panel.
6. Voltage transformers shall only be included into the Incomer and generator switchgear panels.
7. Adequate terminals for outgo feeder voltage referencing shall be provided in the Incomer panel where the voltage transformer is located.

I. Cable Boxes

1. Main boxes shall be suitable for the termination of the following cables having conductors with cross sectional area not exceeding 300mm2:
2. Cross - linked polyethylene (XLPE), Steel wire armoured (SWA) with PVC outer sheath, in accordance with IEC 502.
3. Unless otherwise indicated, cable boxes shall be arranged for vertical entry from below.
4. Cable terminations shall be suitable for use with approved pre-stretched or heat shrink-able cable terminations. The terminations shall be mechanically protected by a sheet steel box and shall be provided with adequate cable support and clamping arrangements.
5. Drawings shall be referred to in order to verify whether cable entry is top or bottom.

J. Interlocks

1. Incoming and bus tie circuit breakers shall be electrically interlocked. Electrical interlocks shall be sourced from two individual 48Vdc feeders of the same battery charger. A change-over contact shall be located in the bus –coupler panel in the event of one of the supplies failing or tripping.
2. Prevention of circuit breaker closing shall be made available if downstream circuit breakers are in the earth position.
3. Mechanical interlocks shall be provided for both the Incomers as well as the Bus Coupler.

K. FM 200 Fire Suppression

1. Contractor shall provide FM 200 fire suppression to each cubicle of all medium voltage switchgear.
2. Each cubicle shall be provided with individual FM 200 cylinders mounted at the top of the panel, with pipework distributed throughout each compartment.
3. This shall be designed and supplied in its entirety by the panel manufacturer, and installed at the factory.

1.13 PROTECTIVE RELAYS

A. All relay software shall be provided in order to adjust settings. Cable connections and cables between relays and laptop shall be provided.

B. Below is a list of the minimum requirements for each protection relay:

ANSI Code	Description	Income r	Transformer Feeder	Bus Coupler	Generator
50/51	Over Current	X	X	X	X
50N/51N	Earth Fault	X	X	X	X
32P	Reverse Power	X			
27	Undervoltage	X			
59	Over voltage	X			
81O	Over Frequency	X			

ANSI Code	Description	Incomer	Transformer Feeder	Bus Coupler	Generator
81U	Under Frequency	X			
25	Synch Check (when required)	X			
46	Negative sequence / Unbalance	X	X		
87	Differential (5MVA Trfr and Larger)		X		

C. Over current and earth fault settings shall have selectable SI, VI, EI and RI curves in order to select adequate discrimination settings.

D. Over current and earth fault settings shall have IDMT and x 2 high set selections available.

E. In the event of tripping, actual parameter values shall be stored and logged in the relay history.

F. Protection settings shall have an approved protocol communication available for tripping and alarm signalling. Type of protocol to be used shall be included in the submittal for approval.

G. Alarming functions to be field changeable to tripping function if desired.

H. The Protection Relay shall have a provision to interface with the PLC System over Profibus-DP / Modbus.

1.14 REVENUE METERING

A. The Consultant / switchgear manufacturer shall be responsible for the Utility metering connection drawing approvals. Co-ordination with the Utility shall be required to ensure correct Utility metering specifications and connections have been adhered to. If approved by the Utility, the Utility measuring current transformer may be combined with the Kahramaa Incomer two (2) core CT to make up a three (3) core CT.

B. All incoming and outgoing feeders shall have ION make Energy Meters with the provision to interface with the PLC System over Profinet / Modbus TCP/IP.

1. Manufacturer: ION.

1.15 MULTI FUNCTION METERS

A. Multi Function Meters shall consist of the following as a minimum:

No	Description	Accuracy Required
1	Voltage (L-N) Per Phase	0.3 %
2	Voltage (L-L) Per Phase	0.5 %

No	Description	Accuracy Required
3	Voltage (L-N) Average	0.3 %
4	Voltage (L-L) Average	0.5 %
5	Current Per Phase	0.3 %
6	Current Average	0,3 %
7	Power (KW) Per phase	0,5 %
8	Power Factor Per Phase	1,0 %
9	Reactive Energy (KVArH) Import / Export	0,5 %
10	Apparent Energy (KVAH)	0,5 %
11	Reactive Power (KVAr) Per Phase and Total	0,5 %
12	Apparent Power (KVA) Per Phase and Total	0,5 %
13	Reactive Power (KVAr) Peak Demand	0,5 %
14	Apparent Power (KVA) Peak Demand	0,5 %
15	THD Voltage and Current Per Phase	1,0 %
16	Energy (KWH) Import / Export Per Phase	0,5 %

B. Multi function meters shall be included in all incomers, unless otherwise stated.

C. Profinet / Modbus TCP/IP communication shall be made available together with RS232 or RS485 connections. Type of protocol to be used shall be included in the submittal for approval.

D. Meters shall consist of a bright front display for easy viewing. Meters shall be flush mounted on the low voltage auxiliary panel door.

E. A minimum of 50 – 60 samples per cycle shall be required.

1.16 INSTRUMENT AND CONTROL WIRING

A. Instrument and control wiring is to be type SIS, THHN or XHHW, stranded, dressed and secured or enclosed to maintain proper separation from medium voltage parts and shortest practicable routes. Wire sizes to remote relay connections are shown on the drawings. Minimum sizes:

1. Controls & PT Secondaries 2.5mm²
2. C.T. secondaries 2.5mm² (within line-up)

B. Instrument and control wiring connections shall be made with crimp-on, insulated, forked lugs to screw terminals or by direct wire connection to box or barrel lugs.

C. Field wiring is to be made up on labelled, barriered terminal strips providing back-to-back pairs of terminals with no more than 2 wires per terminal.

D. IEC standards to apply for cable colours regarding different voltage levels.

E. All wiring and terminals shall be clearly marked and shall match drawings issued.

F. Anti-condensate heater to be provided.

1.17 BUS-BAR EARTHING

A. Means for Bus-bar earthing shall be provided by either of the following two options:

1. By using a separate and integral, 3-pole, linked (ganged), fully rated, spring assisted manual independent Earth-switch located within fixed portion of switchgear panel with different and individual access and location (i.e feeder earth switch and bus-bar earthing switch shall not be in same compartment), having clear and permanent identification labels to differentiate from Feeder E/S. Its 'peak with stand current' (making capacity) and 'short-time (3 sec) with-stand current' ratings shall be equal to that of main Circuit-Breaker. Operation of the switch shall be by means of a separate operating handle, which shall be inserted into the front of the switchgear through a fully inter-locked and lockable access orifice. It shall not be possible to operate the switch by means of any device other than the operating handle. As a minimum, this device shall be fitted to all transformer control switchgear panels.
OR
2. By means of using suitable inter-locks, the feeder earthing switch(es), along with or without the main circuit-breaker, may be used for bus-bar earthing. (Note: Portable earthing trucks are not acceptable for bus-bar earthing]

B. Inter Panels interlocking: An Electrical inter-locking system, between 'bus-bar earthing panel (s)' and the remaining switchgear panels in same section of the substation, need to be provided. The wiring in the inter-locking system shall be such that, closing of 'bus-bar earthing switches' shall be possible only when the CB trucks, in other panels of same section, are placed only in 'TEST' position. Further, it shall be possible to make bus-bar earthing of each section of sub-station individually or simultaneously.

C. Alternatively, a mechanical inter-locking system, by castle key method, between 'bus-bar earthing panel (s)' and the remaining switchgear panels in same section of the sub-station, need to be provided. The inter-locking system shall be such that, closing of 'bus-bar earthing switches' shall be possible only when the CB trucks, in other panels of same section, are placed in 'TEST' position only. Further, it shall be possible to make busbar earthing of each section of sub-station individually or simultaneously. However, a separate wall mounted metallic key-box shall be provided for each sub-station to place these keys. Each parking slot for the castle keys shall be clearly identified with the corresponding panel of the switch-board.

1.18 VT COMPARTMENT & VOLTAGE TRANSFORMERS (VT)

A. VT Compartment

1. VT compartments with Voltage Transformers are to be provided only in the switchgear panels based on the type of panels where these are required (ex: Directional feeder panels & Metering panels). The following options of VT compartments and its locations are considered.
2. Withdraw-able VT-compartment with withdraw-able VT: VT compartment to be located at rear top of switchgear panel as an standalone unit. Draw-out and draw-in positions of VT compartment shall correspond to OFF and ON conditions of the VT respectively. Draw-out and draw-in mechanism shall be accomplished through suitable rollers & guides which does not impede opening of arc venting flaps located on the top of the panels. The VT shall be easily accessible from standing at rear of

the panel, for its operation, without the need for ladder or portable steps. VT shall be fully insulated with cast-resin body. VT primary fuses shall be embedded inside integral cast-resin pockets (primary fuses shall not be mounted openly on the body of VT). Fuses shall be able to be easily replaceable whenever required and necessary safety features are to be included. Both primary and secondary circuits of VT shall be isolated during draw-out action. Secondary circuit isolation shall precede the isolation of primary circuit, during draw-out action, to ensure no load condition. Even when VT is in withdrawn condition all its live terminals shall be automatically covered by a metallic shutter for safety of operator . Provision shall be made for padlocking the VT in both ON and OFF positions. Additional VT rating plate to be fixed on the VT compartment. Suitable handle to be fixed for easy operation (ON/OFF) of VT.

3. Fixed VT compartment with draw-out type VT: VT compartment to be located at rear top of switchgear panel, which shall form as part of the main panel. It shall not impede flow of arc venting gases or flames. Draw-out and draw-in positions of VT shall correspond to OFF and ON conditions of the VT respectively. The VT shall be easily accessible from standing at rear of the panel, for its operation, without the need for ladder or portable steps. VT shall be fully insulated with cast-resin body. VT primary fuses shall be embedded inside integral cast-resin pockets (primary fuses shall not be mounted openly on the body of VT). Fuses shall be able to be easily replaceable whenever required and necessary safety features are to be included. Both primary and secondary circuits of VT shall be isolated during draw-out action. Secondary circuit isolation shall precede the isolation of primary circuit, during drawout action, to ensure no load condition. Status indicators are to be provided on the body of VT compartment, to show IN SERVICE or OUT OF SERVICE conditions of the VT. Provision for padlocking the moving part with the fixed part shall be provided on the front cover of the VT-compartment. Additional VT rating plate to be fixed on the VT compartment. Suitable handle to be fixed for easy operation(ON/OFF) of VT.
4. Any other alternative arrangement of VT shall be considered only after our preapproval of the same on successful demonstration of physical samples through prequalification process.

B. Voltage Transformers for Feeder Panels with DOC & DEF Protection

1. VTs used in Directional Feeder Panels shall generally conform to IEC 60044-2 with additional requirements as specified in relevant sections of this document. The type of VT shall be electro-magnetic, Inductive type, with cast-resin insulated copper windings. VT shall have required secondary winding with star point & territory windings. 3 x single phase transformers, or 3-Ph, 5-Limb transformers to be used to connect in 3-ph system.
2. The transformers shall have adequate insulation levels to withstand during normal and fault conditions. Neutral primary terminal (N) shall be solidly earthed. It shall not be easily possible to isolate neutral terminal from Earthing. Terminals shall be fully shrouded.
3. Primary winding of VT shall be connected to the circuit (Line/Feeder) side of the Switchgear panel. The primary connections shall be made through replaceable 11kV fuses, one per phase. Primary star point may be earthed if required to achieve required functionality. Secondary star point also shall be earthed. Tertiary (residual voltage) windings are connected in open delta. Primary windings of the VT shall be protected with HT fuses mounted on VT itself. Secondary windings shall be protected with MCB mounted close to VT. Delta formation of territory winding shall be done at the terminals inside LV compartment, but not at the VT. Protection and

instruments circuits in the VT secondary shall be independently protected with 2 separate sets of suitably graded HRC fuses or MCBs (miniature circuit-breakers) located in LV compartment. The secondary wiring shall be color coded as per the wiring instructions of this specification. The protection devices will constitute the point of secondary isolation and shall be clearly labeled as such.

C. Voltage Transformers for all Metering Panels

1. The details of the VT for all Metering Panels shall be same as those mentioned in above paragraphs, except for the following points.

   a. a) Use 3 x single phase transformers, or 3-Ph , 3-limb transformers
   b. b) Primary star point shall be floating or earthed type based on manufacturer design for measuring 3-ph unbalanced loads.
   c. c) Tertiary winding is not included in the secondary side of this VT
   d. d) The ratings shall be as mentioned in the tender drawings

1.19 CURRENT TRANSFORMERS

A. Current Transformers shall be provided on all panels in accordance with the tender drawings. Current Transformers shall generally comply with the requirements of IEC Standard 60044-1 along with additional requirements stated in this specification document.

B. Current Transformers shall be made of copper windings, embedded in cast-resin insulating material. Where-ever possible ring-type CTs should be used in preference to wound primary CTs due to their inherent advantage of high ability to withstand destruction during primary short circuits. Tape insulated ring-type CTs are not acceptable. All CTs shall be capable of withstanding, without damage and with no change to the operating characteristics, to the rated short circuit currents of 25/31.5 kA for 3 seconds. Thermal insulation class of all CTs shall not be less than class-B (maximum temperature rise up to 850K)

C. Where ring type CTs are installed over insulated bushings (like insulated contact arms of CB truck), the surface over the bushing where CT is fitted, shall be screened with semiconducting layer and properly earthed to ensure zero potential at the junction point.

D. Ratings of individual CTs are detailed in the tender drawings. All type test reports including partial discharge test shall need to be submitted along with offers for tenders.

1.20 ENERGY METERS

A. Energy meters are generally conforming to the latest IEC standards unless other-wise specified. The generic type of the energy meters shall be static/digital meters. Energy meters are to be fitted only in 'Type-5', 'Type-6', and 'Type-7' panels mentioned in this specification. All Energy meters supplied with these panels shall be provided with 5-years warranty. They shall be suitable for Indoor applications under the special service conditions stated under this specification.

B. Energy meters are to be flush mounted in LV compartment of respective switchgear panels mentioned above. Meter casings shall be fully insulated. They shall be suitable for measuring in 3-Phase, 4-wire system with un-balanced loads. They shall have mechanical roller type counter with numbers/digits for display of energy values. The number/digits size shall be 6mm high. The meters shall give direct reading, without the need for any multiplying factor. The meters shall have facility for accepting a tamper-proof wire seal on all removable covers. Each energy meter shall be provided with its calibration certificate.

EXECUTION

1.21 EXAMINATION

A. Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper or timely completion. Do not proceed until unsatisfactory conditions have been corrected.

1.22 INSTALLATION - GENERAL

A. Install Products in accordance with the manufacturer's instructions.

B. A contractor who is currently approved by Kahramaa must carry out installation. The written approval of Kahramaa for the contractor to carry out the work must be forwarded to the Engineer, and be acknowledged by him, before any installation work commences.

C. Anchor enclosures to supporting concrete pads, or as detailed on the drawings.

D. Provide detailed method statements, with a description of installation procedures including, all risk factors identified in the preparation, handling, installation and disposal of material.

E. Provide current test certificates for all portable electrical equipment utilised in the installation of Medium Voltage Switchgear.

F. Protect switchgear during construction with covering to keep it clean, dry and dust free. Provide heat necessary to eliminate condensation.

G. Equipment shall only be installed when the following civil work has been completed:

1. Walls and ceilings are completed and sealed.
2. Permanent doors are fixed.
3. Air con units are installed. Apply temporary cooling, to maintain temperature according to manufacturer's written instructions, until equipment is ready to be energized and placed into service.
4. Light fittings are installed, wired and terminated.
5. Plug socket chasing and plastering is completed.
6. Painting is completed.

H. Coordinate raceway entry into switchgear so that sections with spare devices, or provision for future devices, have adequate accessible space in raceway entry areas for future raceway.

I. Ground switchboard frames and metal raceway entering switchboards as described in Section 16060. Provide 2- 8mm bonding jumpers, to the building steel, from each indoor line-up,

J. Bond battery rack to switchboard ground bus.

K. Make connections in switchboards complete and secure before energizing and install or tighten fasteners with torques as recommended by the manufacturer.

L. In fusible switches, install fuses specified. Indicate fuse amperage, and type using adhesive labels supplied by the fuse manufacturer, affixed to the inside of each switch cover.

M. Mount and make connections to instrument transformers and meters as directed and/or furnished by Utility. Provide all cutouts and drilling required.

N. Coordinate connection of remote metering and alarms described in Plant Controls Section.

O. Label feeder conduit and power / control cables entering and leaving switchgear.

1.23 INSTALLATION

A. Verify numbering, routing and points of connection of feeders.

1.24 FIELD QUALITY CONTROL

A. Secure the services of the manufacturer's technical representative.

B. Check wire-to-wire phasing of high voltage terminals across any breaker or switch permitting parallel connection to another source, including connections made via low voltage ties and ties which are key-interlocked to prevent unintentional paralleling.

C. Where the equipment does not permit paralleling (including unintentional paralleling) check phase rotation.

D. Perform, or assist in the performance of, any testing required by the Electrical Utility.

E. Adjust pick-up and time delay settings, as directed, and calibrate the proprietary and remote metering.

F. Where differential current sensing is employed, test relay performance by primary current insertion at each individual current transformer.

G. Test the operation and calibration of new and re-worked protective relays prior to closing their respective breakers.

1.25 DEMONSTRATIONS

A. Demonstrate the operation of the medium voltage switching and have Employer's personnel conduct "Hands-On" open, close, trip and reset procedures.

B. Demonstrate the operation of protective relays.

C. Demonstrate the operation of key interlocks.

1.26 GENERAL TESTING, INSPECTION, & DELIVERY

A. Before commencing the production/manufacturing of bulk quantities, against KM tenders, the manufacturer is obliged to produce at least one sample of each type of switchgear panel and inform Kahramaa(KM) for inspection to verify its compliance about design & construction to with KM specification. Manufacturing of first lot shall be commenced after clearance of the samples (prototypes) by KM.

B. The manufacturer is obliged to inform Kahramaa, at least one month in advance before shipment of 1 st lot, against KM purchase orders, for obtaining clearance for dispatch. KM Engineers have the option of inspecting & witnessing all factory acceptance tests, including routine tests, at manufacturer's factory premises.

C. For all subsequent lots against KM tenders, the manufacturer is obliged to inform Kahramaa, at least 20 days in advance before shipment for obtaining clearance for dispatch. KM Engineers have the option of inspecting & witnessing all factory acceptance tests, including routine tests, at manufacturer's factory premises for each lot.

D. Acceptance by KM Engineer(s)/Representative(s) of any switchgear unit(s) shall not relieve the manufacturer from any of their responsibilities, guarantees, or from any other obligations to comply the switchgear with KM specification.

E. Type tests are to be carried out on specimen switchgear panels essentially of same design and ratings, as described in KM specification.

F. Each switchgear panels shall be subjected to all routine tests at factory before delivery. Further, each switchgear unit shall be subjected to inspection on receiving the same at DOHA to verify its healthiness and its conformity with the KM specification.

G. Due regard shall be paid to the special requirements for packing and storage under the adverse ambient environmental conditions to be encountered during transport and whilst awaiting installation

H. Bidder is obliged to submit, detailed test procedures and the reporting formats of each test, for approval prior to testing.

I. Three sets (copies) of FAT & routine test reports to be prepared. One set to be attached with the switchgear body in strong a water-proof envelope along with installation, operation & maintenance instructions. Second copy to be sent along with delivery note. Third copy to be sent to the end-user department.

J. Each delivery note shall include the details of 'serial number' and 'month/year' of manufacture of each switchgear unit.

K. Both the manufacturing date (i.e month/year) and shipping/delivery date should be shown on the rating plate of each switchgear panel, and the time difference between these two dates should not be more than 6-months.

L. The Switchgear shall be packed, prior to shipment, in suitable packaging material suitable to provide adequate protection during transport from the country of origin to the Purchasers Stores within the State of Qatar. Due regard shall be paid to the extremes of environmental hazard which are likely to be encountered during transport and measures shall be taken within the switchgear to prevent damage due to excessive humidity and condensation. The responsibility for the safe delivery of the equipment shall remain within the Supplier or his Agent until an acceptance document is issued by the Purchaser.

1.27 SPECIFIC TESTING

A. Type Tests: Type tests shall be carried out on test specimens as prescribed in IEC test methods. The design and construction of the test specimens shall essentially be as specified in this document. The type tests are to be conducted at internationally reputed independent laboratories (Like KEMA/CESI) in which the manufacturer has no association or stake. The manufacturer shall submit copies of valid type test reports (full text) at the time of tender.

B. The results of all type tests shall be recorded in type-test reports containing sufficient data to prove compliance with the ratings and the test clauses of the relevant standards including compliance of the additional requirements specified in this document shall be included so that the essential parts of the switchgear can be identified. In particular, all details mentioned under clause # 6.1.3 of IEC 62272-1 shall be mandatory. [Note: Any type-test report that does not contain all the information stated above shall be considered as invalid].

C. Below mentioned type tests are to be carried out on the test specimens. However the sequence of tests to be conducted shall be as prescribed under IEC 62271-200 & 62271-1. Even though the test conditions shall generally be in accordance with the specified IEC standards, the special service conditions specified in this document need to considered wherever applicable.

1. Dielectric tests (power frequency voltage tests & LI voltage tests) – IEC62271-200/6.2.
2. Partial discharge tests (IEC 62271-200/6.2.9).
3. Voltage test as condition check (IEC 62271-200/6.2.11).
4. Measurement of resistances of Main & auxiliary Circuits (IEC 62271-200/6.4).
5. Temperature rise tests (IEC 62271-200/6.5).
6. Dielectric tests on auxiliary and control circuits (IEC 62271-200/6.2.10)
7. Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and rated short-time withstand currents (IEC 62271-200/6.6).
8. Tests to prove the making and breaking capacity of the included switching devices (IEC 62271-200/6.101).
9. Tests to verify the satisfactory operation of the included devices and removal parts including interlocks (mechanical operations tests) – IEC 62271-200/6.102.
10. Tests to verify protection of persons against access to hazardous parts and the protection of the equipment against solid foreign objects (IEC 62271-200/6.7).

11. Tests to assess the effects of arcing due to an internal fault (for switchgear classification of IAC-AFLR) – IEC 62271-200/6.106 with all additional test criteria specified in this document.
12. All relevant type tests on circuit-breaker as prescribed in IEC 62271-100/Table-7.

D. Special Tests: Verification of design class for Indoor enclosed switchgear in severe climatic conditions as per IEC/TS 62271-304.

E. Routine Tests: All Routine tests, as specified below are to be carried out on each unit (panel) of switchgear manufactured at the manufacturer's works to ensure that the product is in accordance with the equipment on which the type tests has been carried out. One set of routine test reports to be attached with the body of each switchgear panel in a strong water-proof envelope. KAHRAMAA reserves the right to witness these tests as and when required at factory premises

1. Dielectric Tests on Main Circuit (IEC 62271-1/7.1).
2. Tests on auxiliary and control circuits, and verification of conformity to the circuit diagrams and wiring diagrams (IEC 62271-1/7.2).
3. Power frequency test on aux & control circuit (tests voltage 1kV for 1 sec).
4. Measurement of the resistance of the main circuit (IEC 62271-1/7.3).
5. Mechanical Operations Test (IEC 62271-200/7.102).
6. Design & Visual checks (IEC 62271-1/7.5).
7. Partial discharge measurement (IEC 62271-200/7.101).
8. Verification of Rated time quantities of Circuit-Breaker (IEC 62271-100/6.101.1.3).
9. Measurement of operational torque required for all operating handles.

COMMISSIONING

1.28 COMPLY WITH MANUFACTURERS RECOMMENDATIONS

A. Provide detailed method statements, with a description of testing procedures including, all risk factors identified in the preparation, handling, testing and inspection of Medium Voltage Switchgear

B. The Employer shall witness test reports at the factory where the switchgear is tested. The manufacturer shall budget for witnessing of all the factory tests. Factory test certificates to be issued from place of manufacturer

7.4.14 262200 - Low Voltage Transformers

GENERAL

1.2 RELATED DOCUMENTS

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010. Where there are any discrepancies between these specifications and QCS 2010 the more stringent shall apply.

C. Kahramaa approved materials list.

D. All Kahramaa rules, regulations and requirements.

E. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other discipline's Specification Sections, apply to this Section.

F. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, Kahramaa, 2010.

G. All rules, requirements and regulations of Kahramaa shall be followed ensuring that only materials and installation methods approved by Kahramaa shall be used throughout this project.

H. Qatar Construction Specification (QCS) 2010 is the minimum standard for all aspects of this project. Where there is a conflict between QCS and this specification, the more stringent requirement shall apply.

I. Qatar Civil Defence Department rules, regulations and requirements shall be followed as an absolute minimum. All equipment used in this project shall be approved for use by QCDD.

J. This Specification makes reference to the following Standards:

1. IEC 60296/ BS 148 Insulating Oil for Transformers and Switchgear.
2. IEC 60076 Power Transformers.
3. IEC 60214 Tap-Changers.
4. IEC 60076-7 Loading Guide for Oil Immersed Power Transformers.
5. IEC 60502 Power cables with extruded insulation.
6. IEC 60529 Degrees of Protection Provided by Enclosures.
7. IEC 60076-10 Method of Measurement of Transformer and Reactor Sound Levels.
8. IEC 60404-8-7: 2008 Specification for CRGO Electrical steel strips & sheets.
9. BS 381C 1996 Specification for Colours for Identification, Coding, and Special Purposes.
10. BS EN ISO 1461 Hot Dip Galvanized Coatings on Iron and Steel Articles.
11. BS 2562: 1993 Specifications for Cable Boxes for Transformers and Reactors.
12. BS EN ISO 2063 & Sprayed Metal Coatings.
13. BS 2569-2
14. ISO 4759/1 ISO Metric Precision Hexagonal Bolts, Screws and Nuts.
15. ISO 272/885/888/4759/1 ISO Metric Black Hexagonal Bolts, Screws and Nuts.
16. ISO 8501 Pt# 1 to 4. Preparation of Steel Substrates before application of paints and related products.-Visual assessment of surface cleanliness.
17. ISO 8502 Pt# 1 to 12 - Preparation of Steel Substrates before application of paints and related products.-Tests for assessment of surface cleanliness.
18. ISO 8503 Pt# 1 to 5 Preparation of Steel Substrates before application of paints and related products – Surface roughness characteristics of blast – cleaned steel substrates.
19. ISO 8504 Pt# 1 to 3 Preparation of Steel Substrates before application of paints and related products – Surface preparation methods.
20. ISO 12944-1 PT #1 to 8 Paints & Varnishes – Corrosion Protection.
21. ISO 14713 Protection against Iron & Steel Structures – Zinc and Aluminum Coating – Guidelines.
22. BS 6435 1993 Specifications for Unfilled Enclosures for the Dry Termination of HV Cables for Transformers and Reactors.[Note: Even though this standard become obsolete, it is retained till we identify equivalent standard].

1.2 SUMMARY

A. This Section includes the following types of oil-filled and dry-type transformers rated 11/0.415kV, with capacities of 500 / 1000 / 1600 kVA:

1.3 ACTION SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Compliance Statement: A specific compliance (clause by clause up to sub clause level), statement of conformity with the specification and details of non-conformity. The Engineer reserves the right to reject any submittals which do not fully comply with the specification.

1.4 TENDER INFORMATION FOR OIL-FILLED TRANSFORMERS

A. The following technical and other documents need to be submitted along with technical offers.

B. Technical Details and Documents:

1. Technical data-sheets, containing all technical details including, ratings, parameters, vector group, connections symbols, losses, max. flux density, cooling, tank details, winding details, oil details, temperature rise limits, % impedance values, insulation levels, efficiency, regulation, etc, of the transformer.
2. All technical details, parameters, data-sheets belong to each of the accessories fitted to the transformer, including tap-changer, thermometer, PRV, HV and LV bushings, Oil level indicator, gas pressure gauge with isolating valve, drain valve with sampling device, etc.
3. All Type tests & Special test certificates of the transformer.
4. Type test certificates of tap-changer.
5. Type test certificates of HV & LV bushings.
6. Specific Product catalogues of the transformer, tap-changer, magnetic core material, Oil-level indicator, PRV, Thermometer, HV & LV Bushings, various gaskets used, gas pressure gauge, etc.
7. Details of Painting system applied to the transformer.
8. Detailed Operation & maintenance manuals of transformer.
9. Valid proof of documents showing the sourcing of tap-changer, magnetic core laminations, HV & LV bushings from internationally reputed manufacturers.
10. Valid ISO 9001 certification of the Transformer manufacturer.
11. Compliance/deviation statement against each clause of this specification document.
12. Two sets of Complete drawings, as stated below.
13. Complete sales history of the proposed product, indicating details of the Transformer rating, Client name, Year of supply, quantity supplied etc. The list should highlight the supplies made to clients in GCC countries.

C. Drawings: The following drawings shall need to be submitted along with technical offers.

1. General layout arrangement of transformer: Shall indicate all components, all major dimensions, bill of materials, weight of core and winding assembly, weight of tank & fittings, total weight including oil, oil quantity, thickness of tank walls, overall dimensions of the transformer, base and cover dimensions, thickness of radiator walls, gap between radiators panels, center of gravity position.
2. Detailed dimensional drawing of HV Cable box.
3. Detailed dimensional drawing of LV Cable box.
4. Detailed dimensional drawing of HV bushings.
5. Detailed dimensional drawing of LV bushing assembly.
6. Rating plate details & Connection diagram.
7. Detailed dimensional drawing of thermometer.
8. Detailed dimensional drawing of Oil-level indicator.
9. Detailed dimensional drawing of PRV.
10. Detailed dimensional drawing of Tap-changer.

11. Detailed dimensional drawing of Oil-drain Valve with sampling device.
12. Detailed dimensional drawing of pressure gauge & isolating valve.
13. Each drawing size should be at least in A4 size, drawn as per standard ISO format containing all the standards views (plan, front elevation, side elevation, and sectional views, where-ever necessary). Simple sketches are not acceptable. Details in the drawings should be clearly legible and properly documented. The list of drawings to be submitted is as mentioned below.

D. Deviations from the Technical Specification

1. The bidders are required to attach a separate deviation list to their Technical Offer and include it in the Technical Package if the offered equipment do not meet the requirements of any clause of the Specification.
2. Offers without any deviation list attached to the Technical Offer and included in the Technical Package shall mean that the offer meets the requirements of the Specifications on all the clauses.
3. Offers with deviations listed out shall mean that the offer meets the requirements of the Specification on all the other clauses not included in the deviation list.

1.5 TENDER INFORMATION FOR DRY-TYPE TRANSFORMERS

A. Each manufacturer/bidder shall submit following information/documents along with their offer . At least two sets of documents with all details to be submitted.

1. 1) Technical data-sheets covering all the details as mentioned below.

   a. Rated power.
   b. Rated Voltage ratio, Frequency, and number of phases.
   c. Rated insulation levels.
   d. IP protection class of enclosure.
   e. IK protection class of enclosure.
   f. Type of ventilation.
   g. Vector group.
   h. Thermal insulation class of HV/LV winding.
   i. Maximum flux density.
   j. No-load current and full load current values.
   k. Tapping range and number of steps.
   l. No-load and Load losses at 75°C.
   m. Percentage impedance value at 75°C
   n. Winding material HV/LV.
   o. Guaranteed values of Winding temperature rise limits.
   p. Partial discharge levels.
   q. Noise levels.
   r. Climatic, Environmental & Fire behavior classes.
   s. Weights of transformer with and without enclosure and fittings.
   t. Overall sizes(WxHxD) of transformer with and without enclosure.
   u. Set values of 'alarm' and 'trip' in temperature monitoring unit.
   v. Resistance values of HV & LV windings.

2. The following drawings need to be submitted:

   a. Transformer general layout drawing with enclosure (all views plan, elevation, side elevation) showing details of all components fitted and all dimensions.
   b. Transformer general layout drawing without enclosure (all views plan, elevation, side elevation) showing details of all components fitted and all dimensions.
   c. Separate HV cable box drawing with all views and dimensions

d. Separate LV cable box drawing with all views and dimensions.
e. Separate HV bushing drawing with all views and dimensions.
f. Separate LV cable box drawing with all views and dimensions.
g. Connection diagram showing the sequence of HV & LV+ neutral terminals.
h. Rating plate details.
i. HV and LV terminal connection details.
j. HV and LV cable boxes mounting flange drawings with dimensions.

3. Other details and documents which need to be submitted:

a. Original product catalogue (photocopy not acceptable) with all technical details including all steps of manufacturing.
b. Original product catalogue of temperature monitoring unit (photo copy not acceptable).
c. Installation, Operation & Maintenance, and condition monitoring & trouble shooting manuals, of transformer.
d. Installation, Operation & Maintenance manuals of temperature monitoring unit.
e. Ventilation calculations with room sizing and air flow requirements.
f. FAT documents& check lists used for testing of transformers at factory.

4. Copies of test reports to be submitted:

a. Type test reports (full reports):

1) Lightning Impulse test.
2) Temperature Rise test conducted along with enclosure.
3) Partial discharge tests (routine & special tests).
4) Measurement of sound level (special test).
5) Short circuit test (special test).
6) Environmental test (special test).
7) Climatic test (special test).
8) Fire behavior test (special test).
9) Type testing report of HV bushing.

b. Routine test reports:

1) Measurement of winding resistance.
2) Measurement of voltage ratio and check of phase displacement.
3) Measurement of short-circuit Impedance and load loss.
4) Measurement of no load loss and current.
5) Separate source AC withstand voltage test.
6) Induced AC withstand voltage test.
7) Routine partial discharge test.

c. Test reports of Enclosure painting work:

1) Measurement of thickness of protective coating (ISO 2808).
2) Specular gloss factor at 60 deg (ISO 2813): 90±5%.
3) Falling weight test (ISO 6272): 1kg/50cm.
4) Cross cut test (ISO 2409): classification: 0.
5) Cupping test (ISO 1520): 08mm.
6) Bending test – Cylindrical mandrel test (ISO 1519): 3.0mm.
7) Salt spray (fog) test (ISO 7253): 1000hrs.

1.6 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Section 26 0548 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify centre of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Qualification Data: For testing agency.

C. Source quality-control test reports.

D. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

C. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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

E. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.9 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.10 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

1.11 WARRANTY

A. Manufacturers need to provide a warranty of minimum 5 years from the date of delivery, or 4 years from the date of installation (whichever is earlier) against each unit supplied.

B. Any Transformer unit failed while in service, with-in the warranty period, need to be replaced with new unit free of cost. Further, the manufacturer/supplier need to arrange for carrying-out fault/abnormality analysis of any units(s) by reputed independent agencies, when required by Kharamaa and respective abnormality and fault-analysis report(s) to be submitted.

PRODUCTS

1.12 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, Contractor shall provide products by manufacturers on the Kahramaa approved materials list.

1.13 OIL-FILLED TRANSFORMERS

A. General

1. This Specification details about requirements for design, manufacture, testing, transport, and delivery of transformers of the hermetically sealed, oil filled type, for use on the 11KV distribution network in the State of Qatar.
2. It applies to transformers in the range 500kVA to 1600kVA for continuous service at 50 Hz. It applies to three phase two winding oil immersed naturally cooled (ONAN type) transformers suitable for indoor or outdoor service connected by bushings into cable boxes, to transform energy from 11kV (nominal) to low voltage.
3. 11kV System: The 11kV system is a three phase three wire 50 Hz system with the star point earthed at in-feed substations such that the maximum earth fault current is limited to 4500 Amps. The system maximum fault current is 25kA (rms) symmetrical.
4. Low Voltage System: The output of the transformers, at centre tap, with 11kV applied is 433/250V. This is to provide consumers with a nominal supply voltage of 415/240V (three phase 4 wire 50Hz.), after permitted system voltage drops.
5. The star point is solidly earthed. Transformers are to be suitable for parallel operation.

B. Compliance with Standards

1. The transformers shall generally comply with the requirements of IEC 60076 except where otherwise covered by this Specification. Cable boxes referred to shall comply with BS 2562 1993 and the Oil shall comply with IEC 60296/BS148.

C. Standard Transformer Operating Conditions:

1. Average Continuous Ambient Temperature: 35°C.
2. Maximum Top Oil Temperature Rise, above ambient for Continuous Rated Load: 45°C.
3. Maximum Average Winding Rise, above ambient for Continuous Rated Load: 50°C.
4. Maximum Hot Spot Temperature for continuous Rated Load: 98°C.
5. Oil Temperature shall not exceed 105°C under any conditions.
6. Hot Spot Temperature shall not exceed 118°C under any conditions.

D. Principal Characteristics

1. General Design Requirements

a. The transformers shall be hermetically sealed, oil-immersed type, in which pressure excursions are absorbed by, a) inert gas (preferably by nitrogen gas) cushion placed above the oil surface in a sealed-tank system with detachable panel type radiators, or b) the elastic movement of permanently sealed corrugated tank fins. They shall be completely filled with oil. Note: The required option from the above alternatives (a) & (b) shall be confirmed by KM at the time of initiating purchase tender, through Bill of Quantity document.
b. The transformers shall be of three phase, two winding, oil-immersed, naturally cooled (ONAN type), and suitable for indoor and outdoor service, connected by bushings into cable boxes, to transform energy from 11KV (nominal) to low voltage. Note: Forced cooling system with cooling fans (ONFN) is not acceptable.
c. The transformers shall be designed for operation at ambient temperature up to 50 o C, without application of any de-rating factor.
d. The maximum permissible temperature rise, under full load conditions, of top oil shall not exceed 45°K, and that of winding shall be limited to 50°K.
e. The transformer shall be capable for continuous operation at full load at any tap position with-in their specified temperature rise limits and environmental and operating conditions specified above.
f. The transformer shall be capable of withstanding short circuit at least for 2 sec.

2. Rated Power

a. The standard rated powers shall comply with Table 1 below and be suitable for the application of IEC 60076-7 - Loading Guide for Oil Immersed Power Transformers.
b. The assigned rated power shall be identical for both windings. The rated power refers to continuous loading. This is a reference value for guarantees and tests concerning load losses and temperature rises.

3. kVA Rating / % Impedance

a. The standard no-load voltage ratio shall comply with the following.

1) 500 kVA: 4.75 % Impedance.
2) 800 kVA: 5.16 % Impedance.
3) 1000 kVA: 5.45 % Impedance.
4) 1250 kVA: 6.00 % Impedance.
5) 1600 kVA: 6.00 % Impedance.

b. The above no-load secondary voltages are chosen so as to facilitate provision of the following national low voltages, subject to permitted voltage drops.

1) Three Phase - 415/240V, 4 wire.
2) Single Phase - 240V, 2 wire.

c. The above rated primary voltage of 11,000V relates to highest voltage for equipment of 12kV.
d. The rated power shall be available even when the low voltage fuse-gear (BOFP) is mounted directly on transformers and also when high voltage switchgear is mounted directly on unit substation transformers.
e. The column headed '% Impedance' refers to impedance voltage corrected to 75oC expressed as a percentage of normal voltage.

4. Tapping Range: Tapings shall be provided on the higher voltage winding, for a variation of the noload Primary voltage (specified in Table 1) of ± 2.5% and ± 5%.

5. Tapping Methods and Tap Changer

   a. The tap changer design & its performance shall generally conform to IEC 60214-1.
   b. Tap changing shall be carried out with the transformer off circuit, by means of an externally operated self-positioning tapping switch, which shall be mounted on one end of the transformer tank. . The moving contacts shall be spring loaded, self-aligning roller type. The tap changer selector switch shall be easily accessible to the operator from convenient height from floor/ground.
   c. Switch position No. 1 shall correspond to the maximum plus tapping. Provision shall be made for locking of the tapping switch handle at any position, such means incorporating a hole for accommodating a padlock having a 5mm diameter shackle. The switch shall be retained in a safe position if a padlock with a 5mm diameter shackle is used.
   d. The tap-changer assembly shall be of a robust construction and shall be capable of carrying the same current as the windings when under conditions of short circuit. Current ratings of contacts used in tap changers shall not be less than 63 amps for 1000KVA, 1250KVA & 1600KVA transformers, and not less than 30 amps for 500KVA, 800KVA transformers.
   e. Numerical digits need to be used as indication of the tap positions, shall be embossed or engraved permanently on the knob.
   f. Tap changer shall be of high quality product; type tested according to the requirements of IEC 60214-1, and shall be sourced from internationally reputed manufacturers only.

6. Windings

   a. Windings shall be oil immersed and made of high conductivity electrolytic copper. Insulating material of high quality shall be used. 11kV and low voltage windings shall be separate.
   b. The windings shall be connected Delta Star in accordance with Vector Group reference Dyn11 of IEC 60076.
   c. Electrical insulation shall conform to the requirements mentioned under TABLE-2. Thermal insulation requirements shall be not less than those specified under Class-A (105oC), IEC 60085.

7. Losses

   a. The losses shall be measured in accordance with IEC 60076, at the reference temperature of 75°C. They shall not exceed the maximum values as defined below [Note: the tolerance limits specified in IEC 60076-1 shall not be applicable. The manufacturers need to take sufficient care while designing and manufacturing, so that the below specified maximum limits are not exceeded.
   b. Transformer Size: 500 kVA.
      1) No Load Losses: 610 watts.
      2) Load Dependent Losses: 7200 watts.
   c. Transformer Size: 1000 kVA.
      1) No Load Losses: 1000 watts.
      2) Load Dependent Losses: 10600 watts.
   d. Transformer Size: 1600 kVA.
      1) No Load Losses: 1360 watts.

2) Load Dependent Losses: 15300 watts.

8. Impedances

a. The guaranteed values of impedance, measured at the principal tap and corrected to a reference temperature of 75°C, shall be as shown above and shall be subject to the tolerances specified (± 10%) in IEC 60076.

9. Insulation Levels

a. Complete transformers, arranged for service, shall be capable of withstanding impulse voltages on the higher voltage windings, as shown below.
b. Nominal System Voltage: 0.433/0.25 kV.

1) Highest Voltage Withstand for Equipment Um (r.m.s): 1.1 kV.
2) Rated Lightning Impulse Withstand Voltage (peak): N/A.
3) 50 Hz Withstand Voltage (rms): 3 kV.

c. Nominal System Voltage: 11 kV.

1) Highest Voltage Withstand for Equipment Um (r.m.s): 12 kV.
2) Rated Lightning Impulse Withstand Voltage (peak): 75.
3) 50 Hz Withstand Voltage (rms): 28 kV.

10. Flux Density

a. The flux density at any point in the magnetic circuit, when the transformer is connected at normal tap (3) and operating at normal voltage and frequency, shall be not exceed 1.6 Tesla. .

E. Rating and Connection Plates - Marking of Terminals

1. Rating and Connection Diagram Plates

a. Transformers shall be fitted with a rating plate in accordance with Drawing No. EP-MS-P4/S 4-015 Fig.1 (STD-EQP-63), and the data thereon shall be completed for each transformer. A connection plate in accordance with EP-MSP4/S4-015 Fig.1(STD-EQP-63) shall also be fixed to show the winding connections and tapping in tabulated form.
b. Rating and Connection diagram plates shall be of durable, made from noncorrodible material and shall be securely fixed to suitable supports welded to the tank without forming as water traps.
c. Manufacturing date shall contain both month & year of manufacturing.
d. Both the manufacturing date (i.e month/year) and delivery date should be shown on the rating plate of each transformer, and the time difference between these two dates should not be more than 6-months.
e. Rating plate should also show details of the KM tender No/Purchase order No.

2. Marking of Terminals

a. Terminals shall be identified by characters of a type, which cannot be obliterated, marked on plates of durable and non-corrodible metal securely fixed to the tank.
b. Phase colours shall not be used. Phase Markings shall be in compliance with KAHRAMAA requirements.

F. Oil

1. Mineral oil shall meet the requirements of BS 148/IEC 60296.

G. General Construction and Fittings

1. Tank and Tank Covers for Radiator Type Design

   a. The tank shall be of welded steel, and designed and constructed so that there is no bulging/ deformation of the sidewalls when the transformer is transported full of oil or lifted using the specified lifting fittings. The formation of side walls to be made by means of bending single steel sheet on three edges, and restrict the welding to only one edge, to prevent number of welded joints.
   b. The welding work need to be carried-out through automated or robotic welding process to ensure consistency in quality of welding.
   c. The thickness of the sidewalls of the tank shall not be less than 5mm. The top and bottom of the tank shall not be less than 4.5 mm thick. Radiators wall thickness shall be 1.2mm (minimum)
   d. The bolts/studs used for fixing radiator flanges or any instruments on the tank sides, shall be fixed through 'stud welding' process. Welding of these studs from inside tank walls is not acceptable.
   e. Nitrogen gas volume and oil volume in the tank are so designed that, occurrence of negative gas pressure inside the tank, above 200C of oil temperature, shall be prevented. Note: Negative pressure inside tank may allow outside air into the tank and restrict free flow of oil when sampling device is opened]. At the same time the gas pressure inside tank, at maximum permissible oil temperature, shall not cause false tripping of PRV. A chart or graph showing the relation between the oil temperature and the gas pressure, embossed/engraved on a non-corrosive metallic plate and permanently fixed on each transformer.

2. Tank and Tank Covers for Corrugated Tank Type Design

   a. The walls of flexible corrugated fins shall be made of CRCA steel sheets of 1.5mm (maximum tolerance limits of ±0.1mm) thickness. All fins shall be free of any uneven and/or sharp edges.
   b. The corrugated tank walls shall be capable of providing sufficient cooling of transformer, and also entirely compensate for the changes in the oil volume during operation. Note: Rigid type corrugated walls are not acceptable]. There shall not be any changes in oil pressure inside the tank, during operation, as the same are expected to be entirely absorbed by the elastic action (contraction and expansion) of corrugated fin walls.
   c. The side walls of transformers accommodating the LV and HV cable boxes shall not be less than 5mm thick, and the top and bottom shall not be less than 4.5mm thick.
   d. The welding work need to be carried-out through **automated or robotic welding process** to ensure consistency in quality of welding.

3. Parameters Common for Both Types of Tank Designs

   a. The under-base of transformers shall be in the form of skids, fitted with removable type bi-directional wheels. The design & construction of wheels shall be such that, it should be possible to set their orientation, in installed condition, to either of the direction when required, for easy manoeuvring. Further, these wheels arrangement shall have built-in braking mechanism having braking pads on both sides of wheels to have firm grip, or alternatively use 'anti-vibration' pads made of polycarbonate, having capability of carrying load of transformer, below the wheels. These pads shall serve as wheel blocking device, as well as dampen the intensity of vibrations and avoid resonance. The skid shall be provided with 42 mm diameter holes on axle at each end, clear of the jacking position. Provision shall be made on the skid-

frame-work to park the removed wheel assemblies when not in use, in bolted condition.

b. All the bolts used in the transformers for mounting/fixing tank cover, Cable box mounting flanges, bushings, radiators, etc, shall have consistency in its size & length, and the fixing shall be such that, at least 2 or 3 threads of the bolt shall come out of nut outer face.

c. All the nuts & bolts used for fixing cable boxes, and HV and LV bushing Clamps, shall be accessible from outside the tank (through inside cable boxes) for easy opening or tightening. They should be accessible without opening the top tank cover.

d. For transformers of 1000KVA and less, the clearance between inner edges of corrugated wall panels or radiator fins, on LV cable box side, shall be at least 670mm, to facilitate retrofitting of 'bolt-on' Feeder pillar in place of LV cable box.

e. All welds are required to be tested for oil tightness. Oil pressure test to be conducted on each transformer, at least at a pressure of not less than 0.3bar for a period of 16 hours to verify effectiveness of all welded joints and gaskets against oil leaks. The test results are to be included in the routine test reports being submitted.

f. Overall maximum dimensions of transformers with radiators and corrugated fins shall be in accordance with Drawing EP-MS-P4/S4-015 Fig. 2(STD-EQP-67).

4. Magnetic Core Assembly

a. The magnetic core shall be made of high permeability, low loss, non-aging, grain oriented, cold- rolled silicon steel laminations. Each lamination shall be insulated with high quality coating without burrs.

b. High grade CRGO steel laminations, having 'specific watt loss' of not more than 0.95 w/kg at 1.7T and 50Hz, shall be used. It shall conform to IEC 60404-8-7:2008. Details of actual grade used, name of manufacturer, country of origin, product catalogue need to be submitted along with tender offer, or technical submittal for approval against external projects.

c. All limbs and yokes shall be designed for keeping noise levels, no load losses, and hot spot temperature in core as low as possible.

d. Core and its clamping plates shall form in to rigid unit structure, to withstand all stresses caused by S/C conditions, shipment, transportation, and installation.

e. Ensure to secure uniformly distributed mechanical pressure over all laminations, to limit noise & vibrations to minimum level.

f. Complete core assembly shall be provided with suitable lifting eyes to facilitate its removal from the tank.

5. Windings

a. The insulation materials, and connections shall be free from any insulation compounds or materials prone to softening, shrinking, or collapse during service.

b. They should not disintegrate, carbonize, or become brittle under hot oil, or full load conditions.

c. Use best technology & design to have low inter-turn stresses, and withstanding capabilities to stresses under S/C. Coils must be capable of withstanding movement and distortion caused by all operating conditions.

Adequate barriers need to be provided between windings and core, and between HV and LV windings.

d. All leads & connecting bars from winding to terminal boxes/ bushings must be rigidly supported. Any stresses on coils and connections must be avoided.

6. Gaskets

a. All Gaskets (nitrile rubber bonded cork sheets and nitrile rubber seals or o-rings) shall be heat and oil resistant, and do not contain any joints or openings. They shall be of one piece construction only. Joints in the gaskets are not allowed. The rubber bonded cork shall be of 5mm uncompressed thickness unless otherwise stated.

b. Nitrile rubber seals or O-Rings (used for flange connections, bushings, instruments connections, etc,) shall be laid in grooves or groove equivalent retainers on both sides of tank walls.

c. Hemp materials, or gaskets of neoprene and /or such material which can be easily damaged by over-pressing are not acceptable.

7. Fittings & Accessories: The following fittings & Accessories are to be fitted on each transformer.

a. Drain Valve and Sampling Device Transformer shall be equipped with drain and filler valves. The nominal size of drain valve shall be 1 inch. Good quality, non-corrosive, gate valve type, hand wheel operated valves to be used for this purpose. There shall be separate outlets for oil draining and sampling on the same device. The sampling outlet shall be smaller in size and at right angle direction to the main drain outlet. The valve handles should have locking arrangement. This device shall facilitate filling, draining, sampling, and venting of oil. The location of the drain valve / sampling device shall be so selected that it is easily accessible, and its operation shall not be hindered by any other component (ex: cable connections) installed on transformer.

b. Earthing Terminal: Two stainless steel (SS316) earthing flags as shown in Drawing EP-MS-P4/S4-015 Fig.3 (STD-EQP-64) shall be provided. One each on opposite sides of tank body, shall be provided. They shall be positioned vertically below the cable boxes with the centre line 200 ± 5mm above the underside of the skid base. There shall not be any sharp edges on the earthing flags

c. Jacking Lugs: Four Jacking lugs (i.e. one at each corner of the tank) at 400 + 5mm above ground level are to be provided. There shall be clear access of 200 mm to engage a jack with the lug. Access to the jacking lugs should not have any obstruction. It should not obstruct the fixing of Bolt-on-Feeder Pillar.

d. Skids with removable type wheels Skids shall be fitted and shall be provided with four 42mm diameter axle holes. It is important to note that the orientation of the skid base shall be on the longitudinal side of the transformer (length-wise), but not on width-wise. The skids shall be fitted with wheels.

e. Lifting Fittings: Lifting Fittings shall be provided suitable for lifting the transformer with crane and chains. These shall not be located on the top of the transformer.

f. Oil Level Gauge: This will provide indication of the real (actual) oil levels over the full range of normal temperature excursions. The oil levels shall need to be visible through either prismatic or thick transparent unbreakable glass/plastic with required protection against mechanical damage. It will be calibrated to show the normal oil level at 200C, 35°C, and 950C. Indirect ways of oil level indication (like through magnetic or other indirect indicating types)

are not acceptable. Markings for the maximum and minimum oil levels should be clearly marked on the instrument. Note: Instruments with colour code indications are not acceptable.

g. Sealed Filler Boss: The design shall be such that water cannot collect in the vicinity of the boss.

h. Oil Temperature Gauge (Thermometer) with alarm & Trip contacts.

1) A dial type thermometer to indicate the temperature of the oil at the top of the tank needs to be provided. It's scale shall be graduated in degrees Centigrade and cover the range of 20°C to 120°C with increment marks at not more than 5°C intervals.
2) The dial shall be fitted with pointers to indicate the present oil temperature, and its maximum value. The maximum temperature pointer, alarm and trip contacts, shall be manually re-settable type from the front. Two auxiliary switches, each containing (2NO contacts) and rated @ 10A, 240VAC, shall be provided for Alarm & Trip signals. The contact terminals shall be suitable for terminating 4C x 2.5 sq.mm stranded copper conductor cable.
3) Cable entry hole on the thermometer shall be fitted with suitable conduit fitting (not cable gland) conforming to at least IP 65, and capable of accommodating 4Cx2.5sq.mm, CU/PVC/SWA cable along with flexible conduit.
4) A permanent wiring, to be made to the junction box mounted on side walls of transformer tank, through rain tight conduit & conduit fittings. Cable/conduit entry to the thermometer alarm contacts shall be from bottom.
5) The oil temperature gauge alarm & trip values shall be pre-set at 95°C and 105°C respectively, by default.
6) The Standard thermometer size as described below shall be used.
7) Nominal dial size: Approx 100mm.
8) Sensing element type: Bimetallic, stem type.
9) Bezel and Casing material: Stainless steel (SS-316).
10) Dial and Pointer: Black pointer on white dial.
11) Maximum Pointer: Red Pointer.
12) Measuring Range: 20-140°C.
13) Connection type: Radial bottom.
14) Stem size & material: 120mm(L)x12mm(D), stainless steel.
15) Process Connection: G½ inch male nut, stainless steel fitting.
16) Thermometer pocket(thermo-well): Welded to tank, with matching thread.
17) O-Ring: Suitable size of O ring shall be used.

i. Additional Thermometer Pocket: An additional thermometer pocket (thermo-well without thermometer) of same size shall be fitted in the tank, for the purpose of routine testing & measuring with portable instruments. The thermo-well opening shall be closed with matching cap/plug.

j. Pressure Relief Valve: The device shall be with a fixed pressure setting assigned by the manufacturer to permit pressure relief when the transformer is subject to abnormal operating conditions or an internal fault. It shall be fitted with a prominent indicator, which shall remain in place after an operation of the device. The pressure relief valve shall also be fitted with re-settable auxiliary switch containing 2NO (two normally open contacts) and rated @ 10A, 240VAC and conforming to IP65. Operation of the switches shall

coincide with operation of the pressure relief valve. The limit switch containing these auxiliary switches shall be totally concealed below the PRV outer cover, to protect it from the external environment and rain. The conduit fitting, conforming to at least IP 65, at the cable entry of PRV terminal box, shall be capable of accommodating 4Cx2.5sq.mm, CU/PVC/SWA cable along with flexible conduit. A permanent wiring from the limit-switch to be made, with the cable, to the junction box mounted on side walls of transformer tank, through rain tight conduit & conduit fittings. Cable/conduit entry to the limit-switch shall be from the bottom.

k. Junction Box (for control wiring): A suitable junction box (control box) made of sheet steel body with protective coating and painting, shall be fixed on suitable side wall of tank. It shall be fitted with suitably rated terminal strip, cable gland/conduit fittings, front hinged door and gaskets, etc. The location of the junction box is such that it facilities easy access to its connections. The box shall not hinder functions of any transformer operations or other components. IP rating of the box shall not be less than IP65. Two inlet and two outlet electrical cable entry holes shall be provided to the box through rain-tight conduit fittings. All cable/conduit entries shall be from bottom only. Inlet connections shall be wired from thermometer alarm contacts, and PRV limit switch through flexible conduits. Outgoing terminal connections shall be left free, to make connections during installation. All outgoing and incoming cable entry holes shall be fitted with conduit fittings (IP65) capable of accommodating 4Cx2.5sq.mm, CU/PVC/SWA cable along with flexible conduit. All un-used entry holes shall be closed individually with suitable caps/plugs. A permanent label showing terminal wiring diagram, terminal markings, functions of all terminal connections, shall be fixed inside the front door of the junction box. The front door shall have provision for fixing KM standard pad-lock having 5mm shackle.

l. Pressure Gauge with Isolating Valve (Applicable for Radiator type Transformers): A pressure gauge capable of measuring negative and positive pressures of nitrogen gas inside the tank, over the atmospheric pressure, shall be fitted on the inlet oil pipe line of each transformer. The pressure gauge shall be along with an isolating valve as a combination, capable of isolating the gauge in normal conditions, and measure gas pressure only when required. Suitable manifold, if required, to be used at the Oil inlet valve, to accommodate this 'pressure gauge + isolating valve' combination. Suitable gaskets/seals/O-rings, shall be used at all joints of the fittings to ensure no gas leaks during their service life. There should not be any joints or openings in the gaskets used. The gauge nominal diameter shall not be less than 100mm. The bezel and casing of the gauge, isolating valve, and their fittings shall be made of stainless steel (SS316). The dial of the gauge shall have linier graduations of measuring range, in black letters on white back-ground, with centre zero reading, covering both negative and positive pressures. Further, maximum & minimum values of pressure to be maintained inside transformer tank, shall be marked in RED colour on the dial. All these readings shall be clearly visible through front non-breakable transparent glass. An additional pressure gauge ('Master gauge') is to be supplied, free of cost, as an accessory, for every 100 transformers supplied.

m. Connection Diagram Plate(s): A connection plate shall be provided which gives full details of the tap position.

n. Pressure-VS-Temp chart/graph plate: A permanent chart or graph showing the relation between the gas pressure-vs-top oil temperature inside the tank,

between the operating temperature range of +20°C to +95°C at with incremental intervals of 2°C. The chart or graph shall be indelibly printed or engraved on noncorrosive metallic plate and permanently fixed on the transformer body. PRV setting pressure shall also be clearly mentioned on this plate.

o. Accessories to be supplied as spares (free of cost):

1) One additional nitrogen pressure gauge is to be supplied, for every 100 transformers (Radiator type) supplied.
2) One nitrogen gas filling kit, consists of gas cylinder, pressure regulative valves, pressure gauges, hose pipes, hose fittings, and trolley, to be supplied for every 250 transformers Radiator type) supplied.
3) One additional 'thermometer with alarm contacts' shall be supplied for every 100 transformers supplied.
4) One additional set of complete gaskets, as used in transformers, shall be supplied for every 50 transformers, of each type (radiator/corrugated) and KVA rating, supplied. Each piece of gasket in the kit shall be clearly identified with labels containing details of its function, manufacturer part number, name of manufacturer, country of origin.
5) 10 pieces of Transparent viewing window glasses shall be supplied free of cost for every 100 Transformers supplied.

8. Radiators: Radiators shall be of the panel type, detachable, connected to the Transformer main tank through flanges.
9. Provisions for Cable Box Connections: Facings and internal connections shall be provided for mounting HV and LV bushing assemblies and cable boxes, as detailed in Appendices A, B and C. Fixing studs shall be provided on transformer facings positioned to match the cable boxes detailed in the Appendices.
10. Nuts, Bolts and Washers: All nuts, bolts and washers used for fixing/mounting cables boxes, box covers, tank cover, bushings, oil-level gauges, etc., shall be non-corrosive alloy steel or stainless steel. Both spring & flat washers need to be provided with every bolt fitted on the transformer.

H. Cleaning and Painting Work

1. The definitive guideline document is BS EN ISO 12944 Parts #1 to 8, & BS EN ISO 14713.
2. The atmospheric corrosive category of local environmental conditional is considered to be close to C5-M (as per ISO 12944-2), and it is imperative for the manufacturer to provide a painting system suitable for this classification.
3. It is the responsibility of the manufacturer to select suitable paint system, in accordance with above referred standards withstanding the specified local climatic and environmental conditions, and to give a service life of at least 15+ years.
4. The selection of surface preparation processes, protective paint systems, execution and supervision of paint work shall be made in accordance with the requirements specified above.
5. The exact Specification & procedure of surface preparation and painting system followed by the manufacturer shall be submitted at time of tender. The manufacturer shall clearly justify the selected paint system meeting above mentioned requirements (Refer tables of BS EN ISO 12944 and BS EN ISO 14713)
6. The final coat on the exterior shall be Dark Admiralty Grey, Colour conforming to 632 of BS 381C, or a near equivalent.

7. The manufacturer should possess required testing equipment in their laboratory to test the paint work in accordance with BS EN ISO 12944-6. These test reports should be submitted along with each consignment of delivery.
8. KM Engineers shall have the option of witnessing the tests on painting work, before delivery of each consignment.

I. Cable Boxes and Bushings

1. General

   a. The attached Appendices cover high voltage and low voltage cable boxes for distribution transformers having ratings from 500kVA to 1600kVA.
   b. They apply to cable boxes in which the conductors of cables terminate within the box and are connected to terminals fixed therein.
   c. The cable boxes shall be of the dry type and suitable for using heat shrink terminations.
   d. The cable boxes shall be suitable for operating both indoors and outdoors under the service conditions stated in IEC 60076, and those stated in this Specification.
   e. Cable entry shall be from below.
   f. Cable boxes shall comply with the requirements of BS 2562 and, where applicable BS 6435.
   g. High Voltage and low voltage cable boxes shall be mounted on opposite sides of the transformer.
   h. The low voltage cable boxes shall be suitable to terminate XLPE insulated cables and paper/lead single core cables.
   i. HV bushings are to be mounted in such a way that their mounting brackets and bolts are accessible from outside the transformer tank through HV cable box.
   j. Cable boxes shall be ventilated to permit free access of air, whilst preventing inflow of rain or draining water. The ventilation shall be such as to prevent the entry of vermin.
   k. Lengths of all phase and neutral bus-bars, in the LV mono-block bushing assembly, shall be of equal lengths. Note: Some manufacturers offer shorter length for neutral bus-bar, which is not acceptable.

2. Construction of Cable Box

   a. The construction shall be such that the accumulation of water is avoided and the box is effectively sealed against weather and insects.
   b. Breathing holes, 12mm diameter covered with an internally fitted wire gauge shall be provided. The degree of protection shall be to IP41 of IEC 60529.
   c. The minimum size of any fixing stud or bolt for securing a front cover plate shall be M10 mild steel.
   d. Gaskets, where applicable shall be of synthetic rubber-bonded cork and shall not be less than 5mm thick.
   e. HV & LV Cable Box cover plates shall be provided with handles for easy handling.
   f. Each cable box front cover shall be equipped with inspection window of 3 in. x 5 in. size, covered with unbreakable polycarbonate transparent sheet of at least 4mm thickness. This window assembly shall have at least IP44 degree of protection. The inspection window is located in such a place that, inside bushings are clearly visible without opening the cable box cover plate.

3. Retrofitting LV Fuse Cabinets

a. For Transformers up to and including 1000kVA, the user may remove the LV cable box and replace it by a bolt on fuse cabinet.

b. The format of the fuse cabinet(Feeder Pillar) is as follows:

1) Maximum external width of the cabinet - 610 mm.
2) From the center line of the bushing, To the top of the cabinet - 460 mm
3) From the center line of the bushing, To the bottom of the cabinet -1270 mm.
4) Feeder pillar depth from face of transformer to feeder pillar front – 650 mm.
5) Door hinge on the left hand side and can swing through 180 degrees.

c. This will influence the design of this face of the transformer in the following respect:

1) From the vertical centre line of the LV bushing assembly there shall be a clear, unobstructed clearance of 320 mm either (each) side between the LV side radiators/corrugated panels.
2) The height of the center line of LV bushing assembly will be such that the bottom of feeder pillar cabinet shall not be below the base of the transformer, and shall not touch the ground.
3) The two 'supporting bolts' at rear bottom of the Feeder Pillar, shall properly mate with a solid surface on the tank or base of the transformer.
4) There shall not be any obstruction on the body of transformer for proper fixing of Bolt-on-Feeder Pillar.

1.14 DRY-TYPE TRANSFORMERS

A. The design, construction & testing of Cast-resin transformers shall be generally in accordance with IEC 60076-11, unless other-wise specified. Cable boxes, mounting flanges, bushings shall generally conform to the respective standards mentioned above, unless other-wise specified.

B. The transformer shall be fitted inside sheet steel enclosure having IP protection degree of IP31 with natural air ventilation.

C. The Transformer or its Enclosure shall **not be** fitted with any forced ventilation or exhaust fans. Only the natural air ventilation available in the civil building room shall be able to provide necessary ventilation needs.

D. The manufacturer needs to provide necessary calculations for air flow requirements and sizing details of indoor civil room construction for cooling of transformer with natural ventilation.

E. The transformers shall be capable of delivering full rated power continuously, under specified **service and ventilation conditions**, without any thermal overloading. The design & construction of transformer shall be such that, no de-rating factor shall need to applied on account of specified temperature rise limits, enclosure IP protection, and ventilation requirements.

F. The no-load LV output voltage of the transformers shall be 433/250V, when HV side is applied with 11kV at center tap. This is to provide consumers with a nominal supply voltage of 415/240V (three phase 4 wire/Single phase 2 wire, 50Hz) on full load, after permitted system voltage drops.

G. The sub-assemblies of the transformer shall be so designed that they should not un-duly increase the vibrations or cause resonance. Anti-vibration mounts shall be incorporated to reduce vibration & noise levels.

H. Ratings and Characteristics

1. Service conditions & maximum winding temperature rise limits:

   a. Average of hottest month temperature of cooling air outside enclosure is 35°C.
   b. The maximum temperature of cooling air outside enclosure may exceed 50°C any time.
   c. The relative Humidity surrounding the transformer may reach 100%.
   d. Frequent Condensation may occur during high humid conditions.
   e. The surrounding air may contain very fine, highly penetrating, sand dust with highly corrosive salt laden sea mist.
   f. The maximum temperature rises of the windings shall not exceed by 850K over an ambient temperature of 50°C, when fully loaded inside in the specified enclosure, without forced ventilation.

2. Ratings:

   a. IP protection of Enclosure: IP31.
   b. IK protection of Enclosure: not less than IK7 (2.0 joules).
   c. Ventilation: Natural air cooling-AN (no forced ventilation).
   d. Th. Insulation class of windings(HV/LV): Class F/F.
   e. Winding material (HV/LV): CU/CU.
   f. Voltage ratio: 11000/433V.
   g. No. of phases: 3-Phase.
   h. Connections: Delta- Star, as per vector group Dyn11.
   i. Rated frequency: 50HZ.
   j. Rated voltage (U): 11kV.
   k. Maximum flux density: ≤ 1.6 Tesla at normal voltage and frequency.
   l. No-load current: ≤ 1% of transformer rated current.
   m. Tapping range and steps: +5% to -5%, in 4-steps each of 2.5%.
   n. MV Rated Insulation Levels:

      1) Rated Voltage(U): 11kV.
      2) Rated Highest Withstand Voltage(Um): 12kV.
      3) Rated Lightning Impulse Withstand Voltage (peak): 75kV.
      4) Rated Power frequency withstand voltage: 28kV.

   o. LV Rated Insulation Levels:

      1) Rated Voltage(U): 433/250V (at no load).
      2) Rated Highest Withstand Voltage (Um): 1.1kV.
      3) Rated Power frequency withstand voltage: 3kV.

   p. Guaranteed values of losses (load & no-load), percentage impedances measured at principal tap and corrected to reference temperature of 750C shall be as mentioned below.
   q. Transformer Size: 500 kVA

      1) No Load Losses: 1050 watts.
      2) Load Dependent Losses: 5100 watts.
      3) % Impedance: 4.75±10%.

   r. Transformer Size: 1000 kVA

      1) No Load Losses: 1650 watts.
      2) Load Dependent Losses: 8800 watts.
      3) % Impedance: 5.45±10%.

s. Transformer Size: 1600 kVA

1) No Load Losses: 2200 watts.
2) Load Dependent Losses: 12500 watts.
3) % Impedance: 6.00±10%.

t. The values specified for No-load & load losses are maximum values.
u. The climatic class of the transformers shall conform to: Class C1.
v. The Environmental class of the transformer shall conform to: Class E2.
w. The Fire behavior class of the transformer shall conform to: Class F1.
x. Maximum dimensional limits of Enclosure: 2300 (L) x 1500 (W) x 2300 (H), mm.
y. IP protection of HV & LV Cable boxes: IP43.

3. Short Circuit Ratings: Verification of transformer's ability to withstanding short-circuit conditions, shall be made through type testing in accordance with IEC 60076-5, at reputed independent laboratories.

a. Thermal ability of the transformers to withstand short circuit current shall be verified for a duration of 2 sec. The value of ambient temperature shall be considered as not less than 50°C for calculation of initial winding temperature.
b. Ability to withstand dynamic effects of short circuit shall be verified by tests (not by calculation method)

4. Tapping Range & Tapping Method

a. Off-circuit tapping selection shall be made by the use of bolted links on the HV winding. The tapping range shall be ±5% in steps of ±2.5% For total 5 tap positions.
b. Current carrying capacity of the bolted links for tapping shall be capable of withstanding the rated short-circuits capacity.

5. Magnetic flux density

a. The flux density at any point of the magnetic circuit when the transformer is connected on normal tap (3) and operating at normal voltage and frequency shall not be more than 1.6 Tesla, and well below the saturation level. Proof of this shall be submitted for verification in the form of B/AT magnetizing curves of the magnetic core assembly

6. Thermal insulation Class of windings & temperature rise limits

a. Thermal insulation class of HV & LV windings shall conform to the class-F/F (Insulation system temperature - 155°C) as defined on IEC 60085.
b. The maximum temperature rises of the windings shall not exceed by 850K over an ambient temperature of 50°C, when fully loaded the transformer inside the specified sheet steel enclosure with natural ventilation, without forced cooling.

7. Noise (Sound) Levels

a. Verification shall be done by conducting type test, through reputed independent laboratory, for sound level measurements in accordance with IEC 60076-10 under indoor conditions.
b. The maximum values of sound pressure and sound power levels, measured at a distance of 1 meter from the 'principal radiating surface', are as mentioned below:
c. Transformer Size: 500 kVA

1) Average 'A-weighted' sound pressure level LpA dB(A) 54.
2) Calculated 'A-weighted' sound power level LwA dB(A) 67.

d. Transformer Size: 1000 kVA

1) Average 'A-weighted' sound pressure level LpA dB(A) 57.
2) Calculated 'A-weighted' sound power level LwA dB(A) 71.

e. Transformer Size: 1600 kVA

1) Average 'A-weighted' sound pressure level LpA dB(A) 60.
2) Calculated 'A-weighted' sound power level LwA dB(A) 75.

8. Climatic, environmental and fire behaviour classes

a. Special tests for climatic, environmental and fire behavior classes shall be carried out as per the tests specified in clauses# 26, 27 and 28 of IEC 60076-11 in a reputed independent testing laboratory.
b. A transformer is considered to be passed these tests, when all the prescribed tests are conducted on same transformer in the sequence as given in table-5 of IEC 60076-11.
c. The climatic class of the transformers shall conform to: Class C1.
d. The Environmental class of the transformer shall conform to: Class E2.
e. The Fire behavior class of the transformer shall conform to: Class F1.

I. Rating and Connection Plates - Marking of Terminals

1. Rating and Connection Plates (as per IEC 60076-11/Cl-9): Each Transformer, as well as the associated enclosure, shall be fitted with individual rating plates of weather-proof materials, in a visible position, showing all the items indicated below. The entries on the plate shall be indelibly marked (that is, by etching, engraving, stamping, or by a photo-chemical process)

a. Dry-Type transformer.
b. Compliance standards reference.
c. Manufacturer Name.
d. Manufacturer's serial number.
e. Month & Year of manufacture.
f. KM Contact/Tender number.
g. Insulation system temperature of each winding.
h. Number of phases.
i. Rated frequency.
j. Rated voltage including tapping voltages.
k. Rated current.
l. Connection symbol.
m. Short circuit impedance at 75°C.
n. Type of cooling.
o. Insulation Levels.
p. Degree of Protection.
q. Environmental class.
r. Climatic class.
s. Fire behaviour class.
t. Total mass with and without enclosure.

2. Marking of Terminals & start of windings:

a. HV and LV Terminals shall be identified by characters of a type which cannot be obliterated, marked on plates of durable and non-corrodible metal securely fixed to a visible position. Stickers are not acceptable.
b. The sequence of markings on HV terminals when read from left-to-right, facing HV cable box, shall be as: A, B, C.
c. The sequence of markings on LV terminals when read from left-to-right, facing LV cable box, shall be as: c, b, a, n.
d. Suitable markings to identify the start and end of windings shall be marked on each physical winding.

J. General Construction and Fittings

1. Magnetic Core and connecting bus bars

a. The magnetic core shall be constructed from high grade, low watt loss, cold rolled grain oriented silicon steel sheets, having specific watt loss of not more than 0.95w/kg at 1.7T and 50Hz, and conforming to IEC 60404-8-7:2008 and IEC 60404-1: 2000. (Note: 1.7T is used only for the purpose of comparing the grade, but actual design of transformer shall be made for 1.6T).
b. The construction of yoke and limbs shall be such that best space factor and highest dimensional accuracy is achieved to ensure low core losses and nose levels.
c. The core shall be coated with high performance surface insulation material(s), conforming to the requirements of IEC 60404-11, to obtain good insulation resistance and anticorrosion protection.
d. The clamping structure shall not allow any bolt piercing the core lamination in order to avoid circulating current in the core and local concentration of the flux in the yoke.
e. The limb & yoke core joints shall be interleaved using modern step-lap technology to achieve optimum conformity of magnetic flux pattern.
f. The core shall be pressed and banded and shall be clamped and bolted at the top and bottom in such a manner as to ensure that no distortion shall take place when the transformer is subjected to magneto motive forces equivalent to those which would be present in the event of a total short circuit being applied across the low voltage terminal with an infinite power supply at normal voltage and frequency available, at the high voltage terminals.
g. All bus-bars shall be made of hard drawn high purity electrolytic copper with electro-tin plating.

2. Windings

a. The HV windings of the transformers shall be made of high purity electrical grade copper wire and shall be totally encapsulated in a glass-fiber reinforced resin-cast insulation. The casting shall be made under vacuum in such a manner that all air shall be totally evacuated from casting.
b. The casting shall be such that the composite structure shall have sufficient resilience strength against stresses developed due to differences in co-efficient of thermal expansions between insulation materials and copper.
c. Laying pattern of HV winding wires shall ensure to achieve superior linear lightening voltage distribution characteristics.
d. LV windings shall be made of copper foil with impregnated type interlayer insulation. The interlayer insulation shall be made of solid polyester foil with impregnated fibre glass film which thermo-sets by curing, or by an equivalent process having same or higher performance levels.

e. Sufficient numbers of cooling channels shall be provided in both the LV and HV windings to restrict the temperature rise of the windings within the specified values and thereby minimizing the damage due to hot spot. The cooling channels are arranged in a vertical manner and all coils have even surface to minimize dust accumulation and to give maximum cooling efficiency.

f. The completed winding stack assembly and connections shall have sufficient mechanical rigidity to ensure no distortion or movement of any one winding, or to any other winding or section of windings, shall take place when the transformers is subjected to the short circuit stresses created by a total short circuit at the low voltage terminals with an infinite power supply at normal voltage and frequency available for two seconds at the high voltage terminals.

g. Sufficient barriers shall be provided between windings and core, and between HV and LV windings.

h. The winding insulation shall be such that the transformer may be operated at 155°C with no deterioration of the insulation properties as per IEC 60076-11 requirements. It shall comply with the requirements of Class F/F insulating materials.

i. The high voltage and low voltage connections shall be brought out on opposite sides of the transformer.

j. The windings shall be connected Delta Star in accordance with Vector Group reference Dyn11.

k. All leads or bars from windings to the termination points, shall be rigidly supported. Stresses on coils and connections must be avoided.

l. The insulation materials used on windings and connections shall be shall be free using any insulating compounds prone to shrinking or collapse during service life. Further, there shall not be any joints either in the LV foil or insulation.

3. Enclosure

a. The Transformer shall be contained in a sheet steel ventilated enclosure suitable for indoor service. The overall limiting dimensions of the enclosure and fittings attached there-in shall not exceed the values specified below:

1) Length: 2300 mm.
2) Width : 1500 mm (excluding cable boxes).
3) Height: 2300 mm.

b. The enclosure degree of protection shall not be less than IP 31 including its bottom surface. If so desired, number of ventilation louvers may be increased to take care of ventilation requirements.

c. All side panels (covers) and top of the enclosure shall be removable type using standard metric spanners. No handles or other aids shall be employed for easy removal of panels. All bolts & nuts shall be non-corrosive stainless steel/alloy steel.

4. Fittings and Accessories: The following accessories are required to be fitted on the transformer.

a. Earthing Terminal: Two stainless steel earthing flags, of size 63x63mm , and 6mm thick each, having hole suitable for connecting M14 bolt, or an equivalent arrangement shall be provided at bottom of the transformer frame work on either side. All exposed metallic conductive non-live parts shall be

connected to earth terminals by construction through full earth fault rated conductors/braids.

b. Lifting Lugs on Total assembly: The transformer with enclosure assembly shall be fitted with two lifting lugs enabling lifting of transformer and enclosure assembly. The position of the lugs facilitates easy attachments of lifting slings. The transformer shall be suspended absolutely vertical when it is lifted by means of the lifting hooks.

c. Lifting (hoist) eyelets on transformer (active part): Four lifting (hoist) eyelets shall be provided on all four corners (one at each corner) of upper press-beams/clamp-bars of the transformer, to facilitate lifting of transformer alone (without enclosure) when required.

d. Haulage holes on under base: Four haulage holes shall be provided on all four corners of lower press-beam/clampingbar (one at each corner).

e. Bi-directional rollers at base: Four bi-directional flat rollers with blocking facilities (as mentioned below) are to be fitted at base of the transformer, on to which entire load of transformer and enclosure assembly shall be transmitted.

f. Anti-vibration pads and Roller blocking devices: Anti-vibration pads made of polycarbonate material, having capability of carrying loads of the transformer & enclosure, shall be provided at base to dampen the intensity of vibrations and avoid resonance. They should also serve as roller blocking devices to arrest the movement of transformer unit after installation.

g. Rating & Connection Plate, and colour coding: Rating and connection diagram plates shall be provided both on transformer and enclosure. Colour coding (Red, Yellow & Blue), with indelible markings, shall be provided at suitable locations on the frame of active part, to identify phase of each core, and inside cable boxes to identify phases of HV and LV terminals.

h. Danger Boards: Danger Boards, prepared as per KM specification # ED-01-400 (Drg # STD-PRT-04) shall be fixed permanently on all four sides of the enclosure. Note: Removable labels or stickers are not acceptable.

i. Viewing Window: A transparent viewing window, of 6 inch x 4 inch size, with 5mm thick clear polycarbonate sheet shall be fitted on enclosure at front, to view the tapping position of transformer. This fixture shall have IP 65 protection with necessary gasket(s).

j. Chart of tap-changing link positions: A chart showing the combination of links positions for each tap position shall be permanently fitted on enclosure at front. The details on the chart shall be indelibly marked by etching, or engraving, or stamping, or by photo-chemical process. Note: stickers are not acceptable.

k. Temperature monitoring unit for thermal protection:

   1) At least 2 sets of PT100 based, high accuracy, RTD type PTC Temperature sensors shall be embedded into to each phase of LV winding.
   2) The sensors & its associated wiring shall be insulated, to avoid occurrence of any short circuits with the transformer winding. The sensors shall be placed as close as possible to the hottest spot in the winding.
   3) The insertion of sensors shall be made through capillary tube to enable them to be replaced whenever necessary.
   4) The first set of the sensors shall be set to give 'alarm signal' at 140°C, and the second set shall be set to give 'trip signal' at 150°C. These values shall be in conformity with Class F insulation.

5) The 'alarm' and 'trip' signals shall be in the form of voltage free relay output contacts. Each output relay contacts shall have at least 2NO+2 NC and each rated for 6A@240Vac.
6) The temperature monitoring unit (i.e Electronic converter with relays and wiring terminal block) shall be capable of operating in the specified local ambient conditions. It shall be flush mounted on front side of the enclosure. The unit shall be capable of operating on 240Vac @50Hz power supply.
7) The monitoring unit shall have features of circuit-fault indication, storage of maximum value of temperature, live voltage indication, status of relay positions with different coloured light indications, reset facility, etc.
8) The power supply for the monitoring unit shall be connected from transformer LV output (240Vac, 1-Phase) through suitably rated terminal blocks. The terminal block shall have additional spare terminals, to facilitate connecting external power source (auxiliary source), when required.
9) All wiring, to and fro, from the temperature monitoring unit shall be routed through properly clamped and insulated trunking-channels. No wires shall be left loose or hanging inside the enclosure.
10) The monitoring units shall not cause any false tripping. It shall be sourced from reputed brands and its source and technical details to be submitted along with tendering information.

I. Thermometer:

1) In addition to the temperature monitoring unit as described above, a dial type thermometer, having nominal dia of 100mm, with stainless steel bezel and casing, shall be fitted on the transformer (not on enclosure) with suitable sensing element. The thermometer shall indicate the temperature of the winding and maximum temperature.
2) Its dial shall be graduated in degrees Centigrade and cover the range 0°C to 160°C with increment marks at not more than 5°C intervals. The dial shall be fitted with pointers to indicate the winding temperature, and maximum temperature value with a RED pointer. The maximum temperature pointer shall be manually re-settable. The thermometer shall be located in a safe and suitable place to have clear view.

5. Corrosion protection and Painting of Enclosure

a. The definitive guideline documents are BS EN ISO 12944 Parts #1 to 8, & BS EN ISO 14713. The painting procedure selected by the manufacturer should clearly indicate its relationship to the appropriate parts and tables of BS EN ISO 12944 and BS EN ISO 14713
b. It is the responsibility of the manufacturer to assess environmental classification, select suitable surface preparation process, protective paint system, execution and supervision process, in accordance with above referred standards and requirements.
c. The painting work should render a service life of at least 20 years to the equipment, withstanding local ambient climatic & environmental conditions.
d. The exact Specification & painting procedure going to be followed by the manufacturer shall be submitted at time of tender.
e. The manufacturer should possess required laboratory testing equipment, in their factory, to test the painting work samples in accordance with BS EN ISO

12944-6. The test reports should be submitted along with each consignment of delivery.

f. The paint work shall nee to pass following tests:

1) Measurement of thickness of protective coating (ISO 2808).
2) Specular gloss factor at 60 deg (ISO 2813): 90±5%.
3) Falling weight test (ISO 6272): 1kg/50cm.
4) Cross cut test (ISO 2409): classification: 0.
5) Cupping test (ISO 1520): 08mm.
6) Bending test – Cylindrical mandrel test (ISO 1519): 3.0mm.
7) Salt spray (fog) test (ISO 7253): 1000hrs.

6. Cable Boxes

a. Cable boxes shall comply with the requirements of BS 2562 and, where applicable BS 6435.
b. High Voltage and low voltage cable boxes shall be mounted on opposite sides of the transformer.
c. HV and LV Cable boxes shall be suitable for vertical bottom entry of cables. However LV cable box shall also have suitable facility (in addition to this bottom cable entry) for top entry bus-bar connections, when required. Note: Bus-connections shall be made through cable box only, they should not be made through top of enclosure directly.
d. The bushing heights of HV and LV shall be 1320 mm from the enclosure base to centre of bushings assembly.
e. The construction shall be such that the accumulation of water is avoided and the box is effectively sealed against weather and insects.
f. The minimum size of any fixing stud or bolt for securing a front cover plate shall be M10 mild steel. All bolts used in assembly of cables boxes or enclosure shall be electroplated for corrosion protection
g. Gaskets, where applicable shall be of nitrile rubber-bonded cork and shall not be less than 5mm thick. Note: Neoprene based cork gaskets are not to be used.

EXECUTION

1.15 TESTING, INSPECTION, DELIVERY, TRAINING AND DOCUMENTS

A. Before commencing the production/manufacturing of bulk quantities, against KM tenders, the manufacturer is obliged to produce two samples of transformers (of each rating) and inform Kahramaa for inspection and witnessing factory acceptance tests, including routine tests. KM retains the option of inspecting these proto-type samples either at KM workshop or at factory.

B. The manufacturer is obliged to inform Kahramaa, at least 20 days before, about subsequent dispatch of every lot, against KM purchase orders, and obtain clearance. KM Engineers have the option of inspecting & witnessing all factory acceptance tests, including routine tests, at manufacturer's factory premises for each lot.

C. Acceptance by KM Engineer(s)/Representative(s) of any transformer(s) shall not relieve the manufacturer from any of their responsibilities, guarantees, or from any other obligations.

D. All Type tests & Special Tests are to be carried out on specimen transformer essentially of same design and ratings, as being offered, in an internationally reputed independent laboratory where the manufacturers does not have any association or influence.

E. Each transformer shall be subjected to all routine tests at factory before delivery. One transformer in each lot will be subjected to prescribed tests on paint work. Further, each

transformer shall be subjected to inspection on receiving them at DOHA to verify its healthiness and its conformity with the guaranteed design data.

F. The tests should be performed in accordance with the latest issue of relevant IEC standards 7) Bidder is obliged to submit, detailed test procedure for approval prior to tests.

G. Three sets (copies) of routine test reports to be prepared. One set to be attached with the Transformer body in strong water-proof envelope. Second copy to be sent along with delivery note. Third copy to be sent to the end-user department.

H. Each delivery note shall include the details of 'serial number' and 'month/year' of manufacture of each transformer.

I. Both the manufacturing date (i.e month/year) and delivery date should be shown on the rating plate of each transformer, and the time difference between these two dates should not be more than 6-months.

J. The manufacturer needs to organize training workshops for KM technical staff, to familiarize with installation, operation & Maintenance, trouble shooting guidelines.

K. The manufacturer need to submit 6 copies of:

1. Operation & Maintenance Manuals.
2. Installation Instructions.
3. Trouble shooting manual.
4. Details of condition monitoring parameters, its required data values, frequency of monitoring of each parameter, etc.
5. Technical data-sheets and product catalogues of all accessories mounted on the transformers (i.e, Magnetic core material, PRV assembly, Tap-changer assembly, thermometer assembly, drain valve cum sampling device, LV bushing assembly, HV bushings, pressure gauge & isolating valve assembly, oil-level gauge, all gaskets, etc).

1.16 TESTS

A. Routine Tests

1. Measurement of Winding resistance.
2. Measurement of Voltage ratio and check of phase displacement.
3. Measurement of Short-circuit impedance and load loss.
4. Measurement of no-load loss and current.
5. Separate source AC withstand voltage test.
6. Short duration induced AC withstand voltage test.
7. Main tank Oil pressure test at 0.3 bar for 16 hrs on each transformer.
8. Oil Breakdown voltage test (BDV) and oil acidity test.

B. Type Tests

1. Temperature rise test.
2. Dielectric Type tests (LI).

C. Special Tests

1. Dielectric Special tests.
2. Determination of capacitances windings-to-earth, and between windings
3. Short-circuit withstand test.
4. Determination of Sound levels (report should be submitted for each lot of delivery)
5. Measurement of insulation resistance to earth of the windings, and/ or measurement of dissipation factor (tan delta) of the insulation system capacitances.

D. Tests On Painting Work

1. Measurement of thickness of protective coating (ISO 2808).
2. Specular gloss factor at 60 deg (ISO 2813): 90±5%.
3. Falling weight test (ISO 6272): 1kg/50cm.
4. Cross cut test (ISO 2409): classification: 0.
5. Cupping test (ISO 1520): 08mm.
6. Bending test – Cylindrical mandrel test (ISO 1519): 3.0mm.
7. Salt spray (fog) test (ISO 7253): 1000hrs.

7.4.15 26 2413 - Low Voltage Switchgear

GENERAL

1.1 SUMMARY

A. This section specifies the requirements for service and distribution switchboards rated at 415V and less comprising the following components:

1. Bus-bars
2. Circuit Protective Devices
3. Instrumentation
4. Transient voltage suppression devices.
5. Control power.
6. Accessory components and features.
7. Identification.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0526 – Grounding and Bonding for Electrical Systems
3. Section 26 0553 – Identification for Electrical Systems
4. Section 26 0913 – Electrical Power Monitoring

1.2 DEFINITIONS

A. ACB: Air Circuit Breaker

B. MCCB: Moulded Case Circuit Breaker

C. TVSS: Transient voltage surge suppressor.

1.3 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

D. BS EN 60269 (series) - Low-voltage fuses.

E. BS EN 60439-1:1999, IEC 60439-1:1999 - Low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies.

F. BS EN 60947 (series) - Low-voltage switchgear and controlgear.

G. BS EN 61439 (series) - Low-voltage switchgear and controlgear assemblies.

H. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

1.4 DOCUMENTATION WITH TENDER

A. The Tender shall contain at least the following information and documents:

1. Completed technical data sheets.
2. Description of equipment and services.
3. General arrangement drawings showing particulars of all equipment and accessories their dimensions, weights, front and section views, etc.
4. Descriptive catalogues and literature on the proposed types of equipment,
5. Quality control manual or certificate.
6. Deviation from the Specification, etc.

1.5 DOCUMENTATION AFTER AWARD OF CONTRACT

A. All documents required for KAHRAMAA's approval shall be submitted by the Contractor in accordance with Section 2 - General Technical Requirements.

B. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

C. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

D. Warranty: Sample of special warranty.

E. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

1.6 OTHER SUBMITTALS

A. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

B. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Installer Qualifications: Company specializing in supplying the products specified in this section with minimum five (5) years documented experience and with service facilities within 100 miles (160 km) of Project.

C. Product Selection for Restricted Space: Comply with the minimum clearances as defined by the Local Power Authority.

D. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE, UL, CSA and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

1.9 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without the Construction Manager's written permission.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

C. Coordinate features of accessory devices with remote pilot devices and control circuits to which they connect.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.12 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.13 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.14 STANDARD TRANSFORMER OPERATING CONDITIONS:

A. Average Continuous Ambient Temperature: 35°C.

B. Hot Spot Temperature shall not exceed 75°C under any conditions.

1.15 SYSTEM CONDITIONS

A. Rated Voltage: 240/415 ± 6%, 3 Phase, 4 Wire.

B. Neutral: Solidly Earthed.

C. Fault Level: 31 MVA at 415 V.

D. The nominal mains frequency is 50 Hz. Under normal operating conditions there may be a variation of ± 0.1 Hz. Industrial conditions in the state may occasionally result in a short term variation of ± 0.15 Hz. for duration of only a few seconds.

E. In emergency overload conditions, the frequency would be allowed to drop to 48.8 Hz. At which point load shedding would take place. The nominal voltage is 415/240. It is KAHRAMAA practice to maintain the voltage level at a value not exceeding ±6% variation from the nominal value.

1.16 GENERAL DESCRIPTION

A. Internal Separation: Form 4, type 7 for MDB's, type 4 for SMDB's and MCC's above 800A rated.

B. Indoor Ingress Protection Rating: IP42.

C. Cubicle Switchboard shall be floor standing assembly construction, with enclosure standard complying with BS EN 62208.

D. The switchboards shall be floor mounted, self-supporting, front operated, front and rear access, distribution type, manufactured complete with all parts, fittings and equipment, including buses, circuit breakers, barriers, terminals, wiring and connections.

1. The enclosure shall be made of cold rolled steel on a structural shape, or formed, steel frame and shall be mounted on two continuous channel iron sills, which shall be closed at the ends between the two channels forming an integral plinth.
2. All switchboard sections shall be a minimum of 600 mm deep and shall be constructed of code compliant steel.
   a. All holes, supports, studs and openings shall be standardized to enable interchange of interior and front cover units.
   b. All sections shall be fabricated with right angle corners, plumb edges and surfaces.
   c. All switchboard sections shall line up evenly, front and rear.
3. All wire ways shall extend the full length and depth of the switchboard.

E. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, with tin-plated copper feeder circuit-breaker line connections.
2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with [mechanical] [compression] connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.

3. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

F. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

G. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

H. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

I. All low voltage switchgear shall be provided with internal anti-condensation heaters.

1.17 GENERAL DESIGN REQUIREMENTS

A. The LV AC switchgear shall be designed as an indoor switchgear installation and shall be of fully withdrawable, metal-clad design with fully insulated busbars. The free standing switchgear shall be mounted directly above the cable trench and shall have both front and rear access for maintenance. The switchgear shall be purpose built to meet the requirements of the Specification.

B. The switchgear shall be supplied from the substation auxiliary / earthing transformers with cables. The switchboard shall be equipped with outgoing 3-phase, four wire, 415/240 V circuits to cater for station services. The nominal rating of all outgoing feeders shall be adopted according to the respective load.

C. The AC switchgear shall be of a single busbar arrangement. The main fully insulated busbars shall be divided into two insulated sections with a bus section circuit breaker. The incoming feeder circuit breakers and the bus section circuit breaker shall be provided with automatic changeover facilities and also, shall be interlocked such that only two of three circuit breakers can be closed at one time. The incoming circuit breaker shall be interlocked with the earthing switches of the respective 11 kV transformer circuits. Momentary paralleling facilities shall be incorporated. Auto changeover facility shall be provided in case one out of two breakers opens/trips.

D. All electrical components should be in the withdrawable portion and can be withdrawn completely without opening any termination.

E. In the event of outage of the air-conditioning system in the LV AC/DC room, the switchgear installation shall remain operational at full load, and at the ambient temperature of 50°C.

F. Switchgear shall be provided with humidity controlled anti-condensation heaters with isolation facilities.

G. The complete switchgear shall be capable of carrying rated load current without a temperature rise of any part exceeding 65°C. Parts that may be touched by operating personnel shall not exceed a temperature of 70°C.

1.18 SWITCHGEAR

A. The switchgear shall consist of cubicles and shall be erected in a single row. The switchboard shall be provided with lifting lugs. The height of the switchgear shall not exceed 2250 mm and operating handles of all equipment shall be within the reach of a person standing at ground level.

B. The switchgear shall comply with latest edition of IEC 60439 and other relevant IEC Standards if not otherwise stated and with the requirements of MEW Wiring Regulations. The switchgear shall be designed to comply with the degree of protection of IP4X and shall be vermin and termite proof.

C. The fully insulated busbars shall be located in the rear upper part of the cubicle. The connections from the busbars to the equipment contacts shall be isolated from the incoming or outgoing connections.

D. The cross sectional area of the busbars may be graded according to the current rating, but shall remain capable of withstanding the short time current rating stated in the Schedules.

E. All busbars and connections shall be made of copper and encapsulated.

F. All separately mounted metallic parts which are not normally live shall be earthed. To this end they shall be equipped individually with terminals for the connection of the earth conductor. The switchboard shall be provided with an earth bar directly connected to the earthing system at both ends. All metallic parts that are to be earthed for safety reasons shall be connected to this bar. These connections shall be made in the factory and form part of the wiring system. The cross section of this earth wiring shall be adequate for the short-circuit current. The earth bar shall be provided with terminals for the earth conductors.

G. Hinged doors shall be provided at the rear for easy access to equipment contained within the cubicle. The hinged doors shall be of the lift-off type, secured with integral handles provided with locks and duplicate keys to an approved change system and shall be flush fitting and sealed with a gasket of rubber or other approved material to prevent the ingress of dust.

H. Cubicles and doors shall be structurally stiff and braced to withstand twisting without distortion.

I. Each cubicle shall be equipped with a cable compartment, isolated against other compartments of the cubicle and glands suitable for all incoming and outgoing cables. The cubicle shall be designed for cable entry from the bottom rear side. Armoured cables shall be equipped with armour clamps for connection to the earth bar.

J. It must be possible to work within each cubicle with the equipment withdrawn whilst the incoming contacts are energized. The minimum requirements for protection shall be:

K. □□Insulating barriers installed between phases within the cubicle. These insulating barriers and other insulating parts should have a resistance to thermal stress and flame retardant properties.

L. □□Automatically operated metallic shutters provided to cover busbar and feeder spouts On the front of the switchgear cubicle of each incoming feeder, a colored mimic diagram shall be provided, with the necessary switch position indicators, symbols and signal lamps.

M. In the front panel, an instruction plate shall be fixed for Auto / Manual change over including momentary Paralleling.

N. All equipment installed on the front panel of the cubicle shall be flush mounted.

O. Each incoming feeder unit shall be fitted with an indicating voltmeter with selector switch and one ammeter with a selector switch.

P. Outgoing feeders of 250A or more and feeders to rectifiers shall also be fitted with an ammeter.

Q. The indicating instruments shall be connected to earthed cases and shall comply with IEC 60051.

R. Cast-resin insulated, corona-free current transformers shall be provided for protection and measurement as per single line diagram. The current transformers shall be of the single or three pole, multi ratio type for indoor installation and shall comply in all respects with the requirements of and IEC 60044. The current transformers shall be mounted at the withdrawable units or in case of incoming feeders current transformers shall be mounted in the circuit breaker compartments. The current transformers must withstand the dynamic and thermal short circuit stress.

S. Means shall be provided for LV side of the earthing / auxiliary transformer restrictive earth fault protection, as well as for overvoltage / undervoltage protection on the incoming circuits.

T. Each outgoing circuit from the switchgear shall be controlled and protected by withdrawable moulded case circuit breakers, their short circuit rating being adequate to protect each circuit against the effects of a fault at the outgoing terminal of the unit.

U. In the Switchgear provision shall be made to connect an Emergency Diesel Generator when required. The Diesel Genarator incomer circuit breaker should have necessary interlock arrangement with Main Incomers & Bus coupler.

V. All cubicles shall be supplied complete, including protection, instrumentation, all internal wiring, terminal blocks, etc.

1.19 CIRCUIT BREAKERS

A. The circuit breakers shall be of the air break type in accordance with IEC 60947, be modularly sized, of draw out design and suitably rated to handle the relevant capacities at their installation location.

B. Circuit breakers shall be fitted with 110V DC electric motor wound spring operated mechanisms. Means shall be provided for hand-charging the operation springs.

C. Circuit Breakers shall be provided with In-Built Over Current (Over load) protection, Short circuit protection with Instantaneous element and Ground (Earth) fault protection. These protections shall be provided with respective trip time settings.

D. Circuit breakers shall have a test position, in which their main contacts are separated (with automatic metallic shutters closed), but the mechanism stays fully operational and the auxiliary contacts are still connected. The draw out operation from the service to the test position shall only be possible with the circuit breaker in its off position. In addition, it shall not be possible to put back a closed circuit breaker into its service position. The circuit breaker compartments shall be provided with an adequate number of auxiliary contacts for signalling the circuit breaker position.

E. The main contacts shall be generously dimensioned and shall be silver-plated or equivalent, and arcing contacts shall be fitted. Direct acting overcurrent release shall be provided for protection against short-circuit currents, and shall be adjustable to a multiple of the normal current. These devices must ensure selectivity with the fuses and/or circuit breakers below.

F. The circuit breakers shall further protect the transformers against overload.

G. An adequate number of auxiliary contacts shall be available for each circuit breaker. A trip alarm contact shall be provided for signaling any involuntary tripping of the circuit breaker. All contacts shall be easily convertible from close to open and vice versa. All contacts shall be wired onto the cubicles terminal blocks.

1.20 MINIATURE AND MOULDED CASE CIRCUIT BREAKERS

A. Each outgoing feeder shall be controlled and protected by a withdrawable moulded case circuit breaker.

B. Miniature and moulded case circuit breakers shall be in accordance with KAHRAMAA Specification Section 2 – General Technical Requirements.

1.21 AUXILIARY CIRCUITS POWER SUPPLY

A. For details of the auxiliary circuits power supply please refer to Section 26 3301 DC Battery Systems and Uninterruptible Power Supplies.

EXECUTION

1.22 EXAMINATION

A. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

B. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.23 INSTALLATION

A. Equipment Mounting: Install switchboards on concrete base, 100-mm nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete".

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 450-mm centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

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

G. Install spare-fuse cabinet.

1.24 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

1.25 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1.26 INSPECTION AND TESTS

A. GENERAL

1. Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.
2. Testing shall comply with Section 2 - General KAHRAMAA Technical Requirements. All tests on material and equipment shall be made in accordance with IEC Standards if not otherwise specified.
3. The following lists of tests do not restrict KAHRAMAA's right to call for further tests if they consider these necessary.
4. High temperature operation tests shall be performed at the maximum ambient temperature of 50°C.

B. WORKSHOP TEST

1. Type Test

a. Type test shall be performed on each type and rating of the specified equipment with the purpose of proving its properties.
b. The following type tests shall be performed:

1) Testing of breaking and making capacity of circuit breaker and fuses(breaking capacity);
2) Testing of current-time characteristics of protective releases on circuit breakers and of fuses, verification of selectivity of different elements.
3) Temperature rise test(s).

2. Routine Tests

a. Routine tests shall be performed on each piece of equipment to be supplied for the purpose of revealing faults in material or construction. They shall not impair the properties and reliability of any part being tested or reduce its lifetime.
b. The following routine tests shall be performed:

1) Visual checking of all the equipment to verify conformity with the specifications.
2) Power frequency withstand voltage test for all LV AC equipment with 2500 V, 1 min. and for all DC equipment with 1500 V, 1 min.
3) Electrical test of charging rectifier to check the automatic current limitation, trickle and boost charging, ripple and manual control.
4) Operational test.

3. Site Tests
   a. On arrival at the site and during and after completion of erection all items of equipment shall be inspected and tested in order to check quality, correct operation and correct installation of the equipment.
   b. The following tests shall be performed:
   c. Batteries
      1) Verification of proper and complete erection of the batteries.
      2) Checking of intercell connections.
      3) First filling with electrolyte and initial charging.
      4) Checking of electrolyte level and density.
      5) Checking of voltage of each cell after the charging.
      6) Measuring of the insulation resistance to earth.
      7) Charge and discharge tests.
   d. Chargers
      1) Verification of proper and complete erection of chargers.
      2) Verification of proper AC supply voltage, all connections.
      3) Measuring of insulation resistance to earth.
      4) Checking of operation of chargers in each mode.
      5) Checking of control, signaling and tripping circuits.
      6) Load voltage - characteristics.
   e. LV AC and DC switchgears
      1) Verification of proper and complete erection.
      2) Checking of all connections.
      3) Checking of labeling of the cubicles, fuses, circuit breakers, etc.
      4) Measuring of insulation resistance.
      5) Operation checking of different elements such as contactors, relays, circuit breakers, signaling devices, etc.
4. Commissioning tests shall be done according to a program agreed with KAHRAMAA.

7.4.16 26 2416 - Distribution Boards

GENERAL

1.1 SUMMARY

A. This section specifies the requirements for Distribution Boards supplying lighting and power circuits rated at 415V and less and having the following components:
   1. Bus-bars
   2. Circuit Protective Devices
   3. Instrumentation

B. Related Sections:
   1. Section 26 0500 – Common Work Results for Electrical
   2. Section 26 0526 – Grounding and Bonding for Electrical Systems
   3. Section 26 0553 – Identification for Electrical Systems

1.2 DEFINITIONS

A. ELCB: Earth Leakage Circuit Breaker

B. TVSS: Transient voltage surge suppressor.

C. The terms "Distribution Board" and "Panel Board" shall be used interchangeably.

1.3 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

D. BS EN 60269 (series) - Low-voltage fuses.

E. BS EN 60439-1:1999, IEC 60439-1:1999 - Low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies.

F. BS EN 60947 (series) - Low-voltage switchgear and controlgear.

G. BS EN 61439 (series) - Low-voltage switchgear and controlgear assemblies.

H. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

1.4 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to the Architect and Engineer.

B. Product Data: for each type of distribution board, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

C. Shop drawings:

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
3. Include wiring diagrams for power, signal, and control wiring.
4. Include time-current coordination curves for each type and rating of overcurrent protective device included in the Distribution Boards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

D. Circuit Schedules: For installation in Distribution Boards. Submit final versions after load balancing.

E. Short circuit and Discrimination study of circuit breakers along with submission of drawings

F. Voltage drop calculations using the same software utilized for short circuit and discrimination studies.

G. Point-wise compliance statement to the specifications duly signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

H. Qualification Data: For qualified testing agency.

I. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

J. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

K. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

L. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers: Two spares of each type for each panelboard.
   3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

M. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

N. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

O. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

P. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

Q. Comply with NEMA PB 1.

R. Comply with NFPA 70.

S. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Source Limitations: All switchgear components and equipment should be manufactured by single original product manufacturer to ensure safety, reliability, maintainability, service.

1.6 COORDINATION

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

B. Maintain required workspace clearances and required clearances for equipment access doors and panels.

C. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace circuit breakers and transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.8 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.9 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.10 DISTRIBUTION BOARDS

A. Distribution Boards shall consist of an assembly circuit breakers mounted inside a dead front enclosure.

B. Bus-bars: Copper, ratings as indicated.

1. Provide copper ground bus in each Distribution Board.

C. Minimum Short Circuit Rating: 22 kA RMS symmetrical

D. Additional equipment to be provided:

1. Main circuit breakers
2. Shunt trip circuit breakers
3. Integral remote control switches
4. Subfeed switches
5. Feed through lugs and/or bus
6. Feed through cabling arrangement
7. Double lugs for multiple cables or for future provisions
8. Circumferential compression lugs where aluminium conductors are employed
9. Ground fault interrupting circuit breakers
10. Oversized gutters
11. Door in door construction for power panels

E. Interiors:

1. Rigid removable assembly of copper bus bars and interchangeable bolted branch circuit devices.
2. Bus bars sized to limit temperature rise on any current carrying part to a maximum of 50 degrees C above an ambient of 50 degrees C maximum.
3. Bus bars drilled to permit branch circuit devices of all sizes and number of poles to be interchangeable and installed in any spare space of sufficient size, without disturbing adjacent units; without removing main bus or branch circuit connectors and without machining, drilling, or tapping in the field.
4. Arrange bus in sequence or distributed phasing so that multi-pole circuit breaker can replace any group of single circuit breakers of the same size.

5. Full-size (100 percent -rated) insulated neutral bars shall be included for Distribution Boards shown with neutral. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection. 200 percent -rated neutrals shall be supplied for panels designated on drawings with oversized neutral conductors and panels served from K-rated transformers.
6. Provide ground bus in each Distribution Board. On 208/120 volt Distribution Boards provide an additional isolated ground bus where required.

F. Enclosure:
1. 1.5 mm minimum thick steel box galvanized.
2. Provide a bolt-on ground connector to inside of enclosure.
3. Flush mounted in finished areas and where indicated.
4. Surface-mount elsewhere.

G. Front:
1. Doors must be provided on all lighting and power panels.
2. Heavy 2.0 mm minimum panel face flat.
3. Hold front closed with trim clamps.
4. Factory finished in medium gray enamel or two coats of air-drying lacquer over a rust inhibitor.
5. Provide cylinder locks. All panels keyed alike.
6. Welded angle rest at the bottom of the door to facilitate cover installation.
7. Doors over 1220 mm in height shall have auxiliary fasteners at top and bottom of door in addition to lock and catch.

H. Multiple Section Panelboards:
1. Split type or multi section Distribution Boards shall be permitted as per local wiring regulations and BS 7671.
2. Maximum permitted ways for each section and overall shall comply with the local wiring regulations.
3. Where multi section boards are used, each section shall be provided with residual current protection as per local wiring regulations or each circuit shall be provided with combined MCB/RCD units.

I. Terminal Lugs:
1. Bolted type, labelled for copper conductors.
2. Locate main lugs properly at top or bottom, depending where main feeder enters.

J. Electrical Ratings:
1. Short circuit withstand ratings shall be as indicated on the Drawings.
2. Panelboards shall be labelled with short-circuit rating. All circuit breakers shall be fully-rated unless the drawings specifically indicate series rated. When series ratings are applied with integral or remote upstream devices, a label or manual shall be provided.

K. Circuit Breaker Devices:
1. Plastic moulded case. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
2. Thermal-magnetic trip-free, trip-indicating, quick-make, quick-break, with inverse time delay characteristics. Single-handle and common tripping multipole breakers.
3. Silver alloy contacts with auxiliary arc-quenching devices.
4. Panelboard must be of the type which will accept the field installation of shunt trip devices of 60 amperes or less on the branch devices.
5. Interrupting capacities shall be 16 kA for 415/240 volts Distribution Boards.

6. For lighting circuits provide devices labelled "SWD" for switching purposes.
7. Bolted type terminals for copper 75 degrees C cables.
8. Provide main breakers in panels served from transformers unless separate transformer secondary protection is provided.
9. Locate next to each breaker or space unit an individual number.
10. Circuit breakers serving computer equipment and those serving kitchen equipment beneath cooking hoods shall include a shunt trip coil.
11. Shunt trip breakers shall be supplied with 240 volt coils. Provide 240 volt circuit from nearest 240 volt panel to coil. Where shunt trip breakers are in emergency panels provide emergency 240 volt source for same from nearest 240 volt emergency panel.
12. Provide locking device for designated breakers.
13. For HVAC equipment provide UL listed "HACR" type devices.

L. J. Ground Fault Interrupters:

1. Ground fault interrupter branch circuit breakers shall be as indicated on the Drawings.
   a. Circuit breakers shall be circuit interrupting which will operate manually for normal switching functions and automatically under overload, short circuit, and 0.005 amp line-to-ground fault conditions.
   b. The operating mechanism shall be entirely trip-free so that contact cannot be held closed against an abnormal overcurrent, short circuit, or ground fault condition.
   c. The device shall be bolt-on type with case construction and shall be interchangeable with standard 1P breakers utilized in the Distribution Board.

M. Switch and Fuse Devices:

1. Quick-make/quick-break, motor rated, dead-front type. Each switch shall be a self-contained unit, externally operable from the front, with provision for padlocking handle in OFF position.
2. Fuse and switch compartment interlocked to prevent access to the fuse compartment until switch is thrown to "OFF" position. Interlock intentionally releasable by externally applied tool to permit checking switch and fuses under load.
3. Switch units interchangeable for replacement, without disturbing balance of distribution Distribution Board's operation.
4. Provide with rejection-type clips for Class R type fuses.
5. Provide Class R rejection type fuses as specified elsewhere.
6. Provide spare fuses as specified elsewhere.

1.11 SPARE WAYS

A. Provide spare ways as shown on drawings/schedules and to ensure 25% spare capacity.

EXECUTION

1.12 INSTALLATION

A. Mount all panels at a maximum height in accordance with local wiring regulations.

B. Where flushed mounted, the fire integrity of the wall in which it is installed must be maintained.

C. Mount top of wall mounted cabinets generally 1800 mm above floor. Coordinate location of recessed panels so they are accessible and to avoid interference with other equipment and trades. Mount and anchor floor set Distribution Boards on a 100 mm high concrete pad furnished by Electrical Contractor.

D. The position of breakers in each panel shall be arranged in the field for sequence phasing by this Contractor to best suit wiring conditions and balancing of phases. Fill in, typewritten, the directory of each branch circuit Distribution Board.

E. Plug all knockouts removed and not utilized.

F. Provide nameplate and fill out panel directory. For remedial work or changes, trace circuits to determine loads and provide new updated directory.

G. Provide grounding and bonding jumpers per Section 16450 and as indicated on the Drawings.

1.13 TESTING

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Distribution boards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

1.14 TOUCH UP AND CLEANING

A. Vacuum all back-boxes clean of debris after installation and prior to contract closeout.

B. Touch up scratch marks, etc. with matching paint.

1.15 DEMONSTRATION

A. All panel fronts shall be removed by the Contractor for observation of the panel interiors by the Consultant.

B. Panel fronts shall be removed when directed by the Consultant for observation and reinstalled immediately after the observations.

C. labelledaluminiumlabelledmouldedlabelled

7.4.17 26 2419 - Motor Control Centres

GENERAL

1.1 SUMMARY

A. This section includes Motor Control Centres (MCC) for use with AC circuits rated 415V and less and having the following components:

1. Bus-bars
2. Motor Starters
3. Variable Frequency Drives

B. Related Sections:

1. Section 260500 – Common Work Results for Electrical
2. Section 260526 – Grounding and Bonding for Electrical Systems
3. Section 260513 – Conductors and Cables
4. Section 260810 – Commissioning of Electrical Works

1.2 DEFINITIONS

A. BMS: Building management system.

B. DOL: Direct On-line

C. DCS: Distributed Control System

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCC: Motor-control center.

I. MCCB: Moulded-case circuit breaker.

J. NC: Normally closed.

K. NO: Normally open.

L. PID: Control action, proportional plus integral plus derivative.

M. SCADA: Supervisory Control and Data Acquisition

N. SCR: Silicon-controlled rectifier.

O. TVSS: Transient voltage surge suppressor.

P. VFC: Variable-frequency controller.

Q. VSD: Variable-speed drive.

1.3 TERMINOLOGY

A. Distributed Control System (DCS) and Supervisory Control and Data Acquisition (SCADA) shall be used interchangeably and may also refer to Building Management System (BMS).

B. Direct-on-line (DOL) and Across-the-line starting method shall be used interchangeably and to have the same meaning.

C. Reduced-voltage starting may also be referred to as Wye-Delta or Y-D, starting.

D. Variable Frequency Controller (VFC) and Variable Speed Drive (VSD) may also be used interchangeably to have the same meaning.

1.4 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

D. BS EN 60439-1:1999, IEC 60439-1:1999 - Low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies.

E. BS EN 60947 (series) - Low-voltage switchgear and controlgear.

F. BS EN 61439 (series) - Low-voltage switchgear and controlgear assemblies.

G. IEC 60068 (series) - Environmental testing.

H. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

I. IEC 61000 (series) - Electromagnetic compatibility (EMC).

J. IEC 61800 (series) - Adjustable speed electrical power drive systems.

1.5 SUBMITTALS

A. Product data: for each product and component submit also relevant sheets of manufacturer's catalogues.

B. Short circuit and Discrimination study of circuit breakers along with submission of drawings

C. Voltage drop calculations using the same software utilized for short circuit and discrimination studies.

D. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

E. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

F. Product Data: For each type of controller and each type of MCC. Include shipping and operating weights, features, performance, electrical ratings, operating characteristics, and furnished specialties and accessories.

G. Shop Drawings: For each MCC, manufacturer's approval and production drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Including dimensioned plans and elevations, component and device lists, and a single-line diagram showing main and branch bus current ratings and short-time and short-circuit ratings of switchboard.
2. Utility company metering provisions with indication of approval by utility company.
3. Schedule of features, characteristics, ratings, and factory settings of individual protective devices.
4. Manufacturer's Schematic Wiring Diagram.
5. Point-to-point Control Wiring Diagram: Differentiating between manufacturer-installed and field-installed wiring.
6. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.
   b. Factory-installed devices.

c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
g. Specified optional features and accessories.

7. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
8. Nameplate legends.
9. Vertical and horizontal bus capacities.
10. Features, characteristics, ratings, and factory settings of each installed unit.

H. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze **[possible] [designated]** operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) to specified levels.

I. Standard Drawings: For each MCC, as defined in UL 845.

J. Production Drawings: For each MCC, as defined in UL 845.

K. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

L. Seismic Qualification Certificates: For MCCs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

M. Qualification Data: For qualified testing agency.

N. Product Certificates: For each MCC, from manufacturer.

O. Source quality-control reports.

P. Field quality-control reports.

Q. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

R. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

S. Warranty: Sample of special warranty.

T. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications and field-assigned wiring identification incorporated during construction by manufacturer, Contractor, or both.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
3. Manufacturer's written instructions for setting field-adjustable overload relays.
4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
5. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
6. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

U. 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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and colour installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.6 QUALITY ASSURANCE

A. Source Limitations: All switchgear components and equipment (MCC panel, motor starters, VFD, Soft starter, contactor, overload relays, circuit breakers, PLCs etc) should be manufactured by single original product manufacturer to ensure safety, reliability, maintainability, service.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate features of MCCs, installed units, and accessory devices with remote pilot devices and control circuits to which they connect.

1.8 WARRANTY

A. Provide a five (5) year extended warranty from date of Practical Completion.

1.9 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.10 NETWORK CONDITIONS

A. Rated Voltage: 240/415 ± 6%, 3 Phase, 4 Wire.

B. Neutral: Solidly Earthed.

C. Fault Level: 31 MVA at 415 V.

1.11 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.12 TYPE TEST & ROUTINE TEST – IEC 60439-1

A. Provide complete distribution equipment, which shall comprise main low tension switch boards, Moulded case circuit breakers (MCCBs), isolators, switch fuses, lighting contactors etc.

B. The supply and distribution arrangement shall be as indicated on schematic diagrams in the Drawings.

C. Evidence of country of origin should be produced on request.

D. Complete range of switchboards Motor Control Centres shall be TTA (Totally typed tested) assemblies as per IEC60 439 standards. The Panel assemblers or Manufacturers should have carried out the below mentioned Type Tests on their equipment.

E. The assemblies shall conform to the following 7 type test defined in IEC 60439-1:

1. Verification of temperature rise.
2. Verification of dielectric properties.
3. Verification of short circuit withstand strength.
4. Verification of the effectiveness of protective circuit.
5. Verification of clearances and creepage distances.
6. Verification of mechanical operation.
7. Verification of degree of protection.

F. All short-circuit withstand strength and temperature-rise limits tests shall be certified by an independent test authority and performed with switchgear installed in real conditions (type tests).

G. Three separate routine tests shall be performed by approved franchised panel builder and witnessed by approved original equipment and product manufacturer:

H. Wiring, electrical operation

I. Insulation test

J. Protective measure test

K. The switchboard will be designed to minimize the risks associated with the propagation of an "internal arcing" fault. It will be in conformance with the requirements of the IEC1641 technical report and AS3439-1 relative to the protection of operators and equipment.

L. The complete switchboard including enclosure, busbar system, circuit breakers, motor starters, major switchgear components, etc shall be from one single principal manufacturer only. Local assembly / local adaptation by only franchised panel builders are allowed however keeping in line with requirements of IEC standards and ensuring local adaptations done do not affect type testing results of prototype.

M. If the switchboard is to be used in a seismic area, the supplier will be informed of the specific acceleration levels required. The supplier will determine the switchboard configuration that is appropriate to the stresses involved.

N. The test certificates will be supplied with the switchboard and refer to IEC, IBC or Nuclear HN20E53 standards.

O. The supplier will be informed of any pollutants, if present (e.g. SO2, H2S) on the site and must provide appropriate coating for the conductors (bus-bars, connections) and metal elements (mechanisms, frames, casing).

1. The surface of the copper parts will be treated to guard against the effects of corrosion.
2. The bolted connections will be coated with 30 microns of tin.
3. All friction contact connections will be coated with 20 microns of nickel, to prevent wear and tear due to friction.
4. The level of protection of the switchboard will be in conformance with IEC 721-3-3.

1.13 MOTOR CONTROL CENTRE

A. This section covers the design, engineering, assembly works testing of low voltage motor control centre. As such high reliability and continuity of supply / service are prime requisites.

B. The switchboard shall be of simple, yet robust modular construction providing a factory built assembly for use as a combined power and Motor Control Centre (PMCC).

C. If shall be floor mounting free standing sheet steel clad modular pattern cubicle type.

D. Assembly shall be manufactured to IEC 60439-1, Form 4, type 7 degree of separation with rear access and IP54 for degree of protection.

E. The busbars will be braced by means of insulating busbar supports fixed to the frame, in number according to the short time current Icw 50 / 85kA for 1 second. The configuration should have been type tested according to IEC 60439-1 by the original single source manufacturer.

1.14 CONSTRUCTION

A. The switchboards shall be based on a unit grid system.

1. The top and bottom frames will be of minimum 2 mm sheet steel thickness and of bolted construction.
2. These frames shall be fitted with gland plates or cover plates depending on the cable entry.
3. The top frame with provision for fitting lifting eye-bolts and the bottom frame with mounting holes for fixing to foundation bolts.

B. The bolted frame shall be mounted in multi tier modular assemblies / compartments that are pre-fabricated to accept the complete range of manufacturers products. Mounting assemblies, together with their functional units shall be bolted to the basic structure which is also modular.

C. The compartment front doors shall be folded at the edges and bolted at the corners with concealed hinges and with rotary front operating handles accessible externally. Side and rear covers shall completely enclose all live parts and complete switchboard shall present a neat flush and aesthetic appearance.

D. A quality assurance program shall be submitted for approval for prior to the assembly / manufacturing of the enclosures.

E. The standardized position of the busbars will enable an easy extension of the switchboard.

F. Assembly doors shall be equipped with a closing system locked by a key / triangle tool / square tool / double-bar tool.

1. The connection between earth and neutral terminal blocks must be rigid and removable only using a tool. No connection between earth and neutral is required if there is an upstream low voltage switchboard.

2. Natural ventilation or controlled ventilation shall make it possible for the switchgear and control gear components to operate within the recommended temperature ranges.
3. The compartments shall be located inside a metal enclosure with separations providing protection against direct contact with live parts and guaranteeing a degree of protection IP 2X.
4. It will satisfy EMC conformity requirements. It will be designed for use in a type A environment in accordance with IEC 60439-1. In particular, the design of the functional volumes will ensure that the sensitive circuits are isolated from the power conductors.
5. In the event of the doors of the functional units being open in the test position or removed, its degree of protection will be IP2X or IPXXB.

G. Form of separation shall be Form 4 Type 7.

H. Provide anti-condensation heaters.

I. Ingress Protection: IP42 for indoor use.

1.15 PAINT FINISH

A. All the framework and paneling parts shall be treated with epoxy, epoxy-polyester paint or with a surface treatment according to the IEC 60068-2-11 tests. They will be of the RAL 9002 shade, and will have a minimum resistance to salt-laden fog of 400 hours.

1.16 BUSBARS

A. The main horizontal busbars shall be HDHC tinned copper running the full length of the switchboard. Rating as shown on the drawings rated for the ambient specified. Supports shall be fiber glass reinforced moulded type material. Current ratings shall suit the loads connected on each Vertical busbar.

B. The dimensioning of the horizontal and vertical bus bar system shall be as per the rated current, the short circuit current, the maximum admissible temperature at permanent operation < 110deg. C and the ambient temperature around the bus bars.

C. Bus bar sizing shall also comply to the local authority regulations and the configuration and size of busbars used should have been type tested by the original manufacturer.

D. Busbar supports should be supplied by the original manufacturer of enclosure and components and provided at the distances as defined in the type test certificates for the obligatory short circuit withstand owing to their criticality for safety and reliability of network.

E. Busbar supports supplied by the single source manufacturer will be the same make, size, material as employed for the earlier type tests. Certificates for the same to be submitted by the manufacturer.

F. Neutral shall be of same size as the phases for Horizontal & Vertical busbar assemblies.

G. Earth bar shall be of minimum 300 sq.mm2 and run the entire length of the switchboard.

1.17 TERMINATION

A. Unless otherwise indicated, cable entry shall be from bottom, cabling access is from the rear.

B. In view of the substantial cable de-rating that is normally applied, adequate terminals and cable termination space shall be provided for the main cabling.

C. For main incoming and outgoing power circuit cabling, terminals allowing the conductors to be connected without the use of cable lugs of any type should be used. Adequate bracing and support for the cables shall be provided to avoid unrestrained movement under short circuit conditions.

D. Individual terminals shall be provided for each conductor of external auxiliary cables.

E. For large power feeders suitably staggered links shall be brought out into the cabling area for easy termination of cables of size as shown on the drawings.

F. For starter feeders power and control cables shall be brought neatly to terminal blocks. Power and control terminals shall be adequately segregated. Power wires shall be colour coded at the terminations as per IEC regulation for wiring colour codes. Control wires shall be multi standard copper with black insulation and ferruled. Terminal blocks should be suitable marked for identification and easy termination of field wires.

G. Gland plates and glands for single core cables shall be of non-magnetic material.

1.18 METERING, INDICATION, CONTROL

A. Conventional meters not to be provided if incoming device in MCC is air circuit breaker. In case incoming device is moulded case circuit breaker, an integrated power meter to be provided for current, voltage, energy, pf display.

B. Indicating lamps, push buttons, control and selector switches shall be neatly and logically flush mounted on the front of the respective equipment compartment doors.

1.19 PROTECTIVE DEVICES FOR MOTOR CONTROL CENTRES

A. The panel builder shall select and provide the appropriate type of components using the specification listed below, in accordance with the contract drawings / documents and applicable international & local standards.

B. Product Data Sheet 1 - Air Circuit Breakers (ACB)

1. The air circuit breakers shall be of the air break, trip free, draw out type with the main contacts encased in a reinforced polyester casing and offer double insulation from the operators on the breaker front face.
2. The air circuit breaker shall be fully tropicalized (T2) as defined in IEC 68.2.30 and shall have salt spray resistance as per IEC 68.2.11.
3. The ACB shall comply with IEC 60947.2 utilization category B with Ics=Icu=Icw=65kW and shall accept reverse feeding without reduction of performance.
4. The ACB shall comply with the isolating function requirements of IEC 60947.2 Section 7.1.2 and shall have minimum 500V 50 Hz operational voltage, 1000 V 50 Hz rated insulation voltage and 12kV withstand surge voltage (Vimp). The 3-pole and 4-pole versions shall have ratings as shown in the drawings. In the 4-pole version the neutral pole shall have the same current rating as the other poles from the 800 to 4000A and N/2 from 5000 to 6300A.
5. Evidence of the service breaking capacity (Ics) and withstand capacity (Icw) shall be produced by test certificates from one of the internationally recognized High Voltage Laboratories (ASTA, CESI, ESEF/ASEFA, KEMA, PEHLA, SATS).
6. The operating mechanism shall be of the O-C-O stored energy spring type with a closing time less than or equal to 80 millisecond.
7. Electrically operated circuit breakers shall have the spring charging motor connected so that the springs remain charged always with the motor disconnected after charging.
8. A standby manual operating handle for spring charging shall be provided for operating the circuit breaker in case of power or motor failure.
9. Anti-pumping function shall be provided by integral devices to prevent reclosing after a close-open operation if the closing impulse is maintained after the breaker has opened.
10. The circuit breaker shall have three positions of the draw-out mechanism, namely service position where all main and auxiliary contacts are made, test position where

main contacts are open but auxiliary contacts are closed and isolated position where all contacts are open.

11. Mechanical indication on the front of the ACB shall be provided to indicate
    a. Main Contacts Closed 'ON'
    b. Main Contacts Open 'OFF',
    c. Springs Charged,
    d. Springs Discharged
    e. Service Position,
    f. Test Position, and
    g. Isolated Position for Draw-out Mechanism.
12. Any attempt to withdraw or insert the breaker when it is 'ON' shall trip the breaker automatically. An interlocking shall be provided to prevent insertion of a circuit breaker having a rating higher than the current rating of the ACB cradle. Insulated safety shutters shall screen all live parts in the ACB cradle when the breaker is in the isolated or racked out position.
13. The moving contacts comprising the main and arcing contacts shall have visual wear indicator and be of the spring-loaded type. The main contacts and clusters shall be site replaceable.
14. The circuit breakers shall have sufficient number of auxiliary contacts for interlocking system as indicated and described on the drawings and shall be suitable for interfacing with building automation system (BAS). It shall be possible to connect all auxiliary wirings from the front face of the air circuit breakers and these wirings shall be taken trough a set of disconnecting contacts, so that all auxiliary wirings are automatically disconnected in the isolated and drawout positions.
15. Air circuit breakers shall be supplied in recyclable packing complying with European Directives. The manufacturer shall implement non polluting production processes that do not make use of chlorofluorocarbons, chlorinated hydrocarbons, ink for cardboard markings, etc...
16. The manufacturer shall provide instructions on the removal, dismantling and processing of Air circuit-breaker materials at the end of service life (material composition, weight, toxicity).
17. All Air circuit breakers will be provided with motor mechanism.
18. All ACB's shall be provided with integral solid state type microprocessor based protection with integral LCD display, which shall use digital programming techniques for highest protection accuracy.
    a. The current transformers / sensors and the wiring shall be integrated within the case and shall be self powered.
    b. The current sensors shall be located within the case of the circuit breaker (Sensors shall be non-magnetic or of the Rogovsky type for accurate current measurements up to Ics value).
    c. The over current relay shall have a wide adjustment range to allow flexibility of setting on site.
    d. The trip unit shall measure the true RMS value of any wave form of current.
    e. The control unit shall be equipped with a push to reset mechanical indicator, for anti-pumping function.
    f. Minimum Protection parameters for integral protection units in ACBs employed as Incoming device:
    g. Adjustable Long time protection (LT)
        1) Adjustable (in steps of 4 percent) from 0,4 to 1 of the sensor rating (In).
        2) Time delay adjustable from 0.5 to 24 seconds

h. Adjustable Short time protection (ST)

1) Adjustable from 1.5 to 10 times the long time protection setting (Ir).
2) Time delay adjustable from instantaneous to 0.4 seconds.
3) Time inverse characteristic (I2t) may be switched in order to improve discrimination

i. Adjustable Instantaneous (INST)

1) Adjustable from 2 times up to at least 15 times the rated current.

j. Where indicated in the drawings for incoming device, the trip unit shall be equipped with an earth fault option.

19. Minimum Protection parameters for integral protection units in ACBs employed as Outgoing device:

a. Adjustable Long time protection (LT)
b. Adjustable (in steps of 4 percent) from 0,4 to 1 of the sensor rating (In).
c. Time delay adjustable from 0.5 to 24 seconds
d. Adjustable Instantaneous (INST)
e. Adjustable from 2 times up to at least 15 times the rated current.
f. Minimum Monitoring parameters for integral protection units in ACBs employed as Incoming device:

20. An integral LCD display shall indicate the currents, voltages, energy values and power values.
21. A LED bar graph shall simultaneously display the load level on the three phases.
22. A maximeter shall store in memory and display the maximum current value observed since the last reset.
23. The data shall continue to be stored and displayed even after opening of the circuit breaker. These values shall be displayable on the screen and updated every second. The minimum and maximum values shall be stored in memory.
24. Minimum Monitoring parameters for integral protection units in ACBs employed as Outgoing device:

a. An integral LCD display shall indicate the currents for each phase.
b. LED bar-graph shall simultaneously display the load level on the three phases.
c. Maximeter shall store in memory and display the maximum current value observed since the last reset.
d. The data shall continue to be stored and displayed even after opening of the circuit breaker.
e. These values shall be displayable on the screen and updated every second. The minimum and maximum values shall be stored in memory.

25. Communication on web server for all air circuit breaker incoming devices

a. All incoming ACB devices (outgoing ACBs optional, if deemed necessary by end client) will communicate on Modbus protocol and via web server on internet (Ethernet). A dedicated IP address at site with authorization will provide fast, easy access to information as follows:
b. A menu enabling easy selection of the web pages: Five (5) summary pages preloaded in factory supplying shared data for the units.
c. General page: name of power devices in the equipment, RMS or complex voltage, average current A, Active power kW, power factor, circuit breaker position as appropriate.

d. Instant load current page: power device name in the equipment, RMS current per phase A B C in Amperes.
e. Average load current page: power device names in the equipment, average current per phase A B C in Amperes.
f. Power page: power device names in the equipment, current values in kW, maximum recorded values in kW with date and time of appearance.
g. Energy page: name of power devices in the equipment, active energy in kWh, reactive kVAr and date of last reset.
h. Per unit: detailed page with real time data refreshing adapted to each device, Long term recordings (at least 150 days) of energies as appropriate in the form of value curves and tables. The tables can be exported via the FTP web service on Ethernet in CSV format and excel format.
i. Data logs of incoming device should be periodically pushed by sending e-mails to the relevant maintenance and operational staff at site.
j. Alarm notification on GSM should be available.
k. Web server installed should be from the original manufacturer (refer clause2.01) and should contain preloaded application web pages which allows to view MCC switchboard remotely from any PC terminal with internet connectivity without installing any propriety software on PC and which does not require specialized staff for operation and maintenance.
l. A live simulation shall be demonstrated to site consultant, contractor, and end client. This live demonstration platform should be available for viewing on twenty four (24) hours/seven (7) days basis. This unit shall be complete with all the required software, converters and cabling to enable maintenance and operation staff to become fully conversant with the routine operation and maintenance.

C. Product Data Sheet 2 - Moulded case circuit breakers (MCCBs)

1. The moulded-case circuit breakers shall comply with IEC 60947-1, IEC 60947-2 standards. They shall be of category A with a rated service breaking capacity (Ics) equal to the ultimate breaking capacity (Icu) - on the operational voltage range for the ratings up to 630A. Breaker selection will be done as per short circuit levels mentioned in the drawings however minimum service breaking capacity Ics will be 36KA.
2. MCCBs for feeder application shall be fitted with thermal over load and instantaneous magnetic short circuit protection, whereas MCCBs for motor starters will have integral instantaneous protection only.

D. All the MCCB shall be of current limiting type and shall not require any backup fuses. MCCBs shall be fully fault rated for the duty they perform.

1. MCCBs shall have a rated operational voltage of 690V AC and have a rated insulation voltage of 750V AC.
2. The moulded-case circuit breakers shall provide class II insulation (according to IEC 664 standard) between the front and internal power circuits.
3. The moulded-case circuit breakers shall be designed for both vertical and horizontal mounting, without any adverse effect on electrical performance. It shall be possible to supply power either from the upstream or downstream side.
4. For maximum safety, the power contacts shall be insulated in an enclosure made of a thermosetting material from other functions such as the operating mechanism, the case, the trip unit and auxiliaries.
5. The operating mechanism of the moulded-case circuit breakers shall be of the quick-make, quick-break type with fault tripping overriding manual operation.

6. All poles shall operate simultaneously for circuit breaker opening, closing and tripping.
7. The moulded-case circuit breakers shall be actuated by a rotary handle that clearly indicates the three positions:
   a. ON, OFF and TRIPPED.
8. The moulded-case circuit breakers shall be able to receive a device for locking in the "isolated" position, with up to three (3) padlocks.

E. Product Data Sheet 3 - Earth leakage relays (ELRs):
1. ELR and sensors shall comply with IEC 364 and IEC 755 standards.
2. ELR shall be modular type. ELR shall be suitable for rail mounting or panel front mounting.
3. ELR shall be residual current operated protection relay and core balance current transformer operated type.
4. ELR shall have fixed earth leakage sensitivity setting and shall be instantaneous in operation. Sensitivity will be provided as indicated in the drawings.
5. ELR shall have a test push button built in on the front face of the relay to test the ELR whenever required.
6. ELR shall be of manual reset type and shall have a reset push button built in on the front face of the relay to reset after a earth leakage trip. Wherever required, it shall be possible to have a remote reset type of relay.
7. ELR shall have a built in LEDs on the front face of the relay to indicate the relay is energised and relay trip status.
8. All terminals of the ELR shall be of screw type.
9. Core balance current transformer (CBCT) shall be provided for each relay.
10. Core balance current transformers shall be installed on the power cables and hole the sizes of the CBCT shall be suit the cable sizes. All such transformers shall be supplied with suitable installation accessories.
11. Special screened cables shall be used for interconnection between the CBCT and ELR.
12. Unless otherwise indicated, ELR and CBCT shall be two separate units.

F. Product data sheet 4 - Indication lamps
1. Indicating lamps shall be rated to withstand not less than 20% continuous over voltage and shall be rated to ensure long life. The applied voltage shall not exceed 80% of the lamp rated voltage.
2. Lamps shall well be ventilated and the design shall permit removal lamp glass and bulbs from the front of the unit.
3. The indicating lamps shall of matching design to push buttons arranged for single hole fixing and of small body size to allow close grouping.
4. All terminals shall be of screw type.
5. Indicating lamps on 240V supply shall of the direct bulb type operating at a reduced voltage not exceeding 10 volts to give long bulb life and be of LED type or as approved by the Consultant.
6. Indicating lamps shall have shallow bezels which incorporate plastic lenses of the specified colour.
7. Engraved legend plates shall be fitted with all indicating lamps.
8. The engraved legend plates shall be made from special flexible pvc sheet or anodized aluminium sheet. The minimum characters height on the engraved legend sheet shall be 3mm. The text shall be black colour on a white background.
9. The colour of the lenses shall be as per the specific function and in compliance with applicable IEC standard.

10. The IP index of the front face of the indication lamp shall be IP55 as minimum.

G. Product Data Sheet 5 - Push Buttons:

1. Push buttons shall of matching design to indicating lamps arranged for single hole fixing and of small body size to allow close grouping.
2. Unless otherwise specified, the push buttons shall be of spring return type. Wherever used for emergency shutdown / stop purpose, push button shall be of red colour, mushroom head, push-to-stop, stay-put, turn or pull-to-release type.
3. Push buttons shall accept contact blocks either clipped or screwed to its back holder.
4. Add on contact blocks shall be of N/O or N/C type as required and all such contacts shall be rated for 5A inductive.
5. Push buttons shall be possible to include up to 8nos. of contact blocks.
6. All contact block terminals shall be of screw type.
7. Push buttons shall be of different colour as per their function and in compliance with applicable IEC standard.
8. Engraved legend plates shall be fitted with all push buttons.
9. The engraved legend plates shall be made from special flexible pvc sheet or anodised aluminium sheet. The minimum characters height on the engraved legend sheet shall be 3mm.The text shall be black colour on a white background.
10. The IP index of the front face of the push button shall be IP55 as minimum.

H. Product Data Sheet 6 – Contactors:

1. Contactors shall comply to IEC 60947-4 standards
2. Contactors shall be shall be suitable for rated insulation voltage up to 690 volts.
3. Contactors shall be suitable for operation at 55 deg.C without derrating.
4. Contactors shall be of AC3 duty and of 3 pole type unless otherwise specified.
5. Contactors coils operational voltage(Uc) shall be between 0.8 to 1.1Uc and drop out at 0.3 to 0.6Uc.
6. Contactors, when used in motor starters, shall be coordinated with the upstream protection for Type 2 coordination.
7. It shall be possible to easily replace the coil of the contactor.
8. Contactors at any time shall accommodate auxiliary contacts or pneumatic time delay blocks on front face and at least two auxiliary contact blocks on each side / front facia of the contactor.
9. Contactors for capacitor switching shall be of capacitor switching type contactors suitably rated for the capacitor current. It shall be fitted with a block of early make poles and damping resistors, limiting the value of the current on closing to 80In max. This current limitation increase the life of all the components of the installation, in particular that of the fuses and the capacitors.
10. Contactors shall have an additional front safety cover for dust protection and prevention of inadvertent manual operation.
11. Coil insulation for contactor shall comply to Class H with inbuilt surge suppressor.

I. Product Data Sheet 7 - Over load relays:

1. Overload relays shall comply to IEC 60947-1 and 60947-4 standards.
2. Overload relays shall be shall be suitable for rated insulation voltage up to 690 volts.
3. Over load relay shall be suitable for operation at 55 deg.C.
4. Over load relay shall be three pole bimetal thermal over type and be equipped with the bimetal element on all the three poles.
5. Unless otherwise specified the overload relays shall always be of Class 10A
6. Overload relay setting range shall be adjustable within a range and shall be selected to suit the requirement.

7. Overload relays shall be with suitably rated N/O & N/C contacts
8. Over load relays shall be with a auto / manual mode selector to select the type of fault reset. Unless otherwise specified the reset shall be always selected to manual.
9. Over load relays shall be with a test button accessible with a screw driver to allow the checking of control wiring.
10. Over load relays shall be with a trip indicator.
11. Wherever required it shall be fitted with a external reset push button (mechanical reset) or an electric reset Facility As Indicated On The Drawings.

J. Product Data Sheet 8 - Panel Heater:

1. Thermostatically controlled heaters to prevent condensation and assist ventilation shall be provided wherever required.
2. The rating of any one of the unit shall not exceed 60Watts and the surface temperature of any part there may be contacted accidentally shall not exceed 65 degrees C.
3. The heaters shall be so situated that no deterioration can be caused to any of the apparatus or wiring in the cable.
4. The heating circuit shall be independently fused and controlled by a suitably labelled selector switch mounted in an accessible position with in the cubicle.

K. Product Data Sheet 9 - Motor Starters Feeders

1. All starters shall comply fully with IEC standards stated under clause 1.02 Quality Assurance, prototypes be fully type tested within enclosure and shall be type tested combinations to type 2 coordination. Type test certificates shall be provided with tender documentation. Standardized, engineered, integrated starters shall be available as type tested designs within enclosure system.
2. Basic starter construction for direct on line and star delta upto 75kW will be drawout type. All other types will be in fixed execution. Withdrawable starter compartments shall be built in compliance with IEC 60439-1 which regulates the drawer extraction and locking system.
3. The connection mechanism shall be designed to allow the drawer to be set to any of the four distinct positions namely:
   a. Connected – power and auxiliary circuits are all connected. This position may be locked using up to three (3) padlocks. A safety system prevents door opening as long as the circuit breaker is closed (ON position),
   b. Test - power circuits are disconnected (upstream and downstream), auxiliary circuits remain connected. This position may be locked using up to (3) padlocks,
   c. Disconnected – all circuits are disconnected. This position may be locked using up to (3) padlocks and removed.
4. The degree of protection for starter compartments (minimum IP54) same as Motor Control Centre should be maintained in all positions (connected, test, disconnected and drawer removed). Lower degree of protection in situations of test/ disconnected/removed position is not acceptable.
5. Power connection to vertical busbars (at the rear) shall be via plug-in stab contacts. Cable or flexible bus power connections are not permitted. These stab-in contacts shall have withstood a prospective fault current of 50kA without damage, be self aligning and designed to increase contact pressure under fault conditions. The vertical busbars for withdrawable starters will be bare copper or nickel plated (tin plating for vertical busbars is not acceptable due to possibility of corrosion between stab-in power contacts and vertical busbars).

6. In the case of withdrawable functional units, withdrawing from one position to another must be mechanically latched and should be padlockable. The position of the drawers should be indicated by an indicator and also by the position of the front plate of the drawer.
7. Starter Type 1 - Direct on line starting:
   a. Starter type 1 will be withdrawable type. Motor starter will be engineered with rated MCCB, contactor, overload relay, indicating lamps, pushbuttons, selector switches, control relays etc and shall be designed and certified by original equipment and product manufacturer to ensure full type test conditions are met for type 2 coordination.
   b. All control devices (selector switches, pushbuttons, indicating lamps), metering devices will be mounted on door of the starter compartment.
   c. In case of intelligence starter modules, conventional products will be replaced through integration of motor controller.
   d. Direct on line starters will be limited upto 3.75kW.
8. Starter Type 2 - Star delta starting:
   a. Starter type 2 will be withdrawable type upto 75kW (above 75kW will be fixed execution only). Motor starter will be engineered with rated MCCB, contactors (all 3 equal ratings), overload relay, indicating lamps, pushbuttons, selector switches, control relays etc and shall be designed and certified by original equipment and product manufacturer to ensure full type test conditions are met for type 2 coordination. All control devices (selector switches, pushbuttons, indicating lamps), metering devices will be mounted on door of the starter compartment.
   b. In case of intelligence starter modules, conventional products will be replaced through integration of motor controller.
   c. Starter type 2 will be provided for starter as indicated in Single Line Diagram.
9. Starter Type 3 - Microprocessor based SCR controlled Soft Start and Soft Stop unit with torque control for fan and pump applications requiring fixed speed
   a. Starter type 3 will be in fixed execution with rated MCCB, external by-pass contactor (internal contactor is not allowed to limit temperature rise), soft starter, selector switches, control relays etc and shall be designed and certified by original equipment and product manufacturer to ensure full type test conditions are met for type 2 coordination.
   b. The operating principle of the starter will not have to rely simply on motor current limitation during the transitory phases or on a voltage ramp, but on motor torque control. The starter will have to provide a torque ramp throughout the accelerating phase. Therefore, it will be able to control the torque throughout the entire starting phase and, if necessary, provide a constant motor torque throughout the accelerating phase. For pumping applications, the deceleration will have to be made on a torque ramp.
   c. All motor starters controlled by soft starters will have to have the same control card. This control card will have to be identical for all applications and also, the same starter will be able to be used on a crusher, a pump or a conveyor (taking into account the dimensioning).
   d. The starter will have to be capable of operating, without derating, at an ambient temperature range between –10 and +60 degrees C with a derating factor of 2 percent per degree C above 40 degrees C. The noise level of the Soft Starter, must not exceed 65 dBA switched automatically in relation to the temperature of the heatsink.

e. The utilization category of the starters will be AC 53a conforming to the product standard EN/IEC 60947-4-2. The current range of the starters will be comprised between 17 and 1200 A.
f. The starter will incorporate PTC probe processing.
g. The starter will have to continuously calculate the heating of the motor from the actual current measured (the current having to be measured and not estimated). Several classes of thermal protection will have to be offered conforming to the standard EN/IEC60947-4-2: classes 10A, 10, 20, 30 as well as the intermediary classes; one inferior to class 10A, one between classes 10 and 20 and one between classes 20 and 30. The calculation of the thermal protection must be performed even when the starter is not being supplied. The starter will be protected against thermal overloads.
h. The starter will detect an underload and overload from the motor torque information.
i. The starter will have to have protection against supply line phase inversion and also against phase failure of the supply or motor.
j. The starter will take into account management of an external fault. When the contact is open, the starter goes to fault mode.
k. The protective functions will have to be maintained even when the starter is bypassed by a contactor.
l. The standard starter will have to have a dialogue screen and programming keys.
m. All soft starters shall be able to communicate through a multidrop serial link for direct connection on Modbus.
n. In case of intelligence starter modules, conventional products will be replaced through integration of motor controller.
o. Optional Communication on web server for starter type 3:
p. If deemed necessary by end client (necessary written approval IF NOT needed to be obtained from end client).
q. All soft starters will communicate on same communication bus of the incoming device and via web server on internet (Ethernet). The same dedicated IP address at site will provide fast, easy access to information as follows:
r. A menu enabling easy selection of the web pages: Five (5) summary pages preloaded in factory supplying shared data for the units.
s. General page: name of power devices in the equipment, RMS or complex voltage, average current A, Active power kW, power factor, circuit breaker position as appropriate. For motor feeders – speed variator or direct motor feeder – the thermal status of the motor is given, the open/closed position, output frequency as appropriate and RMS currents.
t. Instant load current page: power device name in the equipment, RMS current per phase A B C in Amperes.
u. Average load current page: power device names in the equipment, average current per phase A B C in Amperes.
v. Power page: power device names in the equipment, current values in kW, maximum recorded values in kW with date and time of appearance.
w. Energy page: name of power devices in the equipment, active energy in kWh, reactive kVAr and date of last reset.
x. Per unit: detailed page with real time data refreshing adapted to each device, Long term recordings (at least 150 days) of energies as appropriate in the form of value curves and tables. The tables can be exported via the FTP web service on Ethernet in CSV format and excel format.
y. Alarm notification on GSM should be available.

z. Web server installed should be from the original manufacturer (refer clause2.01) and should contain preloaded application web pages which allows to view MCC switchboard remotely from any PC terminal with internet connectivity without installing any propriety software on PC and which does not require specialized staff for operation and maintenance.

aa. A live simulation shall be demonstrated to site consultant, contractor, end client. This live demonstration platform should be available for viewing on 24 hours/7 days basis. This unit shall be complete with all the required software, converters and cabling to enable maintenance and operation staff to become fully conversant with the routine operation and maintenance of the SCU, FCU and ICU.

10. STARTER TYPE 4 - Variable frequency drives with external by-pass contactor for Pumping applications (namely Chiller, Landscaping, HVAC)

a. Starter type 4 will be in fixed execution with rated MCCB, external by-pass contactor (internal contactor is not allowed to limit temperature rise), Variable frequency drive (VFD), selector switches, control relays etc and shall be designed and certified by original equipment and product manufacturer to ensure full type test conditions are met for type 2 coordination.

b. The VFD Drive shall be able to start and control the speed of a standard squirrel cage induction AC motor.

c. The materials used in the VFD Drive shall be recyclable, non-toxic and flame retardant. The VFD Drive shall comply with the European directive ROHS (Restriction Of Hazardous Substances) that prohibits the use of materials such as lead, chromium 6 etc.

d. The VFD Drive shall be a digitally controlled drive, using, the Pulse Width Modulation (PWM) with flux vector control open loop. It shall have IGBT's in the inverter section of the throughout the power range.

e. The VFD Drive shall comply with electromagnetic compatibility requirements and line input current harmonics mitigation requirements as per IEC 61800-2, IEC610000-3-12.

f. In case of intelligence starter modules, conventional products will be replaced through integration of motor controller.

L. Motor control type:

1. Quadratic kN^2
2. Energy saving
3. Sensoreless (SVC) voltage vector control for AC motors for multiple motors supply
4. Sensoreless (SVC) current vector control for AC motors for a single motor supply
5. Volt per hertz 2 or 5 points for AC motors
6. Sensoreless vector control for synchronous motors ; permanent magnet motor
7. Speed range in the motor quadrant: 1:100 in sensoreless vector control
8. Speed range in the generator quadrant:1:50 in sensoreless vector control
9. Overtorque capability: at least 130 percent of the rated motor torque (typical value) during 60 s.
10. Speed accuracy: 10 percent of the nominal slip of the motor in sensoreless vector control
11. Torque control accuracy: 15 percent in sensoreless vector control for AC motors.

M. Protections:

1. Circuit breaker coordination and short circuit protection shall eliminate the need for current-limiting and semiconductor fuses. Manufacture who require the use of semiconductor or current limiting fused will not be approved.

2. Upon power-up the VFD Drive shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, dynamic brake failure, DC to DC power supply, control power and the pre-charge circuit.
3. The Power Converter shall be protected against short circuits, between output phases and ground; and the logic and analog outputs.
4. The deceleration mode of the VFD Drive shall be programmable for normal and fault conditions. The stop modes shall include freewheel stop, emergency stop and DC injection braking.
5. Upon loss of the analog process follower reference signal, the VFD Drive shall fault and/or operate at a userdefined speed set by a software programmed speed settings or last speed.
6. The VFD Drive shall integrate a protection against IGBT chips over temperature that is different to the heatsink soverheat.
7. The VFD Drive shall have solid state thermal protection that meets IEC 947.
8. The VFD Drive should be able to protect the motor when PTC probes are connected.
9. The VFD Drive should be able to limit the motor surge at twice the DC bus voltage
10. The VFD Drive shall display all faults.

N. Safety:

1. The VFD Drive shall be integrated directly in the safety chain complying with EN 954-1 category 3, and with IEC/EN 61508-1 SIL2.
2. This safety function shall comply with standard for safety of machinery EN 954-1, category 3 ; standard for functional safety IEC/EN 61508, SIL2 capability (safety control-signaling applied to processes and systems)
3. The VFD Drive manufacturer shall provide the certified schematics and the list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.
4. The relay contacts shall comply with EN-81 13.2.2.3
5. Specifically for VFD drives above 75kW, "Power Removal" safety function should be integrated which prohibits unintended equipment operation. This safety function shall comply with standard for safety of machinery EN 954-1, category 3 ; standard for functional safety IEC/EN 61508, SIL2 capability (safety control-signaling applied to processes and systems).
6. The "Power Removal" safety function shall have a redundant electronic architecture (1) that shall be monitored continuously by a diagnostics function.
7. The "Power Removal" safety function shall comply with the definition of the draft product standard IEC/EN 61800-5-2 for both stop functions, Safe Torque Off ("STO") and Safe Stop 1 ("SS1").

O. Communications:

1. The VFD Drive shall have integrated standard Modbus RS485 port communication.
2. The VFD Drive shall have the capability for internal mounted communication card. The following protocols should be the minimum available:
   a. LonWorks
   b. BACnet
   c. METASYS N2
   d. APOGEE FLN
3. The command and reference may come from different control sources:
   a. I/O terminals
   b. Communication network
   c. Remote display terminal

4. The VFD Drive shall be able the switching of these control sources according to the application requirements.
5. The VFD Drive behavior shall be programmable on communication fault
6. Optional Communication on web server for starter type 4: If deemed necessary by end client (necessary written approval IF NOT needed to be obtained from end client).
    a. All VFD starters will communicate on same communication bus of the incoming device and via web server on internet (Ethernet). The same dedicated IP address at site will provide fast, easy access to information as follows:
    b. A menu enabling easy selection of the web pages: Five (5) summary pages preloaded in factory supplying shared data for the units.
    c. General page: name of power devices in the equipment, RMS or complex voltage, average current A, Active power kW, power factor, circuit breaker position as appropriate. For motor feeders – speed variator or direct motor feeder – the thermal status of the motor is given, the open/closed position, output frequency as appropriate and RMS currents.
    d. Instant load current page: power device name in the equipment, RMS current per phase A B C in Amperes.
    e. Average load current page: power device names in the equipment, average current per phase A B C in Amperes.
    f. Power page: power device names in the equipment, current values in kW, maximum recorded values in kW with date and time of appearance.
    g. Energy page: name of power devices in the equipment, active energy in kWh, reactive kVAr and date of last reset.
    h. Per unit: detailed page with real time data refreshing adapted to each device, Long term recordings (at least 150 days) of energies as appropriate in the form of value curves and tables. The tables can be exported via the FTP web service on Ethernet in CSV format.
    i. Alarm notification on GSM should be available.
    j. Web server installed should be from the original manufacturer (refer clause2.01) and should contain preloaded application web pages which allows to view MCC switchboard remotely from any PC terminal with internet connectivity without installing any propriety software on PC and which does not require specialized staff for operation and maintenance.
    k. A live simulation shall be demonstrated to site consultant, contractor, client. This live demonstration platform should be available for viewing on twenty four (24) hours/seven (7) days basis. This unit shall be complete with all the required software, converters and cabling to enable maintenance and operation staff to become fully conversant with the routine operation and maintenance.
7. Programming terminal:
    a. For ratings upto 75kW the VFD Drive shall have a remote keypad with 4 x 7 segments display for programming and controlling purposes. An IP54 or IP65 remote mounting shall be possible at a distance of 5m.
    b. The programming shall be able to operate in a multi-point connection.
    c. Parameter setting shall be easily accessible and user friendly.
    d. Password protection shall be provided to avoid unauthorized tampering with the set parameters.

e. The programming terminal shall offer the possibility of memorizing and downloading 4 configurations of the AC drives to save time during the commissioning and to avoid mistakes.
f. 4 programmable function keys shall be available for short cuts, application functions
g. The programming terminal shall integrate a Simply Start (Quick) menu for fast and easy commissioning.
h. For higher rating motors (above 75kW) the VFD Drive shall have a detachable keypad with a back lit 8-line, with a minimum of 23-character alphanumeric operating display for programming and controlling purposes. An IP54 or IP65 remote mounting shall be possible at a distance of 10m. The programming shall be able to operate in a multi-point connection. The displayed messages shall be in user friendly, descriptive text. Coded messages are not acceptable.
i. Using a shuttle button shall carry out the navigation in the menu and the parameter setting.
j. Parameter setting shall be easily accessible and user friendly with actual text messages and actual setting range.
k. Visibility and protection shall be selected for each parameter. Password protection shall be provided to avoid unauthorized tampering with the set parameters.
l. The programming terminal shall offer the possibility of memorizing and downloading 4 configurations of the AC drives to save time during the commissioning and to avoid mistakes.
m. 4 programmable function keys shall be available for short cuts, application functions
n. Monitoring shall be possible up a distance of 5 meters. By using digital values and/or bar graph. Dedicated functions shall be provided such as I/O map, Communication map.
o. The programming terminal shall be able to display the commercial reference of the VFD Drive and of the options, the software version, the serial number

P. STARTER TYPE 5 - Variable frequency drives with external by-pass contactor for Industrial applications (Lift, Crane, Crusher, Mixer, Textile)

1. Starter type 5 will be in fixed execution with rated MCCB, external by-pass contactor (internal contactor is not allowed sto limit temperature rise), Variable frequency drive (VFD), selector switches, control relays etc and shall be designed and certified by original equipment and product manufacturer to ensure full type test conditions are met for type 2 coordination.
2. The VFD Drive shall be able to start and control the speed of a standard squirrel cage induction AC motor.
3. The materials used in the VFD Drive shall be recyclable, non-toxic and flame retardant. The VFD Drive shall comply with the European directive ROHS (Restriction Of Hazardous Substances) that prohibits the use of materials such as lead, chromium 6 etc.
4. The VFD Drive shall be a digitally controlled drive, using, the Pulse Width Modulation (PWM) with flux vector control open loop. It shall have IGBT's in the inverter section of the throughout the power range.
5. The VFD Drive shall comply with electromagnetic compatibility requirements and line input current harmonics mitigation requirements as per IEC 61800-2, IEC610000-3-12.
6. In case of intelligence starter modules, conventional products will be replaced through integration of motor controller.

7. Motor Control Type:
   a. Sensorless (svc) voltage vector control for ac motors for multiple motors supply
   b. Sensorless (SVC) current vector control for AC motors for a single motor supply
   c. Closed loop current vector control for AC motors for a single motor supplied□
   d. Sensorless vector control for synchronous motors
   e. Energy Adaptation system (ENA) for unbalanced load
   f. Speed range in the motor quadrant: 1:100 in sensoreless vector control, 1:1000 in closed loop vector control,1:50 in sensor-less vector control for synchronous motors
   g. Speed range in the generator quadrant: 1:50 in sensor-less vector control, 1:1000 in closed loop vector control, 1:50 in Sensor-less vector control for synchronous motors
   h. Overtorque capability: at least 170 percent of the rated motor torque during 60s Speed accuracy: 10 percent of the nominal slip of the motor in sensor-less vector control, □0.01 percent of the nominal speed of the motor in closed loop vector control.
   i. Torque control accuracy: 15 percent in sensor-less vector control for ac motors, 5 percent in closed loop vector control for ac motors
   j. Braking capabilities: up to 160kw, the drive shall integrate a braking LGBT, from 200 kW up to 500kW, the braking LGBT could be external

8. Protection
   a. Circuit breaker coordination and short circuit protection shall eliminate the need for current-limiting and semiconductor fuses. Manufacture who require the use of semiconductor or current limiting fused will not be approved.
   b. Upon power-up the VFD Drive shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, dynamic brake failure, DC to DC power supply, control power and the pre-charge circuit.
   c. The Power Converter shall be protected against short circuits, between output phases and ground; and the logic and analog outputs.
   d. The deceleration mode of the VFD Drive shall be programmable for normal and fault conditions. The stop modes shall include freewheel stop, emergency stop and DC injection braking.
   e. Upon loss of the analog process follower reference signal, the VFD Drive shall fault and/or operate at a user-defined speed set by a software programmed speed settings or last speed.
   f. The VFD Drive shall integrate a protection against IGBT chips over temperature that is different to the heat-sink overheat.
   g. The VFD Drive shall have solid state thermal protection that meets IEC 947.
   h. The VFD Drive should be able to protect the motor when PTC probes are connected.
   i. The VFD Drive should be able to limit the motor surge at twice the DC bus voltage
   j. The VFD Drive shall display all faults.
   k. The VFD drive shall have a minimum AC under-voltage power loss ride-through of 200 msec. The AC Drive shall have the user-defined option of frequency fold-back to allow motor torque production to continue to increase the duration of the power loss ride-through.

l. The VFD drive shall display all faults in plain text and help screens shall be available to guide the user in the troubleshooting. Codes are not acceptable.

9. Safety

a. The VFD Drive shall be integrated directly in the safety chain complying with EN 954-1 category 3, and with IEC/EN 61508-1 SIL2.
b. This safety function shall comply with standard for safety of machinery EN 954-1, category 3 ; standard for functional safety IEC/EN 61508, SIL2 capability (safety control-signaling applied to processes and systems)
c. The VFD Drive manufacturer shall provide the certified schematics and the list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.
d. The relay contacts shall comply with EN-81 13.2.2.3
e. Specifically for VFD drives above 75kW, "Power Removal" safety function should be integrated which prohibits unintended equipment operation.

1) The motor no longer produces torque. This safety function shall comply with standard for safety of machinery EN 954-1, category 3;
2) Standard for functional safety IEC/EN 61508, SIL2 capability (safety control-signaling applied to processes and systems). The "Power Removal" safety function shall have a redundant electronic architecture that shall be monitored continuously by a diagnostics function.
3) The Power removal function shall comply with the definition of the draft product standard IEC/EN 61800-5-2 for both stop functions, Safe Torque Off ("STO") and Safe Stop 1 ("SS1").

10. Communications

a. The VFD Drive shall have integrated standard Modbus RS485 port communication.
b. The VFD Drive shall have the capability for internal mounted communication card. The following protocols should be the minimum available:
c. LonWorks
d. BACnet
e. METASYS N2
f. APOGEE FLN
g. The command and reference may come from different control sources:
h. I/O terminals
i. Communication network
j. Remote display terminal
k. The VFD Drive shall be able the switching of these control sources according to the application requirements.
l. The VFD Drive behavior shall be programmable on communication fault

Q. Optional Communication on web server for starter type 5:

1. If deemed necessary by end client (necessary written approval IF NOT needed to be obtained from end client).
2. All VFD starters will communicate on same communication bus of the incoming device and via web server on internet (Ethernet). The same dedicated IP address at site will provide fast, easy access to information as follows:

a. A menu enabling easy selection of the web pages: Five (5) summary pages preloaded in factory supplying shared data for the units.
b. General page: name of power devices in the equipment, RMS or complex voltage, average current A, Active power kW, power factor, circuit breaker position as appropriate. For motor feeders – speed variator or direct motor

feeder – the thermal status of the motor is given, the open/closed position, output frequency as appropriate and RMS currents.

c. Instant load current page: power device name in the equipment, RMS current per phase A B C in Amperes.
d. Average load current page: power device names in the equipment, average current per phase A B C in Amperes.
e. Power page: power device names in the equipment, current values in kW, maximum recorded values in kW with date and time of appearance.
f. Energy page: name of power devices in the equipment, active energy in kWh, reactive kVAr and date of last reset.
g. Per unit: detailed page with real time data refreshing adapted to each device, Long term recordings (at least 150 days) of energies as appropriate in the form of value curves and tables. The tables can be exported via the FTP web service on Ethernet in CSV format.
h. Alarm notification on GSM should be available.
i. Web server installed should be from the original manufacturer (refer clause2.01) and should contain preloaded application web pages which allows to view MCC switchboard remotely from any PC terminal with internet connectivity without installing any propriety software on PC and which does not require specialized staff for operation and maintenance.
j. A live simulation shall be demonstrated to site consultant, contractor, end client. This live demonstration platform should be available for viewing on 24 hours/7days basis. This unit shall be complete with all the required software, converters and cabling to enable maintenance and operation staff to become fully conversant with the routine operation and maintenance.

3. Programming terminal

a. All VFD Drive for Starter type 5 shall have a detachable keypad with a back lit 8-line, with a minimum of 23- character alphanumeric operating display for programming and controlling purposes. An IP54 or IP65 remote mounting shall be possible at a distance of 10m. The programming shall be able to operate in a multi-point connection. The displayed messages shall be in user friendly, descriptive text. Coded messages are not acceptable.
b. Using a shuttle button shall carry out the navigation in the menu and the parameter setting.
c. Parameter setting shall be easily accessible and user friendly with actual text messages and actual setting range.
d. Visibility and protection shall be selected for each parameter. Password protection shall be provided to avoid unauthorized tampering with the set parameters.

4. The programming terminal shall offer the possibility of memorizing and downloading 4 configurations of the AC drives to save time during the commissioning and to avoid mistakes.
5. 4 programmable function keys shall be available for short cuts, application functions
6. Monitoring shall be possible up a distance of 5 meters. By using digital values and/or bar graph. Dedicated functions shall be provided such as I/O map, Communication map.
7. The programming terminal shall be able to display the commercial reference of the VFD Drive and of the options, the software version, the serial number.
8. Application programming for Starter type 4 & Starter type 5

a. VFD Drives shall be designed for pump and fan applications, and should be user friendly. The VFD Drive shall have built-in application macros available in Macro configuration menu, to allow selection of the range of pre-programmed control configurations and further, the VFD Drive shall be able to store at least two customer modified macro configuration, to suit the specific application. It shall be possible to reset the parameter settings back to the original macro settings through the keypad.

9. Multi-pump applications for starter type 4 and starter type 5

a. The VFD Drive Supplier shall incorporate all the application function for managing pumping installations as sleeping , wake-up, friction loss compensation, low or no flow detection, underload detection, overload detection , PID regulator with preset PID references, night and day algorithm, pressure boost mode, pipe file algorithm, staging and de-staging algorithm, cavitation protection, over pressure protection, low water level protection, pipe burst and pipe blockage protection, cycling protection.

b. The drive shall be able to manage main communication protocols and Smart Card application in the same time (to enable single drive to control upto maximum 5 pump applications). Smart Card feature their own I/O. They shall manage I/0 on the drive as well as those on I/O extension cards. They shall also make use of drive parameters such as those for speed, current, torque, etc.

c. The VFD Drive shall incorporate dedicated menu link to multi-pump application through a graphic keypad.

10. Multipump applications:

a. The Multipump system will operate: through PI regulation and it must maintain any preset value depending upon the user requirement. It can be:

b. Either pressure, or flow, or temperature, or level.

c. The drive shall control a maximum of five motors together without any PLC or HMI, through one integrated Smart Card.(Multipump Card) However for the sequence of operation, mini PLC / Controller to be employed in lieu of plug-in relays.

11. Monitoring Functions

a. The drive will visualize the system status and monitor the system only through the control keypad terminal, the terminal will display the following values: (The electrical values of the motor on drive):

b. Current, Voltage, Frequency, Rpm, Temperature, Kw, cos (Ø)

c. Operating time of each pump in hours

d. The actual value (a.v.)

e. The preset value delays for the switching

f. This system should be user friendly and should be programming and wiring should not require any expertise in PLC or HMI programming. Settings, monitoring & diagnosis shall be done from one display terminal on the drive.

1.20 INTEGRATED INTELLIGENT MOTOR CONTROL SYSTEM (IMCS)

A. This clause pertains to technical requirements for a microprocessor based Integrated Intelligent Controller (ICMS) Integrated in mcc to control, protect and monitor both motors and feeders.

B. Requirements mentioned under clause Part 1, Part 2, Part 3 are applicable over and above technical parameters stated in this clause.

C. The aim of these specifications is to derive a system comprising control modules, central unit(s), a serial bus Motor Control connecting the control modules to the central unit and a System (IMCS) communication facility enabling connection of the central unit to a distributed control system (DCS), a Supervisory Control and Data Acquisition System (SCADA), and/or Building Management System (BMS).

1.21 TERMINOLOGY AND ABBREVIATIONS

A. The following terms are used in this specification:

1. Starter Control Unit (SCU)
   a. This module is a microprocessor-base technology component which includes the control, protection, monitoring and communication functions related to motors (motor starter) Feeder Control Unit (FCU).
   b. This module is a microprocessor-base technology component which includes the control, monitoring and communication functions linked to feeders serving a single contactor, circuit breakers or fuse-switch feeder.
2. Interface Control Unit (ICU)
   a. This interface is a microprocessor-base technology component which concentrates the data of a set of SCUs and FCU's.
3. Integrated Motor Control System (IMCS)
   a. System which includes the SCUs, FCUs and ICU, serial-bus linked to the digital monitoring and control system .
4. Intelligent Motor Control Centre
   a. MCC equipped with IMCS
5. Human Machine Interface- HMI
   a. Interface device for the management of the IMCS parameters and read out data
   b. IMCS Integrated Motor Control System .
   c. FCU Feeder Control Unit
   d. ICU Interface Control unit
   e. SCU Starter Control Unit

1.22 RESPONSIBILITY

A. The ultimate responsibility for the system including the software package(s) required to operate the IMCS shall be with the Manufacturer of the LV Switchgear and Controlgear Assembly. The Manufacturer of the LV Switchgear and Controlgear Assembly shall be responsible for the performance of the IMCS as described in this specification and shall liaise with the Manufacturer of the DCS and/or SCADA for procedures, execution of interface and testing.

1.23 BASIC CONFIGURATION

A. The IMCS shall be a microprocessor based motor/feeder protection, control and monitoring system generally comprising:

B. SCU's and FCU's mounted in or adjacent to the Functional Units (starter or feeder compartments) of the assembly.

C. The ICU(s) shall be able to be connected to at least one HMI.

D. The ICU arrangement shall provide separate serial connections to the plant DCS and SCADA systems via a serial link or an Ethernet connection.

E. Motor circuits and where applicable outgoing feeders shall be controlled by the SCU or FCU which perfoRMS measurement, control and protection and constitutes a complete and self sufficient system with a non-volatile memory of all specific pre-programmed parameters.

F. The use of battery back up for SCU and FCU is not permitted. The Control Units shall be able to automatically maintain operation capability after a voltage interruption.

G. The Control Units shall be adequately protected against external short circuits or earth faults on the connected control cables and shall maintain full operation after clearance of any such fault.

H. In the event of a failure of the protection and control functions of an individual SCU/FCU, the associated circuit shall be field configurable to either automatically trip or to maintain the current operation.

I. In the event of a communication failure of any individual SCU/FCU or any failure of the ICU the associated circuit(s) shall be field configurable to either trip or maintain the current operation. Any such failure of either the communication or the SCU/FCU shall generate an alarm in the ICU for onward transmission to the DCS /SCADA.

J. All protection and control devices shall incorporate self-supervision and checking routines with watchdog function to indicate all system errors and/or failures directly to the ICU and/or HMI for onward transmission to the DCS /SCADA.

K. Programming of the protection and operational parameters shall be carried out via an HMI or via a local keypad on the SCU/FCU. Once protection and operating parameters are loaded into the system, they shall be stored in non-volatile memory so that all information is retained during power failures. The need to reload parameters from an HMI following any power failure is not acceptable.

L. In the event of a failure of an individual SCU/FCU module it shall be possible to replace any failed module and readily download or program the specific drive/feeder parameters to the replacement module via an HMI without specialized software knowledge. The specific drive/feeder parameters shall be stored in the memory of the HMI.

M. The HMI shall be able to set the parameters and to monitor the operating status of any connected drive or feeder.

N. The interface between the installed starter/feeder unit and the communication bus within the Assembly shall be an integral part of the starter/feeder. The starter/feeder compartment shall remain withdrawable and the connection to the communication bus shall be a single connection.

O. Access to change the operating parameters shall be restricted by means of a password or key.

P. Programming and configuration should be easy and to be maintained by the Plug & Play type of Device or through Remote connection.

Q. It should have a facility to connect any Plug & Play type of peripherals to support the management.

R. Human Machine Interface- HMI

1. HMI unit shall manage the communication with all the Motor Starter Unit on either RS485/Ethernet Communication.
2. Maintenance officials must be able to ensure, in real time, monitoring and control of the Motor from the HMI mounted on the front door of MCC panel.
3. HMI unit must have a Touch Screen facility for the navigation and control.
4. HMI unit shall be User Friendly and easy to operate with Function keys.

5. HMI unit must have an in built capability for easier diagnostic and maintenance operations both Local and Remote.
6. It should have a capability to Log the Trend Data, Recipe management, Alarm function for the Fault Traceability, Data Processing and Multiple Window feature to operate multiple motor at a time.
7. Alarm appearance will be accompanied by an audible signal. It should have a facility of connecting either an external speaker or the low cost hooter.
8. It should support Multiple language along with the Numerous font like Latin, Japanese etc.
9. It should have a Certification of UL, CSA,CE.
10. Optional (If deemed necessary by end client)
11. HMI unit should have a capability of remote connection like Ethernet, Radio, GSM/GPRS or PSTN.
12. HMI unit should interface with all equipment and software conforming to PC, PCI, Windows standards. It should have a high end processor with the enough memory and enough space to run the SCADA software also.
13. Alarm notification on GSM should be available.
14. It should have a facility to connect to the Centralized Data Server and should have a 3 rd party interface like DDE Server/Client, ODBC Server/Client or OPC server/Client at no extra cost.
15. The Operator must be able to visualize in real time the state of the Alarm of any Motor and in the event of appearance of an alarm the operator must have the possibility to locate the alarm, generate the report on Daily, hourly or on demand basis and can be easily send to either to a Printer, or to Mail Recipient or available on Network in shared mode.
16. The system shall support casual web browser clients so that personnel on the WAN with the appropriate security settings can have access to the system. The web browser clients shall support view and control capabilities, controlled by both login security and license types.
17. Security shall be fully integrated to allow access to any individual part of the system only to users with appropriate security levels. Security must be checked on the server side and passwords must be encrypted.
18. It should have an integrated high level language specifically designed for SCADA applications and shall be inherently multi-tasking, multi-threading and pre-emptive. In addition, the software shall include a multithreaded VB compatible scripting language.

S. The IMCS shall be capable of displaying the following either directly from SCU/FCU or at the ICU or HMI.

1. Alarm outputs including watchdog alaRMS.
2. Pre-trip conditions.
3. Stop control of motors.
4. Motor/Feeder status - Available/Running/Tripped etc.
5. Trip LED Indication plus type of trip.
6. Running/Stop LED indication.

T. All motor starter units, whether of the direct-on-line or start delta etc., shall be equipped with an SCU. The SCU shall constitute of a self-sufficient monitoring, control and protection system. Each device shall provide as a minimum the following functionality:

1. Status (running stopped, tripped).
2. Number of contactor operations.
3. Motor current.
4. Motor running up time (time from start to reaching operational speed).

5. Motor operating time (operating hours).
6. Motor overload protection, setting, status, pre-alarm and time to trip. The unit shall model the hot and cold motor thermal capacity utilising fixed or adjustable thermal time constants.
7. Load unbalance protection, setting and status, including pre-alarm.
8. Thermal status of the motor, including restart inhibit time.
9. Stalling protection (locked rotor) setting and status.
10. Local Stop.
11. Reset of alaRMS and trips via a password or key for locked rotor and earthfault.
12. Manual reset of all other alaRMS and trips.
13. Configurable inputs for external trips (2 as a minimum).
14. Automatic re-start on loss of voltage.
15. Monitoring of consumed active power and the power factor.
16. Thermistor or Pt100 element for over-temperature protection including pre-alarm.
17. Under-current protection, setting and status, including pre-alarm.
18. Under-voltage trip for latched contactors, setting and status, per unit or from a central unit.
19. The control set-up of the SCU shall allow for possible additional hardwired control of the motor.
20. SCUs may provide either a 4-20 mA or 0-20 mA output for connection to the Remote Control Unit (RCU)ammeter as an alternative to a dedicated 1A secondary current transformer.

U. Trending and recording facilities shall be made available for monitoring and recording by the HMI and the end client's SCADA and/or maintenance management system on an as-required basis. A facility for generating printouts of events and trend logs from the HMI by connecting a standard printer shall be incorporated.

V. It shall be possible to configure all measurable variables such as current, power etc. for trend recording and to define the recording trigger event such as a motor start.

W. Unless specified differently by the end client, every starter feeder shall be controlled as detailed below:

1. Local, adjacent to the motor:

   a. Local control shall be from a position close to the motor. This is done via at least one Remote Control Unit (RCU) and/or Safety Switch (SS) allowing the motors to be started and stopped manually. The RCU is a three position switch with "Off-0-On" positions, spring return to the "0" position allowing remote automatic control by the DCS. For contactor controlled motor starters the "Off" position of the
   b. RCU/SS can be padlocked and shall be regarded as a safety switch. In this position the RCU/SS shall be hardwired into the motor starter contactor circuit. Furthermore an additional contact of the RCU/SS shall be used to short circuit the contactor coil when the RCU is in the "Off" position.
   c. All RCU/SS stop commands shall in all cases overrule the IMCS. The RCU/SS shall at all times be able to stop the drive even with the SCU defective.

2. Remote, from a DCS/SCADA system

   a. Remote control shall be possible from the DCS or SCADA system. This type of control, if required for plant operation, shall be applied in addition to the manual control described above. Automatic process control shall consist of the following:

b. "On" and "Off" controls.
c. SCADA control signals, which shall be hardwired into the motor starter circuit.
d. DCS control signals, which may be hardwired into the motor starter circuit or preferably serially connected into the IMCS.
e. No "On" command may be given by the SCU, HMI during normal plant operating conditions.

3. An automatic restart facility shall be provided within the IMCS to restart the motors after voltage dips of duration up to typically 4 s. If specified, this facility shall be incorporated in all SCU's, and shall be fully configurable per drive.
4. Unless specified differently by the end client, every circuit breaker feeder shall be controlled as detailed below:

a. Feeders that are equipped with an FCU shall provide as a minimum the following:

1) Switching device status.
2) Feeder current.
3) Consumed active power.
4) Power factor.
5) Overcurrent protection (adjustable for co-ordination purposes).
6) Earth fault protection (With adjustable tripping time for co-ordination purposes).
7) Reset of earth fault alarm and trip via a password or a key.

1.24 REDUNDANCY

A. Dual redundant ICU shall be provided. It should be a 'Master – Slave' hot standby system, such that in the event of a failure of one unit, the second shall take over control in a bumpless fashion and shall also provide both a local and remote alarm to indicate the failed unit. The system shall be designed so that any failure in any part of the system shall not result in loss of availability of the system.

1.25 RESPONSE TIME

A. The set up of the IMCS shall be such that 'stop' commands from the SCADA / DCS system shall always have priority over data collection and other SCADA / DCS commands.

B. The SCADA and maintenance management systems are primarily data collection and monitoring systems. The preferred method of data collection is for the ICU data to be loaded into a table, which is then refreshed at regular intervals, and the SCADA system only accesses data on request.

C. The Manufacturer of the IMCS shall specify the response and scan times of the system for control and monitoring. The maximum response time for priority control/data signals shall not be greater than 0.6 s with the maximum number of SCU/FCU modules connected to the system.

1.26 COMMUNICATION

A. The SCU / FCU units shall be communicating through one communication port and integrable in a communication architecture with information remote access. It shall be an open communications system, to enable direct connection to any of the main industrial network protocols. Each SCU / FCU shall be able to communicate, as a minimum on ModBus, Profibus DP, DeviceNet & CANopen.

B. The IMPR shall have the options to connect with these networks, each one per each application, with native connectivity, embedded from the factory.

EXECUTION

1.27 GENERAL

A. Install main board as indicated in accordance with equipment manufacturer's written instructions and with recognized industry practices to ensure that the equipment fulfils requirements.

B. Provide earthing connections for the Motor Control Centre as indicated on the drawings. Tighten connections to assure permanent and effective grounding.

C. Prior to energization of the main switch board, check with megger tester to ensure requirements of IEE Wiring Regulations are fulfilled.

D. Frame and mount printed, basic operating instructions for switch boards, including control and key interlocking sequences, and emergency procedures, fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on the front of the switchboards.

1.28 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as required under Section 26 0553.

1.29 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Arrange and pay for the services of a factory-authorized service representative to supervise the pretesting and adjustment of switchboard components.

B. Testing Organization: Arrange and pay for the services of an electrical testing organization to perform quality control electrical testing and calibration, visual and mechanical inspections, and tests of overcurrent protective devices switchboards.

C. Pre-testing: Upon completing installation of the system, perform the following preparations for tests:

1. Make insulation resistance tests of switchboard buses, components, and connecting supply, feeder, and control circuits.
2. Make continuity tests of circuits.
3. Provide set of Contract Documents to test organization. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
4. Provide manufacturer's instructions for installation and testing of switchboard to test organization.

1.30 QUALITY CONTROL TESTING PROGRAM: CONFORM TO THE FOLLOWING

A. Program Objectives: To assure switchboard installation meets specified requirements, is operational within specified tolerances, provides appropriate protection for systems and equipment, and is suitable for energizing.

B. Procedures: Make field tests and inspections and prepare switchboard for satisfactory operation in accordance with manufacturer's recommendations and these specifications.

C. Schedule tests and notify Consultant at least one week in advance of test commencement.

D. Reports: Prepare written reports of test results and observations. Report defective materials and workmanship. Include complete records of adjustments and remedial efforts.

E. Labeling: Upon satisfactory completion of tests and related effort. Apply a label to tested components indicating test results, person responsible, and date.

F. Protective Device Ratings and Settings; Verify indicated ratings and settings and make the final system adjustments of Overcurrent Protection Devices.

1.31 VISUAL AND MECHANICAL INSPECTIONS: INCLUDE THE FOLLOWING INSPECTIONS AND RELATED WORK

A. Inspect for defects and physical damage, testing laboratory, labels, and nameplate compliance with up-to-date circuit connections.

B. Verify that potential transformers, including their overcurrent protection and current transformers, meet specified requirements.

C. Perform operational test and exercise of mechanical components and other operable devices in accordance with manufacturer's instruction manual.

D. Check switchboard anchorage, area clearances, and alignment and fit of components.

E. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

F. Clean switchboard interior and exterior-using manufacturer's approved methods and materials.

G. Perform visual and mechanical inspection and related work for Overcurrent Protective Devices.

H. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation resistance test of buses and portions of control wiring that disconnect from solid state devices through normal disconnecting features.
2. Ratio and polarity tests on current and voltage transformers.
3. Ground resistance test on system and equipment ground connections.
4. Verify appropriate capacity, overcurrent protection, and operating voltage of control power elements including control power transformer and control power wiring.
5. Check phasing of alternate supply sources to the same bus.
6. Test overcurrent protective devices as specified for compliance.
7. Retesting: Correct deficiencies identified by tests and observations and retest switchboards. Verify by the retests that switchboards meet specified requirements.

1.32 CLEANING

A. Upon completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

1.33 PROTECTION

A. Temporary Heating: Apply temporary heat in accordance with is manufacturer's recommendation within each section of switchboards throughout periods during which the switchboard is not in a space that is continuously under normal control of temperature and humidity.

1.34 DEMONSTRATION & SERVICES

A. The Original Manufacturer (as defined in clause 2.01.01) shall have a permanent representative office with a trained and skilled support staff, in the country where the goods are delivered, in order to prove commitment for local support and to provide a channel for communication. The local representatives shall be easily accessible and shall be able to arrive at the site within 24 to 48 hours' notice.

B. The engineers employed by the Original Manufacturer office shall provide start-up service including physical inspection of the all products supplied, connected wiring and final adjustments, to ensure that the equipments and products meet the required performance.

C. The Original Manufacturer is obliged to give basic training to the Client's engineers (minimum 4 hour training), preferably on the site, in the country where the End client's site is. The training shall, as a minimum, include system concepts and basic troubleshooting.

D. Most common spare parts shall be available in 48 hours from the notification through a regional distribution centre of the Original Manufacturer . The more rarely used spare parts should be available in maximum 5 days on site.

E. All Soft starter and VFD drives shall have a common windows based PC software for monitoring and controlling the loads. This software will be given complementary by the original equipment and product manufacturer with 2 hour class room training on usage of this software at the project site office for site consultant, site contractor engineer, site project manager and end client representative, at no extra cost.

F. The Original Manufacturer supplying products and equipment should have capability to allow remote support via Internet by analytical experts for electrical networks. This support can be one-off or permanent. On the basis of the equipment described in the present document clause 2.04, the simple addition of a modem to the site's Ethernet network enables transmission of electrical data. The modem shall be supplied by the service supplier: it is connected on one hand to the site Intranet network and on the other it has telephone access or access via the site messaging server to be able to regularly send data to the service provider. It shall be designed so it is not possible to activate the modem from outside the site for security reasons.

G. The Original Manufacturer shall have a permanent call centre service in the country of project site for online technical services.

H. With a financial offer, the end client should have the option of professional technical training through Training Centre of the original manufacturer located within the GCC Countries.

I. Since harmonics are likely to generate in network due to single phase, soft starter, VFD starters Contractors are advised to consider a minimum of 2 Nos. of 60A active harmonic filters for harmonic suppression along with the capacitor bank to limit the total harmonic distortion to below the specified limits of National regulatory bodies as well as IEEE Recommendations for all locations.

1. Provisions shall be made for 2 Nos. of 100A Breakers in the MCCs to connect the active harmonic filters.
2. The Contractor shall employ a recognized specialist to advise on the power factor correction / harmonic control requirements for the project as a whole.
3. Calculations shall be submitted with the use of a suitable simulation software to prove compliance with Total Harmonic Distortion / Individual Harmonic Distortion requirements as per Engineering Recommendations G-5/4.
4. The capacitor bank and the active harmonic filters should be integrated in the same enclosure and should be from the same original manufacturer detailed in previous sections of this specification.
5. The capacitor units shall be of internal fuse design and shall be of the dry metalized polypropylene film resin encapsulated type with a maximum loss of 0.4 watts / kVAr.
6. The metalized film shall allow self-healing in the event of an internal fault and minimizing damage to other capacitor units.
7. Each capacitive element shall be contained in a hermetically sealed non metallic enclosure.
8. The active harmonic filters should be of a 3 phase 4 wire configuration and shall comply with the latest technical standards.

7.4.18 26 2500 - Enclosed Bus Assemblies

GENERAL

1.1 SUMMARY

A. This section includes:

1. Feeder-bus assemblies.
2. Plug-in bus assemblies.
3. Bus plug-in devices.

1.2 RELATED SECTIONS:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0509 – Fire Barriers and Cable Transitions
3. Section 26 0526 – Grounding and Bonding for Electrical Systems:

1.3 REFERENCES

A. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

B. BS EN 60439-1:1999, IEC 60439-1:1999 - Low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies.

C. BS EN 61439 (series) - Low-voltage switchgear and controlgear assemblies.

D. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

E. Local Electricity Supply Authority Regulations.

1.4 SUBMITTALS

A. Shop Drawings: For each type of bus assembly and plug-in device.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
2. Show fittings, materials, fabrication, and installation methods for fire-stop barriers and weather barriers where applicable.
3. Indicate required clearances, method of field assembly, and location and size of each field connection.
4. Detail connections to switchgear, switchboards, transformers, and panelboards.

B. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:

1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
2. Clearances for access above and to the side of enclosed bus assemblies.
3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
4. Support locations, type of support, and weight on each support.

C. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.

D. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

G. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

H. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Conforming the CE BSI, IEC and UL requirements and acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with BS EN 61439-6:2012, "Low-voltage switchgear and control-gear assemblies. Busbar trunking systems (busways)"

D. Comply with Local Electricity Supply Authority Wiring Regulations.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to manufacturer's recommendations. Ensure bus bars are stored indoors and retained in original packaging until ready for installation. Do not store in areas prone to flooding or water ingress.

1.7 PROJECT CONDITIONS

A. De-rate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 50 deg C.

1.8 COORDINATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PRODUCTS

1.9 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.10 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: low-impedance bus assemblies in non-ventilated housing; single-bolt joints; ratings as indicated.

1. Voltage: 600 V; 3 phase; 100percent neutral capacity for typical installations, installations likely to encounter high levels of harmonics shall be 200percent neutral.
2. Temperature Rise: 55deg C above 40deg C ambient maximum for continuous rated current.
3. Bus Materials: Current-carrying copper conductors, fully insulated except at joints; plated surface at joints. Aluminium shall not be permitted under any circumstance.
4. Ground:

   a. Internal bus bars of material matching bus material. Size shall be in accordance with equipment earthing busbar.

5. Enclosure (indoor use): Steel with manufacturer's standard finish.
6. Enclosure (outdoor use): Weatherproof, steel with manufacturer's standard finish, sealed seams, drains, and removable closures. IP 54 minimum.
7. Fittings and Accessories: Manufacturer's standard. The joints shall be so designed as to allow removal of any length without disturbing adjacent lengths.
8. Mounting: Arranged flat, edgewise, or vertically without de-rating.

B. Plug-in Bus Assemblies: low-impedance bus assemblies in non-ventilated housing; single-bolt joints; ratings as indicated.

1. Voltage: 600 V; 3 phase; 100percent neutral capacity for typical installations, installations likely to encounter high levels of harmonics shall be 200percent neutral.
2. Temperature Rise: 55deg C above 40deg C ambient maximum for continuous rated current.
3. Bus Materials: Current-carrying copper conductors, fully insulated except at joints; plated surface at joints.
4. Ground:
   a. Internal bus bars of material matching bus material. Size shall be in accordance with equipment earthing busbar.
5. Enclosure (indoor use): Steel with manufacturer's standard finish, tap-off outlets on both sides of the trunking shall be at no more than 1m interval. It shall be possible to use them simultaneously.
6. Enclosure (outdoor use): Weatherproof, steel with manufacturer's standard finish, sealed seams, drains, and removable closures. IP 54 minimum. Tap-off outlets on both sides of the trunking shall be at no more than 1m interval. It shall be possible to use them simultaneously.
7. Fittings and Accessories: Manufacturer's standard. The joints shall be so designed as to allow removal of any length without disturbing adjacent lengths.
8. Mounting: Arranged flat, edgewise, or vertically without de-rating.

C. Tap-off units:
1. Shall be from the same manufacturer as the busbar trunking system and shall be provided with off-load isolator suitable for fuses or circuit breakers according to ratings as indicated in the drawings.
2. All circuit breakers used shall be able to operate normally when mounted upside down or at any angles. The tap-off units shall also have the provision to mount the earth fault relay together with the breaker. Tap-off units shall be of dust and damp proof version, degree of protection IP 54 minimum with silver plated contacts suitable for all ratings of busbar and shall be suitably earthed.
3. The earthing contact of the tap-off unit shall always be made before that of the live conductors and the last to break during removal.
4. The MCCB used in the tap-off unit must comply with IEC 60947-2. All MCCBs shall have a rated service breaking capacity (Ics) of RMS value at 415VAC equal or higher than the prospective fault level of installation. It shall have current limiting capabilities to protect the busbar trunking system and co-ordination table shall be furnished by manufacturer.
5. The tap-off unit and the busbar trunking system shall be interlocked to ensure that the MCCB is in the 'OFF' position prior to installation or removal of the unit.
6. The tap-off unit for MCCB shall have an interlock which prevents the cover from being opened while the device is in the 'ON' position and to prevent accidental closing of the device when the cover is opened.
7. Tap off units for fuses or MCB's shall have an isolator. Isolation shall be achieved by opening the cover of the unit.

D. Short Circuit Capacity: The whole busbar trunking system shall be capable of withstanding the short circuit capacity of the electrical installation without damaging the electrical, mechanical and thermal stress under fault condition at a service voltage of 415V 50Hz. Co-ordination of the distribution shall be guaranteed such that the Circuit breaker / trunking combination will limit the peak current to a value less than the rated peak current of the busbar trunking. The short circuit capacity shall be no less than that of the equipment it supplies.

E. Neutrals: Reduced neutrals shall not be accepted. The neutral shall be of equal cross sectional area to the line conductors.

F. Anti-condensation heaters shall be provided throughout the entire length of the assembly.

EXECUTION

1.11 INSTALLATION

A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
2. Support bus assembly to prevent twisting from eccentric loading.
3. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
4. Fasten supports securely to building structure according to Division 26 Section "Hangers and Supports for Electrical Systems."

B. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

C. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to manufacturer's recommendations.

D. Install weather seal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weather tight according to manufacturer's recommendations.

E. Install a concrete curb at least 100mm high around bus-assembly floor penetrations.

F. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

G. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

H. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

I. Fix identification and warning labels throughout system length

J. Install busbar trunking in accordance with manufacturer's instructions and the relevant standards.

1.12 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect cable feeders according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

1.13 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test in accordance with the manufacturer's requirements. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests and inspections and retest as specified above.

D. Infrared Scanning: Four (4) months after Substantial Completion, perform an infrared scan of bus assembly including joints and plug-in units.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

1.14 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges as indicated.

1.15 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

1.16 PROTECTION

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

1.17 TYPE TESTS

A. The appropriate type tests specified in this clause shall be made before the manufacturer supplies on a general commercial basis the type of enclosed bus assembly described in this specification in order to demonstrate satisfactory performance requirements.

B. These tests excepting those which are also required as additional regular tests need not be repeated once they have been performed successfully, unless alterations are made to cable design or materials which might affect the performance.

C. The accessory manufacturer must demonstrate by type test approval tests on the specific enclosed bus assembly that any joint or termination that it is intended for use with the enclosed bus assembly supplied for a specific contract is compatible with that enclosed bus assembly.

D. Tests are required to demonstrate satisfactory performance characteristics of the basic accessory design.

E. Designs suitably tested may be used for applications where the electrical design stresses are the same or lower than those tested.

F. Type Testing will be in full accordance with IEC.

G. Enclosed bus assembly installation at site will not be started till successful completion of type test.

H. In case of type test failure, repetition of type test will be allowed only one time, after full investigation for type test failure, witnessed and endorsed by accepted third party.

I. In case of type test failure for second time KAHRAMAA reserve their rights to reject the manufacturer and select another one from the preferable vendor list.

1.18 SCHEDULE OF TYPE TESTS

A. The type tests shall comprise electrical tests on complete cable and the appropriate tests on cable components.

B. The electrical tests shall be carried out in sequence on one sample of cable. The bending test shall be included in this sequence of tests to check that the electrical properties of the cable after bending are satisfactory.

1.19 ELECTRICAL TESTS

A. The normal sequence of tests shall be:

1. Heating cycle voltage test, followed by partial discharge measurement (IEC Publication 60840).
2. Impulse withstand test followed by power frequency voltage test (IEC Publication 60840).
3. Megger test.
4. Phase rotation test.
5. Resistance test.
6. And all other tests as necessary and required by Kahramaa.

1.20 TESTS ON COMPONENTS

A. The following tests should be completed on the components:

1. Check of construction
2. Tests for determining the mechanical properties of the insulation before and after ageing (IEC Publication 60840)
3. Ageing tests on pieces of complete cable to check compatibility of materials (IEC Publication 60840)
4. Impact test

7.4.19 26 2713 - Metering

GENERAL

1.1 SUMMARY

A. This section specifies the requirements for electricity metering.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0913 – Electrical Power Monitoring and Control

1.2 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. ANSI C12.1-01 - Electric Meters Code for Electricity Metering.

D. ANSI C12.10-04 - American National Standard for Watt-hour Meters.

E. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

F. DIN EN 50022:1978-05 - Low voltage switchgear and control gear for industrial use; mounting rails for fixing terminal blocks.

G. EN 13757 (series) - Communication systems for remote reading of meters.

H. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

I. IEC 62052-11 - Electricity metering equipment (AC) - General requirements, tests and test conditions - Part 11: Metering equipment.

J. IEC 62053-21 - Electricity metering equipment (a.c.) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2).

K. IEC 62053-31 - Electricity metering equipment (a.c.) - Particular requirements - Part 31: Pulse output devices for electromechanical and electronic meters (two wires only).

L. Underwriters Laboratories, Inc. (UL): 414-04 Standard for Safety Meter Sockets.

1.3 DEFINITIONS

A. BMS: Building Management System

B. CT: Current Transformer

C. EEPROM: Electrically Erasable Programmable Read-Only Memory

D. LCD: Liquid Crystal Display

E. M-Bus (Meter-Bus): a networking protocol for the remote reading of gas and electricity meters defined in European Standard EN 13757 (series).

F. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

G. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

H. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

I. RS-485: A TIA standard for multipoint communications using two twisted-pairs.

J. VT: Voltage Transformer

1.4 SUBMITTALS

A. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Include electrical ratings, dimensions, mounting details and clearances required for servicing.

B. Manuals:

1. Complete maintenance, operating and testing manuals including wiring diagrams
2. Technical data sheets
3. Information for ordering replacement parts

C. Warranty: Sample of special warranty.

D. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

1.5 QUALITY ASSURANCE

A. Certifications required:

1. Certification by the manufacturer that the instruments for metering conforms to the requirements of the drawings and specifications, and has been and can be properly calibrated by an independent laboratory.
2. Certification by the Contractor that all metering instruments have been properly installed, adjusted, and tested.
3. Certification by the Contractor that the metering instruments comply with the Local Supply Authority requirements.

1.6 COORDINATION

A. Coordinate with the monitoring equipment specified in Division 26 Section "Electrical Power Monitoring and Control" for successful transmission and remote readout of remote monitoring data specified in this Section.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace any components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

1.8 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.9 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.10 ELECTRONIC METERS

A. General:

1. Meters shall have easy-to-read facility with a LCD display.
2. The metering instrument shall have an IEC approval, built-in memory backup (EEPROM) and internal clock.
3. Shall be microprocessor-based using the M-BUS communciations protocol:
   a. Microprocessor meters shall monitor the energy used on the ac systems 22 kV and 415/240 volts, 3 phase.
   b. The unit shall be able to transmit information via twisted pair cable or coaxial cabling to a central metering computer.
   c. The unit shall be provided with an adjustable demand window of 5-, 10-, 15-, 30-, or 60-minute intervals.
   d. Accuracy of the meter shall be ±1 percent. All readings shall be adjustable from a remote location.
4. Operating temperature range: -40 degrees C to 60 degrees C.

B. Accuracy Class:

1. The accuracy shall be Class 1 or 2. The meter shall comply with IEC 62053-21 and IEC 62052-11, alternating current static watt-hour meters for active energy with any amendments made.

C. Mechanical Design:

1. The material used in the meter shall be of polycarbonate in the frontal glass and casing.
2. The terminal base shall be of glassfibre - reinforced polycarbonate.

D. Presentation of Information:

1. The display shall be of LCD-type with minimum 7 digits and minimum 7 mm of height.
2. The display shall be able to present following information:

a. Active and reactive energy, primary reading
b. Active energy value in kW or MW with decimal(s) (Automatic swifting depending on programmed CT resp. VT ratio)
c. Load indicator
d. Presence of phase voltages
e. Current transformer symbol (Indication of primary reading)
f. Installation status (Automatic installation check – Error status/code)
g. Programmed CT and VT-ratio
h. Instrumentation values (analyzer) V, A, W, Hz, Pf (Cos ø)

E. Primary reading:

1. The meter shall have a programmable CT and VT ratio, allowing a 4-digit ratio to be set for primary reading.

F. Automatic Installation check (Error status/code):

1. The meter shall have an automatic installation check which shall verify the installation of the meter. Any error(s) shall generate error code(s) displayed on the LCD. The installation check shall include:

a. Phase Voltage presence test. Shall verify if some voltage is missing
b. Maximum current test. Verifying if the current exceed the maximum rated.
c. Maximum and Minimum frequency test. Shall verify that the frequency is within permitted range of the specified nominal frequency, 45 Hz- 65Hz.
d. Phase angle test. Shall verify correct phase sequence (L1, L2, L3)
e. Power measurements. Shall verify that the power measured is positive on each phase swell as on the total. (The meter shall measure active energy in only one direction, from utility to customer, i.e positive active energy)

G. Technical Data:

1. Electric data and accuracy classes:

a. Base / Max current: CT/VT connected 1/6A – Direct connected 5/80A
b. Accuracy: Class 1 or 2 according to IEC 62053-21
c. Starting current: < 2mA for CT / VT connected resp < 20mA for direct connected
d. Frequency: 50/60 Hz ± 5%
e. Temperature range: Operating -40°C to +55°C / Storage -40°C to +70°C
f. Voltages: 3x57-288/100-500 V (4-wire /3 elements/Unbalanced load)
g. 3x100-500 V (3-wire/2 elements/Balanced load)
h. 1x57-288 V (single phase)
i. (-20% to +15% of nominal voltage)

2. Pulse output:

a. Maximum current: 100 mA
b. Maximum voltage: 247 V AC/DC
c. Pulse length: 100 ms
d. Pulse output frequency: Programmable after a table
e. Pulse frequency table 0.01,0,1 1 10,100, 500, 640, 5000 imp/kWh
f. Polarity independent, galvanic ally isolated
g. LED - Red Light Emitting Diode flashes proportionally to energy measured
h. Mechanical data
i. Resistance to heat and fire: IEC 695-2-1
j. Protection against penetration of dust and water : IEC 529 class IP51 with long cover and IP20 without long cover

k. Mounting: DIN-rail. Option: Front panel mounting, IP 51.
l. Size: 122.5x100x50 mm / 7 DIN modules
m. Max. Connection at terminal: 10 mm2 for CT / VT o. connected types resp 25 mm2.

3. Standards:

a. Standard electrical values: IEC 62052-11
b. Mechanical requirements: IEC 62052-11
c. Climatic conditions: IEC 62052-11
d. Electrical requirements: IEC 62052-11
e. Electromagnetic compability: IEC 62052-11
f. Accuracy requirements according: IEC 62053-21
g. Pulse Output: S0 Interface, DIN 43864

4. Load indicator:

a. The meter shall on the LCD have a load indicator indicating that the meter is recording energy. Starting current ≥ 2 mA for CT / VT connected resp ≥ 20 mA for direct connected

5. Storage of data:

a. All data and recorded energy shall be saved in a non-volatile memory (EEPROM) in case of power-failure.

6. Light Sensor / External scroll:

a. A light sensor shall operate the LCD when the meter is front mounted or sealed and allow complementary reading of information:
b. Installation check status - Error code/status
c. Active energy consumption
d. Programmed CTxVT ratio
e. Complete LCD segment test
f. The light sensor shall operate with a standard filament lamp

7. IR output

a. Shall be provided with infrared port which allow possibly for a serial communication with the meter via standardized adaptor for protocols eg M-bus, LON, GPRS, TCP/IP, RS232 etc

8. Sealing:

a. Shall be provided with sealings possibilities in 2 positions on each upper lid (Covers set and scroll buttons) resp. lower lid (Covers terminals).

9. Options

a. Panel mounting kit
b. Built in interface for serial communication (Mbus, LON and EIB) 1, 2 or 4 tariffs
c. Internal clock with built in calendar (No battery but super cap back up 48h to conditions -40°C to +55°C)
d. Configurer software and adapter for tariff programming
e. Built in I/O interface – 2 inputs or 2 outputs or 1 input + 1 output All galvanically isolated from other electronics in the meter. (Output eg for cut out signal for main supply of energy media / Input eg for pulse input for water or gas meter)

f. Load profile log
g. Voltage quality log
h. Maximum demand

EXECUTION

1.11 CABLING AND DISTANCE LIMITATIONS

A. All cabling shall be limited to the manufacturer's recommended limits to ensure accuracy of data.

B. Fibre optic cables shall be used where large distances are involved..

1.12 INTERFACE TO BUILDING MANAGEMENT SYSTEM

A. The metering system shall also be interfaced with the building management system to enable control strategies to be implemented for the conservation of energy and to reduce demand peaks which have an impact on total energy costs.

7.4.20 26 2726 - Wiring Devices

GENERAL

1.1 SUMMARY

A. Section includes:

1. Single and twin socket outlets
2. Single-pole and double-pole snap switches and dimmer switches.
3. Device wall plates.
4. Floor service outlets, poke-through assemblies, and multi-outlet assemblies.

B. Related Sections:

1. Section 26 0500 – Common Works Results for Electrical
2. Section 26 0533 – Raceways and Boxes for Electrical Systems
3. Section 26 0923 – Lighting Control Devices
4. Section 27 0500 – Common Works Results for Communications

1.2 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. TVSS: Transient voltage surge suppressor.

1.3 REFERENCES

A. BS 1363-1 - 13A Plugs, Socket-Outlets, Adaptors and Connection Units – Part 1: Specification for Rewireable and Non-Rewireable 13A Fused Plugs.

B. BS 1363-2 - 13A Plugs, Socket-Outlets, Adaptors and Connection Units – Part 2: Specification for 13A Switched and unswitched Socket-Outlets.

C. BS 1363-3 - 13A Plugs, socket-outlets, adaptors and connection units – Part 3: Specification for adaptors.

D. BS 1363-4 - 13A Plugs, socket-outlets, adaptors and connection units – Part 4: Specification for 13A fused connection units switched and unswitched.

E. BS 4177:1992 - Specification for cooker control units.

F. BS 546:1950 - Specification. Two-pole and earthing-pin plugs, socket-outlets and socket-outlet adaptors.

G. BS 5733:2010 - General requirements for electrical accessories. Specification.

H. BS 6972:1988 - Specification for general requirements for luminaire supporting couplers for domestic, light industrial and commercial use.

I. BS 7001:1988 - Specification for interchangeability and safety of a standardized luminaire supporting coupler.

1.4 BS 7288:1990 - SPECIFICATION FOR SOCKET OUTLETS INCORPORATING RESIDUAL CURRENT DEVICES (S.R.C.D.S)"

A. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

B. BS EN 60309-1:1999 / IEC 60309-1:1999 - Plugs, socket-outlets and couplers for industrial purposes. General requirements.

C. BS EN 60669-1:1999+A2:2008 - Switches for household and similar fixed-electrical installations. General requirements.

D. BS EN 60669-1:1999+A2:2008. - Switches for household and similar fixed-electrical installations. General requirements.

E. BS EN 60669-2-1:2004+A12:2010 - Switches for household and similar fixed electrical installations. Particular requirements. Electronic switches.

F. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

1.5 SUBMITTALS

A. Product Data: Provide wiring device manufacturer's catalogue information showing dimensions, configurations, and construction.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate specified, in each finish specified.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

F. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

G. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.6 QUALITY ASSURANCE

A. Source Limitations: Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source, unless explicitly detailed elsewhere in the project documentation.

B. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

C. Comply with BS 7671 (IEE Wiring Regulations) and the Local Supply Authority Regulations.

1.7 COORDINATION

A. Socket Outlets for Client/Owner-Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

C. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.

1.8 SPARES

A. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PRODUCTS

1.9 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.10 SWITCHED / UNSWITCHED SOCKET OUTLETS

A. Manufactured in accordance with BS 1363-2: 1995 & BS 546:1950 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):

1. Front of house areas to be brushed stainless steel.
2. Back of house areas to be white PVC.
3. Service areas and plant spaces to be metal clad, manufacturer standard finish.
4. Finishes/colours for non-standard or essential outlets shall be red.
5. Outdoor areas (including plant areas) and areas exposed to the external environment to be UV stabillised polycarbonate, and:

   a. IP 65 minimum rated.
   b. Complete with fail safe (closed) hinged cover.
   c. Sealing grommet / compression track to ensure seal is maintained once plug & flexible cable is in position.
   d. Lockable or with keyed switch where indicted on the drawings.

C. Shutters and pins:

1. 13A outlets to be standard 3 flat pin for normal services, keyed for use with non-standard requirements.
2. 5A outlets to be standard 3 round pin as per BS 546.
3. 15A outlets to be standard 3 round pin as per BS 546.
4. All devices to include safety shutter to ensure access to live and neutral connections are protected until earth pin is depressed.

D. Switches (where applicable):

1. Inboard or outboard rocker.
2. Illuminated rocker unless otherwise noted.
3. Rocker to be as per face plate material finish and colour.
4. Rockers shall be located so they can be operated with plug in position, plugs or adopters shall not interfere with switch operation.

E. Earthing:

1. All socket outlets to include dual earth terminals.

F. Integral RCD protection:

1. Where detailed elsewhere within the contract documents provide socket outlets complete with integral 30mA trip rating with active control circuit.

G. Labeling:
   1. Where socket outlets are provided for a specific function and not considered general purpose provide permanently engraved markings by manufacturer.
   2. All socket outlets using non- standard terminal arrangements or for essential services shall labelled accordingly.

1.11 FUSED CONNECTION UNITS (SPUR UNITS)

A. Manufactured in accordance with BS 1363-4: 1995 as applicable.

B. White moulded inserts and fuse holders shall be fitted to each unit, together with an appropriately rated cartridge fuse to BS.1362.

C. Where fused connection units serve remote items the Contractor shall include for the supply of an independent flex outlet with each unit. The flex outlet shall be located adjacent to the terminals of equipment being supplied.

D. Material and Finishes (Unless stated elsewhere within the contract documentation):
   1. Front of house areas to be brushed stainless steel.
   2. Back of house areas to be white PVC.
   3. Service areas, above ceilings, within concealed / blind spaces and plant spaces to be metal clad, manufacturer standard finish.
   4. Finishes/colours for non-standard or essential outlets shall be red.
   5. Outdoor areas (including plant areas) and areas exposed to the external environment to be UV stabillised polycarbonate, and:
      a. IP 65 minimum rated.
      b. Complete with fail safe (closed) hinged cover.
      c. Sealing grommet / compression track to ensure seal is maintained once plug & flexible cable is in position.
      d. Lockable or with keyed switch where indicted on the drawings.
   6. Where required unit to be complete with integral flex outlet.

E. Switches (where applicable):
   1. Illuminated rocker or pilot light unless otherwise noted.
   2. Rocker to be as per face plate material finish and colour.

F. Labeling:
   1. Provide permanently engraved markings by manufacturer clearly identifying the purpose of the connection unit.

1.12 DOUBLE POLE SWITCHES

A. Manufactured in accordance with BS EN 60669-1: 1999 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):
   1. Front of house areas to be brushed stainless steel.
   2. Back of house areas to be white PVC.
   3. Service areas and plant spaces to be metal clad, manufacturer standard finish.
   4. Outdoor areas (including plant areas) and areas exposed to the external environment to be UV stabillised polycarbonate, and:
      a. IP 65 minimum rated.
      b. Complete with fail safe (closed) hinged cover.
      c. Lockable or with keyed switch where indicted on the drawings.
   5. Where required unit to be complete with integral flex outlet.

C. Switches:

1. Illuminated rocker unless otherwise noted.
2. Rocker to be as per face plate material finish and colour.
3. Standard switch ratings shall be 20A, 32A and 45A.

D. Labeling:

1. Provide permanently engraved markings by manufacturer clearly identifying the purpose of the switch.

1.13 COOKER CONTROL UNITS

A. Manufactured in accordance with BS EN 60669-1: 1999 as applicable.

B. Integral 13A socket outlet shall only be utilised where allowed by Local Authority Wiring Regulations.

C. Material and Finishes (Unless stated elsewhere within the contract documentation):

1. Generally to match other electrical devices in the same space.
2. Where required unit to be complete with integral flex outlet.

D. Switches:

1. Illuminated rocker or pilot light unless otherwise noted.
2. Rocker to be as per face plate material finish and colour.
3. Standard switch ratings shall be 45A.

E. Labeling:

1. Provide permanently engraved markings by manufacturer clearly identifying the purpose of the switch.

1.14 FAN ISOLATORS (NON-INDUSTRIAL TYPE FANS)

A. Manufactured in accordance with BS EN 60947-3: 1992 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):

1. Front of house areas to be brushed stainless steel.
2. Back of house areas to be white PVC.
3. Service areas and plant spaces to be metal clad, manufacturer standard finish.
4. Where required unit to be complete with integral flex outlet.

C. Switches (where applicable):

1. Illuminated rocker unless otherwise noted.
2. Rocker to be as per face plate material finish and colour.
3. Standard switch ratings shall be 10A.

D. Labeling:

1. Provide permanently engraved markings by manufacturer clearly identifying the purpose of the switch.

1.15 FLEXIBLE CABLE OUTLET PLATES

A. Manufactured in accordance with BS 5733: 1995 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):

1. Generally to be white PVC.
2. Service areas and plant spaces to be metal clad, manufacturer standard finish.

C. Each unit shall be fitted with three pairs of terminals, each being able to accommodate the required size of conductor.

D. A cord grip shall be fitted into each unit.

1.16 SHAVER UNITS

A. Manufactured in accordance with BS EN 61558-2-5: 1998 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):
   1. Generally to match other electrical devices in the same space.

C. Voltages and safety:
   1. Unless otherwise noted shaver outlets shall be dual voltage, 115V / 240V 50Hz.
   2. Double wound transformer to be used, primary side energised / de-energised by the insertion of the shaver plug.
   3. Integral solid state overload device shall be provided.

D. Labeling:
   1. Provide permanently engraved markings by manufacturer clearly identifying the purpose of the switch.

1.17 INDUSTRIAL SOCKET OUTLETS

A. Manufactured in accordance with BS EN 60309-1: 1999 as applicable.

B. Number of Phases: Single or three phase as required.

C. Material and Finishes:
   1. Polybutylene Terapthalate (PBT), Nlon or Polycarbonate.
   2. Finishes/colours shall be grey or white, manufacturers standard.
   3. IP 44 minimum rated where moderate conditions are anticipated
   4. IP 67 to be provided for exposed external areas and industrial areas where wash down / spray & jet water use is expected.
   5. Voltage colour code marking as per standards.

D. Ratings, poles and voltages:
   1. Standard current ratings shall include 16A, 32, 63A and 125A.
   2. Standard pole options shall include 2P + E, 3P + E, 3P + N + E as required.
   3. Voltage ranges shall include 25V, 50V, 110V, 240V and 415V.

E. Switches (where applicable):
   1. Rotary or paddle type.
   2. Lockable in the on or off position.

F. Mounting options:
   1. Manufacturers standard options to include surface, semi recessed, angled or panel mounted configurations.

G. Mounting options:
   1. Where detailed elsewhere within the contract documentation multiple components may be combined within proprietary manufactured enclosures to form combination devices.
   2. Combination devices shall comply with the requirements of the Local Authority Wiring Regulations and may combine multiple services and voltages, be complete with circuit protection devices and isolation switches.

1.18 STANDARD SWITCHES

A. Manufactured in accordance with BS 5733: 2010 and BS EN 60669-1 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):
   1. Front of house areas to be brushed stainless steel.
   2. Back of house areas to be white PVC.
   3. Service areas and plant spaces to be metal clad, manufacturer standard finish.
   4. Outdoor areas and areas exposed to the external environment to be UV stabillised polycarbonate, and:

a. IP 56 minimum rated.
b. Complete with fail safe (closed) hinged cover.
c. Lockable or with keyed switch where indicted on the drawings.

C. Switches:
1. Light switches to be rocker type unless otherwise noted or required by controls package.
2. Rocker to be as per face plate material finish and colour.
3. Standard switch ratings shall be 10A or 20A.
4. Bell push to be push to make momentary type switches

D. Labeling:
1. Provide permanently engraved markings by manufacturer clearly identifying the purpose of the switch.

1.19 TELEVISION OUTLETS

A. Manufactured in accordance with BS 3041: 1997, IEC 169-2: 1965, BS EN 50083 & BS 5733: 1995 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):
1. Front of house areas to be brushed stainless steel.
2. Back of house areas to be white PVC.

C. Labeling:
1. Provide permanently engraved markings by manufacturer clearly identifying the purpose of each outlet.

D. Connectors (as required) consisting of:
1. Coaxial (male / female); and
2. F-Type connector.

E. Where required, device shall be permitted to be a modular / grid type device.

1.20 TELECOMMUNICATIONS OUTLETS

A. Manufactured in accordance with TIA/EIA-568-C, ISO/IEC 11801 as applicable.

B. Material and Finishes (Unless stated elsewhere within the contract documentation):
1. Front of house areas to be brushed stainless steel.
2. Back of house areas to be white PVC.

C. Labeling:
1. Outlet to be complete with clear window over paper label, Contractor to label / reference port / connection back at the upstream patching equipment panel.

D. Connectors:
1. Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP.

E. Where required, device shall be permitted to be a modular / grid type device.

1.21 GRID TYPE ACCESSORIES

A. Where required or as noted elsewhere in the contract documentation, modular / grid type switches and outlets shall be permitted.

B. In general, grid type accessories shall confirm to the specifications listed above and be from the same manufacturer as the general electrical accessories.

C. Finishes:
1. Finishes for the switch / accessory modules shall match the associated front-plates.

2. Finishes shall match the above sections.

EXECUTION

1.22 INSTALLATION

A. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

B. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

C. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film, until the last possible moment.
4. Connect devices to branch circuits using tails that are not less than 150 mm in length.
5. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
6. Tighten unused terminal screws on the device.
7. Ensure devices are installed plumb and level. Where multiple devices sit adjacent to each other all plates shall be set at the same level with the same spacing between plates when plates are grouped in a cluster.

1.23 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Test Instrument: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

C. Tests to be conducted in accordance with the Local Authority Wiring Regulations and BS 7671 as applicable.

1.24 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

B. Socket Outlets: Identify distribution board and circuit number from which served. Use hot, stamped or engraved machine printing with white filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

7.4.21 26 2813 - Fuses

GENERAL

1.1 SUMMARY

A. This Section includes cartridge fuses rated 600-V and less for use in control circuits, enclosed switches, distribution boards, switchboards, enclosed controllers and motor-control centers

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0553 – Identification for Electrical Systems
3. Section 26 0800 – Commissioning of Electrical Systems
4. Section 26 2413 – Switchboards
5. Section 26 2416 – Distribution Boards

1.2 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 1362:1973 - Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs).

D. BS 2692-2:1956 - Fuses for voltages exceeding 1000 V a.c. Expulsion fuses.

E. BS 2950:1958 - Specification. Cartridge fuse-links for telecommunication and light electrical apparatus.

F. BS 3036:1958 - Specification. Semi-enclosed electric fuses (ratings up to 100 amperes and 240 volts to earth).

G. BS 5564:1978 - Specification for high-voltage fuses for the external protection of shunt power capacitors.

H. BS 6885:1988 - Specification for miniature cartridge fuse links for use on printed wiring boards.

I. BS 7632:1993, IEC 60594:1977 - Internal fuses and internal overpressure disconnectors for capacitors for inductive heat generating plants.

J. BS 7654:2010 - Specification for single-phase street lighting cut-out assemblies for low-voltage public electricity distribution systems. 25 A rating for highway power supplies and street furniture.

K. BS 7656:1993 - Specification for low-voltage pole-mounting fuses (cut-outs). 315 A rating.

L. BS 7657:2010 - Specification for cut-out assemblies up to 100 A rating, for power supply to buildings.

M. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

N. BS EN 60127 (series) - Miniature fuses.

O. BS EN 60143-3:1998, IEC 60143-3:1998 - Series capacitors for power systems. Internal fuses.

P. BS EN 60269 (series) - Low-voltage fuses.

Q. BS EN 60282-1:2009 - High-voltage fuses. Current-limiting fuses.

R. BS EN 60871-4:1997, IEC 60871-4:1996 - Shunt capacitors for a.c. power systems having a rated voltage above 1 kV. Internal fuses

S. BS EN 60947 (series) - Low-voltage switchgear and controlgear.

T. PD IEC/TR 60787:2007 - Application guide for the selection of high-voltage current-limiting fuse-links for transformer circuits.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

6. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
   For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
7. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
8. Current-limitation curves for fuses with current-limiting characteristics.
9. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
10. Coordination charts and tables and related data.

B. Point-wise compliance statement to the specifications duly signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

C. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE, UL, CSA and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

1.5 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.6 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.7 CARTRIDGE FUSES

A. Characteristics: BS, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

1.8 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 1 mm - thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

B. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.

C. Upon completion of the building, the contractor shall provide the Client with spare fuses as indicated below:

D. Ten (10) percent (minimum of 3) of each type and rating of installed fuses shall be supplied as spare.

E. A spare fuse cabinet shall be provided to store the spare fuses. Cabinet shall be wall-mounted, hinged cover with latch and nameplate with the word "SPARE FUSES" on the front.

1.9 LABELS

A. Identification labels for building standard fuses of 600A and below to read: "WARNING: INSTALL CLASS RK1 FUSES ONLY".

EXECUTION

1.10 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.11 FUSE APPLICATIONS

A. Motor Branch Circuits: Class RK5, time delay.

B. Other Branch Circuits: Class RK5, time delay.

C. Where required on drawings.

1.12 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Fuses shall not be installed until equipment is ready to be energized.

C. Provide and install fuses of proper type, voltage and ampere ratings for all fusible devices furnished under this section and all other sections of this specification.

1.13 LABELS AND IDENTIFICATION

A. Provide identification per Section 26 0553.

B. Install labels indicating fuse replacement information on inside door of each fused switch.

C. Apply appropriate label within each switch, motor starter, or panelboard door or at location next to fuse clips, where fuses shall be furnished and installed by this Contractor.

D. Fill-in, in ink blank spaces on labels for non-standard fuses with appropriate fuse data.

1.14 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 5 deg C or more than 38 deg C, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.15 COORDINATION

A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.16 COMMISSIONING

A. The equipment and systems referenced in this section are to be commissioned as per the requirements of Section 26 0810 – Commissioning of Electrical Systems.

B. The Contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation.

C. Coordinate all commissioning activities with the Commissioning Authority.

7.4.22 26 2816 - Enclosed Switches and Circuit Breakers

GENERAL

1.1 SUMMARY

A. This section includes individually mounted enclosed switches and circuit breakers used for following:

1. Sub-main and sub-circuit protection.
2. Motor and equipment disconnecting means.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0526 – Grounding and Bonding for Electrical Systems
3. Section 26 0573 – Overcurrent Protective Device Coordination Study

1.2 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 7071:1992 - Specification for portable residual current devices.

D. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

E. BS EN 60898-1:2003+A13:2012 - Electrical accessories ± Circuit breakers for overcurrent protection for household and similar installations. Circuit-breakers for a.c. operation.

F. BS EN 60898-2:2006 - Electrical accessories. Circuit-breakers for overcurrent protection for household and similar installations. Circuit-breakers for a.c and d.c. operation.

G. BS EN 61439-2:2011 - Low-voltage switchgear and controlgear assemblies. Power switchgear and controlgear assemblies.

H. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

1.3 DEFINITIONS

A. ELCB: Earth Leakage Circuit Breaker

B. GFCI: Ground-Fault Circuit Interrupter.

C. RCD: Residual Current Device

D. RMS: Root Mean Square.

E. SPDT: Single Pole, Double Throw.

1.4 SUBMITTALS

A. Product Data:

1. Provide product data for each type of switch, circuit breaker, accessory, and component indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
3. Provide a complete coordination study stamped and sealed by the consultant.

B. Shop Drawings:

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include following:
   a. Enclosure types and details for types other than NEMA 250, Type 1.
   b. Current and voltage ratings.
   c. Short-circuit current rating.
   d. UL listing for series rating of installed devices.
   e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Informational Submittals - Submit following:

1. Field Test Reports: Submit written test reports and include following:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Closeout Submittals:

1. Maintenance Data: For enclosed switches and circuit breakers and for components. Include:
   a. Routine maintenance requirements for components.
   b. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
   c. Time-current curves, including selectable ranges for each type of circuit breaker.

E. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

F. The Contractor shall follow to the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories shall be Listed and labelled, ES, CENELEC, UL or CSA and,or by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Comply with IEE Wiring Regulations

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces.

B. Maintain required workspace clearances and required clearances for equipment access doors and panels.

C. Undertake the Overcurrent Protective Device Coordination Study as per Section 26 0573.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.9 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.10 ENCLOSED SWITCHES

A. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle or equivelent.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with rejection clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position or equivelent.

1.11 ENCLOSED CIRCUIT BREAKERS

A. Moulded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with following field-adjustable settings:

a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long- and short-time time adjustments.
d. Ground-fault pickup level, time delay, and I2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
7. Moulded-Case Switch: Moulded-case circuit breaker without trip units.

B. Moulded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment, type HID for switching H10 lighting.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and timedelay settings, push-to-test feature, and ground-fault indicator.
4. Shunt Trip: 240-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1-to 0.6-second time delay.
6. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b"contacts operate in reverse of circuit-breaker contacts.

1.12 ENCLOSURES
A. Rated to meet environmental conditions of installed location or equivelent.
1. Outdoor Locations: IP66 or equivalent.
2. Other Wet or Damp Indoor Locations: IP55 or equivalent.

1.13 FACTORY FINISHES
A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosures before shipping.

EXECUTION

1.14 EXAMINATION
A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
1. Proceed with installation only after unsatisfactory conditions have been corrected.

1.15 INSTALLATION
A. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

1.16 IDENTIFICATION
A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 26 0553 - Identification for Electrical Systems.
B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

1.17 CONNECTIONS
A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.
B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.

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

1.18 FIELD QUALITY CONTROL

A. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.

B. Test continuity of each line- and load-side circuit.

C. Testing: After installing enclosed switches and circuit breakers 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 indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for moulded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

1.19 ADJUSTING AND CLEANING

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

B. Cleaning: On completion of installation, inspect interior and exterior of enclosures.

1. Remove paint splatters and other spots.
2. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
3. Repair exposed surfaces to match original finish.

7.4.23 26 2913 - Enclosed Motor Controllers

GENERAL

1.1 SUMMARY

A. This section includes the following types of motor controllers:

1. Manual motor controllers.
2. Magnetic motor controllers.
3. Combination magnetic motor controllers and disconnects.

B. Related Sections:

1. Section 26 0500 – Basic Electrical Materials & Methods
2. Section 26 0529 – Hangers and Supports for Electrical Systems
3. Section 26 0553 – Identification for Electrical Systems
4. Section 26 2813 – Fuses
5. Section 26 2419 – Motor Control Centers

1.2 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Moulded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.3 REFERENCES

A. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

B. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

C. IEEE 399-1997 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).

D. IEEE 519-1992 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

E. Local Electricity Supply Authority Regulations.

1.4 SUBMITTALS

A. Shop Drawings:

1. Include dimensions, materials, ducts, inserts, junction boxes, supports, fittings and terminations, service outlet fittings, receptacles and telecommunications outlets.
2. Drawings shall show the layout of the duct system, junction boxes, and termination at panelboards, telecommunications closets and cabinets.

B. As-built Drawings:

1. Deliver four sets of drawings to the Resident Consultant showing the exact location of all underfloor ducts and junction boxes dimensioned from the centerline of columns.
2. Show the location and circuiting of all power service outlet fittings.
3. Show the location of all telephone and data service fittings.

C. Manuals:

1. Provide a complete description of the system and instructions as to allow additions to, and proper maintenance of the system. Instructions shall include information on locating and installing inserts of preset and afterset types.
2. Two weeks prior to final inspection, submit four copies of the manuals to the Consultant.

D. Certifications:

1. Two weeks prior to final inspection, submit four copies of the following to the Resident Consultant:
2. Certification that the materials are in accordance with the drawings specifications.
3. Certification that all materials have been properly installed.

E. Product Data:

1. Provide catalogue sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

F. Test Reports:

1. Indicate field test and inspection procedures and test results.

G. Manufacturer's Instructions:

1. Indicate application conditions and limitations of use stipulated by testing agency.
2. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

H. Maintenance Data:

1. Replacement parts list for controllers.

I. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

J. The Contractor shall follow to the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 100 miles (160 km) of Project.
2. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: minus 20 deg C to 60 deg C.
2. Relative Humidity: 0 to 95 percent, noncondensing.
3. Altitude: sea level to 1000m above sea level.

1.8 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.9 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.10 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.11 MANUAL CONTROLLERS

A. Manual Motor Controllers: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller with overload element, red pilot light, NO auxiliary contact, and push button operator.

B. Fractional Horsepower Manual Controllers: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, red pilot light, and key operator.

C. Enclosures: NEMA ICS 6, Type 1 or equivelent.

D. Equivelent controllers constructed in accordance with alternate British or European standard.

1.12 AUTOMATIC CONTROLLERS

A. Magnetic Motor Controllers: NEMA ICS 2, AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

B. Reversing Controllers: Include electrical interlock and integral time delay transition between FORWARD and REVERSE rotation.

C. Two-Speed Controllers: Include integral time delay transition between FAST and SLOW speeds.

D. Coil Operating Voltage: 120 volts, 60 Hertz.

E. Overload Relays: NEMA ICS 2; bimetal.

F. Enclosures: NEMA ICS 6, Type 1.

G. Equivelent controllers constructed in accordance with alternate British or European standard.

1.13 ACCESSORIES

A. Auxiliary Contacts: NEMA ICS 2, 2 normally open contacts in addition to seal-in contact.

B. Cover Mounted Pilot Devices: NEMA ICS 5, standard duty oiltight type.

C. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.

D. Pushbuttons: Unguarded type.

E. Indicating Lights: Transformer, incandescent type.

F. Selector Switches: Rotary type.

G. Relays: NEMA ICS 2

H. Control Power Transformers:

1. 240 volt secondary, 100 VA minimum, in each motor starter.
2. Provide fused primary, secondary, and bond unfused leg of secondary to enclosure.

I. Equivalent controller accessories constructed in accordance with alternate British or European standard.

1.14 DISCONNECTS

A. Combination Controllers: Combine motor controllers with disconnects in common enclosure. Obtain IEC Class 2 coordinated component protection.

B. Thermal Magnetic Circuit Breakers: Integral thermal and instantaneous magnetic trip in each pole; UL listed.

C. Motor Circuit Protector: Circuit breakers with integral instantaneous magnetic trip in each pole; UL listed.

D. Non-fusible Switch Assemblies: NEMA KS 1, enclosed knife switch with externally operable handle.

E. Fusible Switch Assemblies: NEMA KS 1, enclosed knife switch with externally operable handle. Fuse clips: Designed to accommodate Class R fuses.

F. Equivalent controller constructed in accordance with alternate British or European standard.

EXECUTION

1.15 INSTALLATION

A. Install enclosed controllers where indicated, in accordance with manufacturer's instructions.

B. Provide supports in accordance with Section 26 0529.

C. Provide fuses for fusible switches; refer to Section 16491 for product requirements.

D. Select and install overload heater elements in motor controllers to match installed motor characteristics.

E. Provide engraved plastic nameplates; refer to Section 26 0553 for product requirements and location.

F. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place label in clear plastic holder.

1.16 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with Section 26 0710.

B. Inspect and test in accordance with NETA STD ATS, except Section 4.

C. Perform inspections and tests listed in NETA STD ATS, Section 7.16.2.

7.4.24 26 2923 - Variable Frequency Motor Controllers

GENERAL

1.1 SUMMARY

A. This section includes separately enclosed, pre-assembled Variable Frequency Controllers for speed control of AC induction motors.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0553 – Identification for Electrical Systems
3. Section 26 2419 – Motor Control Centers

1.2 DEFINITIONS

A. BMS: Building management system.

B. DCS: Distributed Control System

C. DOL: Direct On-line

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCC: Motor-control center.

I. MCCB: Moulded-case circuit breaker.

J. NC: Normally closed.

K. NO: Normally open.

L. PCC: Point of Common Coupling

M. PID: Control action, proportional plus integral plus derivative.

N. RFI: Radio-frequency interference.

O. SCADA: Supervisory Control and Data Acquisition

P. SCR: Silicon-controlled rectifier.

Q. TDD: Total demand (harmonic current) distortion.

R. THD(V): Total harmonic voltage demand.

S. TVSS: Transient voltage surge suppressor.

T. VFC: Variable-frequency controller.

U. VSD: Variable-speed drive.

1.3 TERMINOLOGY

A. Variable Frequency Controller (VFC) and Variable Speed Drive (VSD) may also be used interchangeably to have the same meaning.

1.4 REFERENCES

A. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

B. IEEE 399-1997 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).

C. IEEE 519-1992 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

1.5 SUBMITTALS

A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of enclosed unit.
f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
g. Specified modifications.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Harmonic Analysis Study and Report:

1. A harmonic analysis report complying with IEEE 399 shall be submitted with the Shop Drawings to verify compliance with the voltage and current distortion limits as specified in the latest version of IEEE-519 Tables 10.2 and 10.3.
2. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at the defined PCC to specified levels.

E. Field test and inspection reports.

F. Point-wise compliance statement to the specifications duly signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

G. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.6 QUALITY ASSURANCE

A. Variable frequency drives shall utilize a field proven design. The VFC manufacturer shall demonstrate at least five (5) years of continuous field operating experience with equipment of similar size and design.

B. A factory authorized service and parts organization shall be located within 100 miles (160km) of the project location.

C. Provide the name and address of the factory authorized service and parts organization nearest to the project location at the time of the bid/material submission.

D. Equipment shall be UL or ETL labelled or its equivalent as recognized internationally.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Package the equipment for maximum protection during delivery and storage.

B. Store the equipment indoors in a clean, dry, heated storage facility until ready for installation.

C. Do not install the equipment in its final location until the facilities are permanently weather tight.

D. Protect the equipment at all times from exposure to moisture, chemicals, hydrogen sulfide and chlorine gas.

E. If required in the driven equipment specifications, the VFC manufacturer shall ship equipment to the driven equipment manufacturer's testing facility for use during factory acceptance test.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:

1. Ambient Temperature: minus 20 deg C to 60 deg C.
2. Relative Humidity: 0 to 95 percent, noncondensing.
3. Altitude: sea level to 1000m above sea level.

B. Under normal operating conditions, harmonic currents introduced into the power system supply network from the variable frequency drives shall not exceed the distortion limits for a general system as defined in IEEE Standard 519.

C. The VFC shall not produce motor noise in excess of the manufacturers published noise standards for 50-Hz operation.

1.9 COORDINATION

A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, and horsepower requirements of the load.
2. Ratings and characteristics of supply circuit and required control sequence.
3. Ambient and environmental conditions of installation location.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

C. Refer to the Mechanical, Plumbing and Fire Protection specifications for description of system operation.

D. VFCs shall be incorporated into the Control Panels specified in Section 26 2419 – Motor Control Centres.

E. Provide all labor, equipment, supervision and materials for the installation, testing and start-up of the variable frequency controllers (VFC).

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: five years from date of Substantial Completion.

1.11 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.12 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.13 RATING

A. Service Conditions:

1. Input power: 415 V, plus 6-percent, minus 6-percent, 3-phase, 50Hz.
2. Input frequency: 47 to 53 Hz.

B. Minimum drive efficiency: 97 percent or better at 4/4 motor base speed and rated torque.

C. Displacement power factor: 95 percent or higher throughout the entire speed range, measured at drive input terminals.

D. Drive output:

1. 100 percent rated current continuous, suitable for operation of the driven equipment over the required speed range without overloading.
2. Drives shall be capable of a continuous overload up to 110 percent rated current for variable torque loads and 150 percent rated current for constant torque loads.
3. Starting torque shall be matched to the load.

E. Voltage regulation: Plus or minus 1 percent of rated value, no load to full load.

F. Output frequency drive: No more than plus or minus 0.5 percent from setpoint.

G. Drives shall withstand five cycle transient voltage dips of up to 15 percent of rated voltage without an under-voltage trip or fault shutdown, while operating a variable torque load.

1.14 CONSTRUCTION

A. General:

1. The VFCs shall utilize a digital pulse width modulated (PWM) design to convert the fixed AC input to a variable voltage, variable frequency AC output. Construction shall be modular, using plug-in type component mounting or keyed ribbon cable connections wherever possible to minimize downtime during repair.
2. The VFC shall operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 10 percent total harmonic voltage distortion and commutation notches up to 36,500 volt

microseconds, or when other VFC's are operating from the same bus. The drive shall include transient voltage suppression to allow reliable operation on a typical commercial power distribution system.

3. The VFC shall consist of a full-wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage.
   a. Provide a DC link choke smoothing reactor to limit fault throughput.
   b. The PWM strategy shall be of the space-vector type implemented through a microprocessor which generated a sinecoded output voltage.
4. The output shall be generated by power transistors which shall be controlled by six identical, optically isolated base driver circuits.
   a. The VFC shall have an output voltage regulator to maintain correct output Volt/Hertz despite incoming voltage variations.
   b. The VFC shall have a continuous output current rating equal to or greater than the motor full load nameplate current.

B. Features and Options:
1. Each VFC shall have a moulded case, circuit breaker type main powerdisconnect switch, with an external operating handle. The circuit breaker shall have a short circuit rating of 100,000 amperes RMS symmetrical and shall be labelled in accordance with UL Standard 489.
2. Provide the following safety features:
   a. Provision to padlock main disconnect handle in the OFF position.
   b. Mechanical interlock to prevent opening cabinet door with disconnect in the ON position, or moving disconnect to the ON position while the unit door is open.
   c. Barriers and warning signs on terminals that are energized with the power disconnect OFF.
3. Provide an equipment ground bus or lug connectors in each enclosure, suitable for connection to the copper grounding conductors shown on the Drawings.
4. Each VFC shall have a soft-start bypass starter to allow the driven load to run in the event of VFC shutdown.
   a. The transfer from the VFC to the bypass starter shall be manual, by means of a selector switch.
   b. Bypass starter shall be fully digital, closed-loop (current ramp) with bypass capability.
5. Each VFC shall be equipped to receive a signal from a remote pushbutton station to remove power from the VFC.
6. Drive shall be capable of operating the load at the distance from the controller as installed. Line reactors shall be provided if required.

C. Interface Features:
1. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFC and determine the speed reference.
2. The VFC shall be able to be programmed to provide a 24 V DC output signal to indicated that the VFC is in Auto/Remote mode.
3. The VFC shall provide digital manual speed control. Potentiometers are not acceptable.
4. The keypads for all sizes of VFC's shall be identical and interchangeable.

5. To set up multiple VFC's, it shall be possible to upload all setup parameters to the VFC's keypad, place that keypad on all other VFC's in turn and download the setup parameters to each VFC. To facilitate setting up VFCs of various sizes, it shall be possible to download from the keypad only size independent parameters.
6. The following controls and indicators shall be provided, either separately or as part of the keypad/display:
   a. POWER ON, RUN AND FAULT indication.
   b. FAULT RESET.
   c. MANUAL-AUTO control mode selector.
   d. Manual START/STOP controls.
   e. Manual speed adjust capability.
7. Two set-point control interface (PID control) shall be standard in the unit. VFC shall be able to look at two feedback signals, compare with two setpoints and make carious process control decisions.
8. Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFCs unable to show these four displays simultaneously shall provide panel meters.
9. The following displays shall be accessible from the control panel in actual units:
   a. Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFC Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.).
   b. VFC will read out the selected engineering unit either in a linear square or cubed relationship to output frequency as appropriate to the unit chosen.
10. The VFC shall have temperature controlled cooling fans for quiet operation and minimized losses.
11. The VFC shall store in memory the last 10 faults and related operational data.
12. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two current (4 to 20 mA) inputs.

D. Auxiliary Contacts:
1. Provide one set of Form C auxiliary dry contacts for remote indication of VFC running status.

E. Marking and Identification:
1. Provide 1-in by 3-in, nominal, engraved lamicoid equipment nameplates on each VFC fastened with stainless steel screws or rivets. Nameplates shall be black with white core, 19mm (3/8-in.) high lettering.
2. Provide permanent warning signs as follows.
   a. A Warning - Hazard of Electric Shock - Disconnect power before opening or working on this unit on main power disconnect.

F. System Communications:
1. VFC shall have the capability of communicating via RS-232, RS-422, or RS-485 port.
2. VFC parameters, fault log and diagnostic log shall be downloadable via the RS-232, RS-422, or RS-485 port.
3. VFC will support an integral PID algorithm.

1.15 PROTECTIVE AND OPERATIONAL FEATURES

A. Make provisions for field adjustment of the following parameters through the keypad/display:
   1. Current limit and boost.
   2. Voltage (Volts/Hertz)
   3. Frequency (Minimum/Maximum).
   4. Independently adjustable acceleration and deceleration rates.
   5. Auto restart delay.

B. Make provisions to accept a remote dry contact closure to start and stop the drives with the drive control system in the AUTO mode.

C. Make provisions to accept a 4-20 mA DC input signal for remote speed control.
   1. Input shall be isolated at the drive and active with the drive control system in the AUTO mode.
   2. Zero and span adjustability shall be provided.

D. Provide a 4-20 mA DC isolated output signal proportional to speed for remote speed indication.

E. Provide the following short circuit and input protective features:
   1. High speed current limiting input fuses and line reactors.
   2. Solid state instantaneous overcurrent trip.
   3. Undervoltage protection with automatic restart.
   4. Ground fault protection.

F. Provide the following internal protective features:
   1. Transient surge protection.
   2. Transistor overcurrent protection.
   3. Current limit, inverse time type.
   4. DC bus fuse protection and discharge circuit.
   5. DC bus overvoltage trip.

G. Provide the following output protective features:
   1. Inverse time motor overload protection.

H. VFC Automatic Control:
   1. PID utilizing an internal or external setpoint.
   2. Selectable critical speed avoidance bands with programmable bandwidths.
   3. Auto start functions: On/Off, Delay On/Off. Operable from a 4-20mA signal or from the PID output, command, feedback signal.
   4. Speed Profile: Programmable entry and exit points. Programmable entry and exit speeds.
   5. Programmable loss of signal control: Stop, maintain speed, or default to preselected setpoint.

1.16 DIAGNOSTIC AND FAULT CAPABILITY

A. The following conditions shall cause an orderly drive shutdown and lockout:
   1. Incorrect phase sequence.
   2. Blown input fuse or single phasing of supply.
   3. Control power supply failure.
   4. Instantaneous overcurrent.
   5. Sustained overload.
   6. Transistor overcurrent.

B. Provide complete built-in diagnostic and test capability to enable maintenance personnel to rapidly and accurately identify the cause of equipment failure.

1.17 SURFACE PREPARATION AND SHOP COATINGS

A. All non-current carrying metal parts of the equipment cabinet shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pre-treatment to inhibit rust.

B. Equipment shall be finish painted with one coat of manufacturer's standard electrocoated, heat cured enamel.

C. Unpainted non-current carrying parts shall receive a protective zinc plating to prevent corrosion. Printed circuit boards shall be coated with a protective conformal epoxy. All device contacts shall be silver cadmium plated.

1.18 SHOP TESTING

A. Perform manufacturer's standard production testing and inspection prior to delivery to project site.

EXECUTION

1.19 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

1.20 HARMONIC ANALYSIS STUDY AND FILTERING

A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system.

B. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at the defined PCC to specified levels.

C. The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformers.

D. If, as a result of analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid.

1.21 INSTALLATION

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

B. Remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.

1.22 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

1.23 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system.

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

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

1.24 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 5 percent of motor nameplate rated voltages. If outside this range for any motor, notify the Consultant and Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

1.25 ADJUSTMENT

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Make all VFC internal adjustments and all adjustments necessary for manual and automatic operation of the entire system of driven equipment.

1.26 CLEANING

A. Remove all rubbish and debris from inside and around the equipment.

B. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags.

C. Do not use compressed air.

1.27 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

7.4.25 26 3213 - Packaged Engine Generators

GENERAL

1.1 SUMMARY

A. This Section includes packaged engine-generator sets for emergency power supply with the following features:

1. Diesel engine.
2. Unit-mounted cooling system.
3. Unit-mounted control and monitoring.
4. Performance requirements for sensitive loads.

B. Related Sections include the following:

1. Section 26 0913 – Electrical Power Monitoring and Control

1.2 DEFINITIONS

A. Generator Ratings:

1. Standby rating. Applicable for supplying continuous electrical (at variable load) in the event of utility power failure. No overload is permitted on this rating. (usually runs for less than 60 hours per year)
2. Prime power. Applicable for supplying variable load for an unlimited time with 10% overload permissible for 1 hour in 12.
3. Continuous power. Applicable for supplying variable load for an unlimited time.

B. LP: Liquid petroleum.

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

1.3 REFERENCE STANDARDS

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Civil Defence Department requirements.

C. Qatar Construction Specification 2010.

D. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

E. BS EN 55015:2006+A2:2009 - Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment.

F. BS EN 60439 (series) - Low-voltage switchgear and controlgear assemblies.

G. BS EN 60529:1992 - Specification for degrees of protection provided by enclosures (IP code).

H. IEEE 115-2009 - IEEE Guide for Test Procedures for Synchronous Machines.

I. ISO 3046 (series) - Reciprocating internal combustion engines.

J. ISO 8528 (series) - Reciprocating internal combustion engine driven alternating current generating sets.

K. NFPA 110 - Standard for Emergency and Standby Power Systems.

L. NFPA 30 - Flammable and Combustible Liquids Code.

M. UL 142 - Steel Aboveground Tanks for Flammable and Combustible Liquids.

1.4 SUBMITTALS

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

1. Thermal damage curve for generator.
2. Time-current characteristic curves for generator protective device.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.
1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

G. Warranty: Special warranty specified in this Section.

H. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

I. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. Maintenance Proximity: Not more than three hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200km of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

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

E. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

F. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

G. Noise Emission: Comply with applicable state and local government requirements for < maximum noise level at project boundaries, due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

H. The Engineer reserves the right to witness factory test and shall witness all on-site test.

1.6 PERFORMANCE REQUIREMENTS

A. The generated voltage and frequency shall be maintained at all times within limits appropriate to performance class and suppress radio interference in accordance with BS EN 55015.

B. The generating set shall be capable of running up to normal speed and accepting full load within 10 seconds.

C. Noise Emission: The installation, including air intakes, air discharges and exhaust shall limit noise emission from the generator room/enclosure to not greater than 70 dBA when measured at 5 meters from the enclosure (when measured in any plane).

1.7 PROJECT CONDITIONS

A. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:

1. High salt and dust content in the air.
2. High ambient temperature.

1.8 COORDINATION

A. Locate the generating set into position to facilitate on-site maintenance and repairs and other main engine components. Provide access for removal of pistons and connecting rods.

B. Coordinate size and location of concrete bases for package engine generators and remote radiators mounted on grade. Cast anchor-bolt inserts into bases.

C. Coordination the following with other trades:

1. Size and location of equipment supports and roof penetrations
2. Acoustic attenuation
3. Ventilation
4. Fuel storage
5. Generator exhaust discharge
6. Size and rating of the life safety systems and plant.

D. Fuel storage facilities for the generator(s) will be provided by Division 22 Mechanical trade. Division 26 trade shall provide all necessary power supplies and pathways associated with this content of work.

E. The final rating of the generator set shall be verified against the final selection of HVAC equipment, lift motors, fire pumps, etc.

1.9 WARRANTY

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

1. Warranty Period: five years from date of Substantial Completion.

1.10 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and

adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.11 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.12 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.13 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

   a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

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

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
    a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

1.14 ENGINE

A. Fuel: Diesel, Grade DF-2.

B. Rated Engine Speed: 1500 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 11.4 m/s.

D. Lubrication System: The following items are mounted on engine or skid:
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:
1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
    a. Rating: 345kPa maximum working pressure with coolant at 82 deg C, and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

I. Muffler/Silencer: Industrial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   1. Minimum sound attenuation of 12 dB at 500 Hz.
   2. Sound level measured at a distance of 8m from exhaust discharge after installation is complete shall be 87 dB or less.

J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

K. Starting System: 24-V electric, with negative ground.
   1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
   2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
   3. Cranking Cycle: As required by NFPA 110 for system level specified.
   4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
   5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
   6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
   7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
   8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
      a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
      b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
      c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
      d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
      e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
      f. Enclosure and Mounting: IP66, wall-mounted cabinet.

1.15 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. General Requirements:

1. The fuel tanks shall comply with Woqod requirements.
2. Tanks shall be constructed from steel.
3. 110% bunded to reduce the risk of leaks and spills.
4. Fully baffled and pressure tested inner tank.
5. Tough, fully galvanised tubular steel chassis (on Fuelstores up to 3000 litres).
6. Lockable cabinet to protect fuel dispensing equipment and inlets/outlets to the tank.
7. Fully sealed magnetic drive tank contents gauge.
8. GPI HP-100 alloy bodied hand pump (flow rate up to 85 Litres/min), 4m hose, manual dispensing trigger and filter with replaceable element.
9. Fitted with automatic breather and pressure relief valve.
10. To ensure mechanical integrity, storage tanks should be designed and constructed in accordance with the following:
    a. All Woqod requirements.
    b. BS 2594 Carbon steel welded horizontal cylindrical storage tanks.
11. The materials used in the construction of the tank or, where appropriate, the tank lining, should be compatible with the chemical and physical properties of the liquid, to ensure that no interaction occurs which might cause failure of the tank.
12. Where a manhole is fitted to a tank the manhole should be at least 460 mm inside diameter. For tanks over 2 m in diameter and for tanks where personnel may have to wear protective clothing and breathing apparatus for entry, the manhole should be at least 600 mm inside diameter.
13. Tanks may be compartmented. Different materials should not be stored in the same tank, if leakage from one compartment to another is likely to cause a hazard. Mixing of chemically incompatible materials may cause an unwanted and possibly dangerous reaction within the tank. Even accidental mixing of apparently compatible solvents may create a hazard if the contaminated solvent is then fed into a process.
14. Corrosion protection:
    a. Corrosion protection shall be provided in accordance with BS 5493 Code of practice for protective coating of iron and steel structures against corrosion.
    b. Chemical-resistant coatings or paints shall be applied in accordance with manufacturers recommendations. These are generally sprayed on in several layers to the required thickness. Coatings should be inspected for thickness, continuity and hardness prior to installing the tank. For underground tanks, a bituminous coating can be applied using the following standards:
        1) BS 34 16 Bitumen-based coating solutions for cold application, suitable for use in contact with potable water.
        2) BS 6949 Bitumen-based coatings for cold application, excluding use in contact with potable water.

C. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
    a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 8 hours' operation at 130 percent of continuous load without being refilled.

3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain-line with shutoff valve.

D. Bulk Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
1. Tank level indicator.
2. Capacity: Fuel for seven days' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

1.16 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
2. Switchboard Construction: Freestanding unit complying with Division 26 Section "Switchboards."
3. Switchgear Construction: Freestanding unit complying with Division 26 Section "Low-Voltage Switchgear."
4. Current and Potential Transformers: Instrument accuracy class.

D. Indicating and Protective Devices and Controls:
1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).

9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Generator overload.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

F. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 26 Section "Electrical Power Monitoring and Control."

G. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.

1. Engine high-temperature shutdown.
2. Lube-oil, low-pressure shutdown.
3. Overspeed shutdown.
4. Remote emergency-stop shutdown.
5. Engine high-temperature prealarm.
6. Lube-oil, low-pressure prealarm.
7. Fuel tank, low-fuel level.
8. Low coolant level.

H. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labelled. Push button shall be protected from accidental operation.

1.17 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.

3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

1.18 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Dripproof.

G. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

H. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

I. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

J. Subtransient Reactance: 12 percent, maximum.

1.19 MOTORS

A. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

1.20 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, moulded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 6-mm thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

1.21 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

1.22 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
9. Report factory test results within 10 days of completion of test.

EXECUTION

1.23 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.24 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 25 mm on a 100-mm high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

1.25 HEALTH AND SAFETY

A. The Generator shall be complete with guards to protect personnel and components from all exposed hot or moving parts.

B. Hot surfaces presenting a contact or combustion hazard shall be guarded or insulated with 50mm thick mineral wool mattress to density 90 kg/sm and suitable for a temperature of 950°C. The mineral wool shall be encased in hammer clad aluminium overall.

C. Suitable warning notices shall be displayed on guards.

1.26 CABLING & WIRING IN GENERATOR ENCLOSURE

A. All wiring within the generator enclosure/compound shall be oil resistant to prevent damage in the event of spillage.

1.27 CONNECTIONS

A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Division 23 Section "Facility Fuel-Oil Piping."
2. Natural-gas piping, valves, and specialties for gas distribution are specified in Division 23 Section "Facility Natural-Gas Piping."
3. LP-gas piping, valves, and specialties for gas piping are specified in Division 23 Section "Facility Liquefied-Petroleum Gas Piping."

E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

1.28 IDENTIFICATION

A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

1.29 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
   a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer's specifications.
4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust Emissions Test: Comply with applicable government test criteria.
7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
8. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
   1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

1.30 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."

7.4.26 26 3301 - DC Battery Systems and Uninterruptable Power Supplies

GENERAL

1.1 SUMMARY

A. This section includes the following equipment used to form a complete DC Battery System for control of switchgear and protection circuits:
   1. Convertor.
   2. Battery charger
   3. Batteries.
   4. Invertor.
   5. By-pass.
   6. Fused disconnect switches and circuit.
   7. DC distribution/control panels.
   8. External bypass.

B. Related Sections:
   1. Section 26 0500 – Common Work Results Electrical

1.2 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

D. BS EN 50272-1:2010 - Safety requirements for secondary batteries and battery installations. General safety information.

E. BS EN 50272-2:2001 - Safety requirements for secondary batteries and battery installations. Stationary batteries.

F. BS EN 60086-2 - Primary Batteries. Physical and Electrical Specifications.

G. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

1.3 PERFORMANCE REQUIREMENTS

A. DC battery systems shall include a primary input circuit breaker, isolation transformer, batteries, battery charger, dc filter, battery racks, fused disconnect switch, dc distribution panel, and related accessories as specified herein.

B. Battery systems shall be sized to provide additional capacity over the calculated equipment power load; unless otherwise required additional capacity shall be 50 percent.

1.4 SUBMITTALS

A. Documentation with Tender: The Tender shall contain at least the following information and documents:
   1. Completed technical data sheets.
   2. Description of equipment and services.
   3. General arrangement drawings showing particulars of all equipment and accessories, their dimensions, weights, front and section views, etc.
   4. Descriptive catalogues and literature on the proposed types of equipment.
   5. Quality control manual or certificate.
   6. Deviation from the Specification, etc.

B. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product. Include equipment installation outline, connection diagram for external cabling, internal wiring diagram, and written instruction for installation.

C. Power consumption calculations: Estimated average power and peak power demand shall be provided.
   1. Battery and battery charger sizing calculations: Maximum battery load for the purposes of sizing is 25 Amperes.
   2. Product data and catalogue cuts for battery, battery chargers, dc distribution panels, circuit breakers, and fused disconnect switches.
   3. The Contractor shall base the battery and battery charger sizing calculations on actual equipment / vendor selected.

1.5 WARRANTY

A. Provide five (5) year warranty for batteries.

1.6 SPARES

A. Contractor shall provide a list of spares required for each installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.7 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Battery and battery charger sizing shall be verified by the Contractor based on actual equipment / vendor selected.

C. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.8 110V DC SERVICE EQUIPMENT

A. General Design Requirements
   1. Control, protection, alarm and indication devices, tripping and closing circuits, emergency power and lighting shall be supplied by a 110 V DC safe supply.
   2. The 110 V battery systems shall contain 2 x 50% rated duty Nickel-Cadmium (Ni-Cd) type battery units 2 x 100% rated duty float/boost/equalizing charger units, switchboard unit and 2 x 110V DC voltage regulator unit. These shall be arranged such that under normal conditions both float chargers are operating to supply the

specified DC load and at the same time automatically float charging the battery to keep it fully charged within the specified voltage limit for the correct operation of equipment.

3. There shall be four modes of operation for each battery charger as follows:
   a. Float Mode for trickle charging the batteries under normal DC loading condition.
   b. Equalizing mode to correct the irregularities of cell voltage. Selection shall be both auto and manual.
   c. Boost Mode for manual charging of batteries following a deep discharge or prolonged absence of AC supply. This mode shall permit charging of the batteries only by manual mode with auto - manual isolation of DC loads connected to the charger.
   d. Manual charging mode for commissioning of batteries.
4. It shall be possible to switch either charger or battery out of service leaving the other charger and battery to carry the full DC load requirement and at the same time the full battery float charge requirements. It shall not be possible to switch off more than one battery unit and one charger at one time.
5. The system shall be such that either section of the battery may be connected to the chargers through changeover contactors, which shall be mounted in the DC voltage regulator unit.
6. Under equalize charge condition charger shall be capable of supplying the full equalize charge requirement, taking care of load voltage not exceeding maximum voltage increase by allowable margin.
7. Under boost charge condition charger shall be capable of supplying the full boost charge requirement, taking care of Battery Voltage not exceeding maximum voltage increase by allowable margin.
8. Only one battery unit (50% of total battery capacity) shall be on boost charge and it shall be disconnected from DC bus-bar during the boost charge.
9. In case of loss of AC supply during boost charging and equalize charge, the charger shall return automatically to the float charge position and the battery shall be automatically connected to the DC busbar.
10. The second 100% charger shall be in float charge position and shall be connected to the DC busbar and to the second battery unit, thereby supplying the DC load requirement.
11. Selection of the equalize charge shall be both Auto and Manual and the period controlled automatically by a preset timing switch. Each equalize charge will be such that recharging the whole battery from the discharge condition does not exceed 15 hours. The control of the equalize charge condition shall be such that the charging rate is reduced as the battery approaches full equalize charge to avoid excessive gassing.
12. Selection of the boost charge shall be Manual and the period controlled automatically by a preset timing switch. Each boost charge will be such that recharging the whole battery from the discharge condition to 100% of fully charged capacity does not exceed 8 hours. The control of the boost charge condition shall be such that the charging rate is reduced as the battery approaches full charge to avoid excessive gassing.
13. 110 volt battery system shall be centre point earthed through a limiting resistance to limit earth fault D.C. current to maximum 10 mA. A suitable D.C. centre zero milli-ammeter shall be provided for detecting and clearing of 110 volts D.C. faults. A suitable battery earth fault scheme shall be provided, which shall be capable of

detecting, in the event of an earth fault, whether the positive or negative pole is earthed. Earth-fault alarm shall be initiated locally and at the NCC.

14. Design of the complete charger, bus bars, transformers and regulator unit shall be strictly with natural ventilation. In the event of outage of air conditioning system in LVAC/DC room, battery charging equipment and switchboards shall remain operational at full load without exceeding the permissible temperature rise of 65K, at an ambient temperature of 50DegC.This requirement shall be validated by type tests. Additionally, a minimum of two fans in each charger cubicle with ratings as specified in the technical schedule and protected through MCB shall be provided.
15. Fan failure signals, preferably group alarm, shall be available locally and for remote signaling. For maintenance convenience, it is required to have the fans installed at the bottom of the cubicle with exhaust grills at top. Dust filters shall be accessible from outside without opening the cubicle door.

B. Switchboard, Dc Voltage Regulator Unit and Charger Cubicles

1. The DC switchboard, DC voltage regulator unit and charger cubicles shall be designed for indoor mounting and shall be of fully metallic design. The free standing switchboard, DC voltage regulator unit and charger cubicles shall be mounted directly above the cable trench and shall have both front and rear access for maintenance. DC voltage regulator unit and Battery charger cubicles shall be of single tier construction and a separate DC distribution panel shall be incorporated.
2. The switchboard shall consist of cubicle(s) and shall be erected in a single row. Each charger and DC voltage regulator unit shall be arranged in a metallic cubicle which shall match the switchboard cubicles in height and other dimensions. The height of the cubicles shall not exceed 2250 mm and operating handles of all equipment shall be within the reach of a person standing at ground level.
3. The switchboard shall comply with latest revision of IEC 60439 and other relevant IEC Standards if not otherwise stated. The switchboard shall be of draw out design.
4. DC voltage regulator unit and charger cubicles shall be designed with a degree of protection IP43 and shall be vermin and termite proof.
5. The switchboard shall be designed with a degree of protection IP4X and shall be vermin and termite proof. Hinged doors shall be provided to provide easy access to equipment contained within the cubicle. The hinged doors shall be of the lift-off type, secured with integral handles provided with locks and shall be flush fitting and sealed with a gasket made of rubber or other approved material to prevent the ingress of dust. Cubicles and doors shall be structurally stiff and braced to withstand twisting without distortion.
6. The cubicle shall be designed for cable entry from the bottom rear side and equipped with glands suitable for all incoming and outgoing cables. Adequate working clearance shall be maintained inside the cubicles.
7. The main busbar shall be installed in the rear upper part of the distribution panel and shall be fed by battery/charger units. The incoming circuits to the main busbars shall be controlled and protected by two pole type MCCBs.
8. Sufficient number of two pole MCBs for outgoing circuits including spare unused feeders shall be provided.
9. The main DC switchboard shall be designed with a single busbar system containing two sections with a coupling load switch in between.
10. Each section shall be supervised by undervoltage, overvoltage and earth fault relays.
11. Outgoing circuits shall be controlled and protected by miniature circuit breakers, their short circuit rating being adequate to protect each circuit against the effects of a fault at the outgoing terminal of the unit.

12. Coloured mimic diagrams shall be provided on the front of the DC equipment cubicles with the necessary switch position indicators, device symbols, alarm, LEDs, status of chargers and change over contacts. It shall be fixed properly in a secure, legible and aesthetic manner For individual cubicles the necessary instruments, control switches and switch operating devices shall be installed on the front panel.
13. In DC switch board Ammeters shall be provided to indicate load output current, Voltmeters shall be provided for measuring load volts. Voltmeter shall be connected via miniature circuit breakers to the busbar. The indicating instruments shall be provided with connections from the back side and in accordance with IEC 60051.
14. DC voltage regulator unit and charger cubicles shall be provided with ammeter to indicate battery output current, DC voltage regulator output current. Voltmeters shall be provided for measuring battery and charger load volts. Voltmeter shall be connected via miniature circuit breakers to the busbar. The indicating instruments shall be provided with connections from the back side and in accordance with IEC 60051. Dropping diodes arrangement shall be designed in such a way to maintain a load voltage of 110V DC during equalize mode.
15. The following local alarms shall be provided by means of indicator lamps, together with facility for remote indication and audible alarm (at power Control System and Substation Control System):
    a. AC Supply Fail.
    b. Battery - High Voltage.
    c. Battery - Low Voltage.
    d. Charger Fail Indication.
    e. Battery Earth Fault.
    f. DC Supply Fail.
    g. Float Charger On;
    h. Equalize charger ON.
    i. Boost Charger On.
    j. Output DC MCB Trip (Common for all MCBs).
    k. Load High Voltage.
    l. Load low voltage.
    m. Battery fuse fail.
    n. Fan failure alarm.
    o. Commissioning Charging On.
16. Multiplication relays with three contacts for each alarm generated in the 110 V DC power supply system, should be provided.
17. The "LV DC O/G Feeders Trip/off" Signal shall be taken from MCB's off contacts through Isolatable type Terminal Blocks in order to avoid the above signal shall be going to NCC continuously, if the spare outgoing feeders shall be kept off after energization.
18. In the event of outage of the air-conditioning system in the LV AC/DC room the switchgear installation shall remain operational at full load and at the ambient temperature of 50°C. DC service equipment shall be provided with humidity controlled anti-condensation heaters with isolation facilities.

C. 110 V Battery Units

1. The battery units shall be Nickel-Cadmium (Ni-Cd) type. The batteries shall comply with IEC 60623, IEC 60478, IEC 60439 and IEEE 1115 standards as specified in corresponding Technical Data Sheet and other relevant Standards if not otherwise stated.

2. The battery units shall be located in a battery room and shall be connected to the distribution board and battery charger by PVC insulated copper cables.
3. The battery shall be mounted on heavy duty epoxy coated metal racks suitably protected against corrosion and attack by the battery electrolyte. The battery shall be spaced so as to permit sufficient access to all individual cells to allow replacement of cells and/or checking cell voltages and connections. Racks shall be assembled clear of walls to permit access on all four sides of the battery bank.
4. Battery trays shall be factory treated with an electrolyte corrosion resistance coating.
5. The cell container shall be made for non-flame propagating "translucent" shock resistant and leak-proof plastics.
6. Positive and negative terminals of each cell shall be clearly and permanently indicated. Intercell connections shall be nickel plated. Each terminal connector shall be stamped with the associated battery numbers.
7. The float voltage of the battery shall be the optimum required. It shall not exceed the maximum voltage rating of the equipment being supplied.
8. At the end of the rated discharge period the voltage available at the terminals of the equipment being controlled shall not be less than the minimum operating voltage of the equipment being supplied.
9. The discharge capacity of the battery shall be sufficient to supply loads during a discharge time of 10 hours.
10. Contractor shall provide battery with actual capacity based on the design calculation. The same is subject to KAHRAMAA approval.
11. The capacities of batteries selected shall be justified by calculation using the principles laid down in IEEE 1115 - Recommended Practice for Sizing Nickel - Cadmium batteries for stationary Applications. The minimum ambient temperature relevant for the calculation of the normal standing load must be 0°C.
12. The battery duty shall be sized based on the following load cycle:
    a. Normal standing load for the full discharge period at the minimum stated ambient temperature
    b. Simultaneous tripping of all circuit breakers due to bus zone fault plus two sequential closing and tripping of all circuit breakers one after the other
    c. Emergency lighting load for a period of one hour
    d. Sequential closing of the most distant group of circuit breakers when the battery is at the end of its discharge period and random operation of the bay disconnectors Minimum 25% spare capacity in each battery shall be considered while sizing the batteries and ageing factor as per standards / as recommended by the manufacturer for a life period of 25 years shall be considered.
13. Actual rated load of UPS system shall be considered in sizing calculation for each battery. Above required 25% spare capacity for battery sizing is not applicable to UPS load, considering that spare is already included in sizing of UPS.
14. The battery sizing shall consider that the service voltage required shall not drop below recommended figures (permitted voltage tolerances of the individual loads) and the voltage fluctuations caused by power consumption of various loads shall be kept within permitted limits
15. Protective relays which need non-standard DC voltages shall be supplied with DC/DC converters.
16. A fuse box, located in the battery room, shall be provided for each 50% battery. The positive and negative fuses for each battery shall be arranged in pairs and shall be

fully segregated from each other by an insulating barrier. The fuses shall be of the high breaking capacity type in accordance with IEC 60269.

17. Sufficient electrolyte shall be provided to permit the first filling of each cell and 5% spare electrolyte in solid form shall be provided for topping up during commissioning and another 5% spare electrolyte in solid form shall be delivered to KAHRAMAA Stores.

D. Battery Charging Equipment

1. The battery chargers shall be of three phase, full wave, fully controlled thyristor devices and shall operate fully automatically.
2. The battery charger output voltage shall be maintained constant at the float voltage recommended by the battery manufacturer to keep the battery in a fully charged condition, independent of load variations or variation of the AC input voltage.
3. The DC output of each charger unit shall remain within ± 2 per cent under any of the following conditions:
   a. System frequency: ± 5 per cent
   b. Rated voltage input: ± 10 per cent.
   c. Applicable for output range between 5 - 100 per cent of rated output.
4. The chargers shall be equipped with an automatic current limiting device to make them short-circuit proof. Current limitation shall be at 110% of rated output current. Each charger shall be designed to carry 110% of rated output current for an indefinite time. The chargers shall have the setting point adjustment with a range of ±10%.The Charger charging current shall be limited to maximum allowed battery charging current as recommended by the battery manufacturer.
5. The charger shall be equipped with input isolation switches, charger output isolation switch, charger to battery isolation switches, fuses, protective devices, indication instruments, switches, lamps and other necessary equipment.
6. Battery charger shall have battery test facility to test the capacity of battery bank automatically and manually. Provision shall be made to turn OFF automatic testing of battery from the rectifier front control panel.
7. When AC supply fails, the rectifier shall automatically turn over to the "Equalize charge" mode immediately after the A.C. supply returns, if the interruption of AC power lasts for more than five minutes.
8. Each mode shall be selected and signaled on the front of the rectifier cubicle. No break in voltage shall occur during such switchover.
9. In case of failure, battery low voltage, input breaker trip, battery fuse fail etc, it shall be possible to switch charger out of service, manually and automatically, leaving the other charger and battery to carry the full DC load requirement and both battery bank requirement and at the same time the full battery float charge requirements.
10. The chargers shall be provided with suitable name plate with all the details as per relevant standards.
11. Rectifier stacks shall comply with the requirements of IEC 60119 and IEC 60146 as appropriate.
12. Rectifier transformer shall be double wound to prevent galvanic connection between the DC and LV AC systems. All electronic components shall comply with the requirements of BS 9000 series.
13. Rectifier transformers shall be of the air cooled type, rated in accordance with the requirements of the Schedules and comply with BS EN 61558-1, IEC 60076, as appropriate.
14. They shall be capable of withstanding the "let through" energy of the fuse controlling the AC supply to the transformer.

15. The rectifiers shall be fed from the LV AC switchgear.

1.9 BATTERY AND CHARGER EQUIPMENT

A. Batteries

1. The batteries shall provide power supply for the telecommunication equipment demand and be designed to give at least 10 years life from the date of installation.
2. Nickel-cadmium batteries are required and shall be of sealed type, housed in totally enclosed stainless steel containers located beside battery charger cubicle or housed in drawers in the same battery charger cubicle if space is available. Each cell shall be provided with a vent cap/electrolyte filler plug and a pressure operated gas release valve designed for intermittent operation.
3. The batteries shall operate in floating service, i.e. they shall be continuously connected to load and to the charging rectifiers.
4. The batteries shall be housed in the telecommunication room. The battery shall be spaced so as to permit sufficient access to all individual cells to allow replacement of cells and/or checking cell voltages, and connections. Battery drawers/containers shall be factory treated with an electrolyte corrosion resistance coating.
5. The positive and negative terminals of each cell shall be clearly marked and permanently indicated. The positive and negative terminals of each complete battery and their cabling shall be indicated by red and black markings respectively in an approved form. Each cell shall be identified by a number formed in a non-corrodible material and fixed to the cells to be visible when installed in place.
6. A diagram of Battery bank cell arrangement is to be fixed inside the battery cabinet on the door.
7. The Contractor shall select the Ah capacity as per load calculations, taking into consideration the following:
   a. The 100% spare capacity (with a minimum of 600Ah).
   b. The service voltage required shall not drop below recommended figures (permitted voltage tolerances of the individual loads).
   c. The voltage fluctuations caused by power consumption of various loads shall be kept within permitted limits.
   d. Design factors (Temperature derating factor, Ageing factor, design margin ,etc) should be considered in the calculations.
   e. Number of batteries should be 38, 39 or 40 nos.
   f. Fully loaded telecom equipment sub-racks shall be considered in the power budget calculations.
8. Cells shall be formed into a sub-assembly by mounting in groups, in robust containers. Taping together of cells will not be accepted. Stainless steel containers shall be insulated one from the other.
9. Each cell container shall be equipped with an electrolyte level indicator and the electrolyte capacity shall be sufficient to ensure long intervals between topping-up.
10. A fuse box shall be provided for the battery. The positive and negative fuses shall be arranged in pairs and shall be fully segregated from each other by an insulating barrier. The fuses shall be of the high breaking capacity type in accordance with IEC 60269 and shall be fixed inside the battery charger cabinet.
11. In case batteries are accepted to be installed in the battery room, the battery fuse box shall be fixed outside the battery room inside a wall mounted box.
12. The Contractor shall submit a calculation of battery capacity for KAHRAMAA approval.

B. Battery Chargers

1. The batteries shall normally be kept fully charged by a dual battery charger unit. Each battery charger shall be capable of simultaneously supply the full load, trickle charging the batteries and a 100% of the full load for future expansion. Under normal condition, each battery charger shall support half the load.
2. In the event of a failure of one of the battery chargers, the healthy charger shall automatically take-over the full load current without supply interruption. Manual change-over of chargers shall also be possible.
3. The battery charger shall be of the solid state static thyristor or switch-mode rectifier type suitable for dc power supply and charging of the associated storage battery. The rated output and current of rectifier shall correspond to the requirements of system load and battery charging. The operation of the rectifier shall be fully automatic.
4. The output voltage shall be maintained constant and just sufficiently above the open circuit voltage of battery to keep the battery in a fully charged condition, independent of load variations or variations of ac input voltage within the specified limits. Provisions shall be made to adjust the charging voltage for a fully charged battery with an accuracy of at least 1%, and to move the setting point within a range of □ully
5. The rectifiers shall be fed from two separate feeders from LV AC main switchgear. Double wound transformers shall be provided at the input side of rectifier to prevent galvanic connection between the DC and AC system.
6. The charging rectifier shall normally operate in the float charge mode. It shall be possible to select the charger to 'Boost charge' mode. When selected to 'Boost charge' mode, the battery condition shall be monitored and on achieving a fully charged condition, the rectifier shall automatically regulate the charging current and change over to the 'Trickle charge mode'. In addition to Boost and Float Charge modes, the charger shall also be equipped with manual equalizing mode for initial conditioning and periodical maintenance of batteries. Irrespective of the mode of operation the load voltage will be maintained to nominal level by the automatic introduction of suitable dropping diodes of two steps minimum.
7. When an AC supply failure occurs which lasts for a while (more than around five minutes), the rectifier shall automatically select the 'Boost charge' mode immediately on restoration of the ac supply and shall return back to float mode charge when the battery full charge is reached.
8. Each mode shall be signalled on the front of the rectifier cubicle. Manual or automatic switchover from one mode to the other shall be possible. No break in voltage shall occur during such switchover as the load will be permanently connected to the charger.
9. Rectifier ratings in all modes of operation shall be adequately adjustable to deliver the optimum charging rate recommended by the battery manufacturer while also supplying the normal steady state loads. The Contractor shall submit a calculation of rectifier load for KAHRAMAA's approval.
10. The rectifiers shall be equipped with automatic current limiting devices to make them short-circuit proof.
11. Current limitation shall be 100% of rated output current. Each rectifier shall be designed to carry 110% of rated output current for an indefinite time.
12. All fuses shall be equipped with a flag, enabling an easily visible detection of any blown fuse. The fuses shall be of H.R.C. type. Battery fuse shall be equipped with signalling contact.
13. The charging rectifiers shall be of approved construction and shall be equipped with all necessary fuses, protective devices, indicating instruments, switches, lamps, etc.

and shall be suitable for automatic and manual control. All voltmeter instruments shall be connected via fuses to the busbars, feeders, batteries, etc.

14. The mains supply voltages available to the chargers will be 415V AC, 50 Hz three phase or a 240V AC, 50 Hz single phase.
15. Internal cooling of the charger shall be by natural ventilation with adequate designed mechanical airflow from bottom to top. If forced ventilation is unavoidable then 100 per cent redundant fans shall be provided.
16. In case - for any reason- the charger reaches the maximum allowed operational temperature, a high Temperature protection is preferable to be applied individually for each charger The output DC voltage control range shall be adjustable and the range of voltage shall be stated in the Tender.
17. Contractor shall select the charger current rating (capacity) according to load calculation, taking into consideration the following:
    a. The 100% spare capacity (with a minimum of 60A).
    b. Fully loaded telecom equipment sub-racks.
    c. One charger capability to take full load and batteries in case of the other charger is faulty.

C. Control and Instrumentation

1. A mimic diagram shall be mounted on the front panel and shall clearly display the main circuit in relation to the various switching equipment.
2. The battery and charger system shall have a local control panel (i.e A Liquid Crystal Display - LCD) to show the status of the key parameters and mode of operation of the system; in addition to the LCD each of the two rectifier cubicles shall contain at least the following indications/meters:
    a. DC output voltmeter.
    b. Ammeters for charger current output & battery current.
    c. LED indications for:
        1) Charger on.
        2) Float mode.
        3) Boost mode.
        4) Manuel Equalizing mode.
        5) Under voltage.
        6) Over voltage.
        7) Current limit.
        8) Charger fail.

D. Construction

1. The cubicles shall be completely self supporting, made of a required number of standardized, prefabricated, vertical sections bolted together to form indoor metal clad, dust-proof rigid unit, degree of protection IP41. The cubicles shall be free standing, equipped with bottom frames suitable for bolting to the floor. Sheet steel thickness shall not be less than 2 mm. The switchboard and charger cubicles shall be vermin and termite proof.
2. Hinged doors shall be provided to provide easy access to equipment contained within the cubicle. The hinged doors shall be of the lift-off type, secured with integral handles provided with locks and shall be flush fitting and sealed with a gasket made of rubber or other approved material to prevent the ingress of dust. Cubicles and doors shall be structurally stiff and braced to withstand twisting without distortion.
3. The cubicle shall be designed for cable entry from the bottom rear and equipped with glands suitable for all incoming and outgoing cables. Adequate working

clearance shall be maintained inside the cubicles for maintenance and for future expansions requirement to utilize the spare DC breakers provided in the D.B.

4. A light suitably positioned to ensure even illumination of the entire panel shall be provided inside each cubicle as well as 1-phase, 10A, socket-outlet of the same type as other outlets in the installation.

E. 48V DC Distribution Board

1. The 48 V DC distribution boards shall supply power to telecommunications equipment. The board shall be composed of standard cubicle of approved construction. The distribution board shall be mounted in the telecommunication room.
2. The busbars shall be made of copper painted with suitable paint while all connection points shall be inplated.
3. The busbars shall be supported by insulators having high mechanical and electrical strength, sufficient creepage distance and shall be able to withstand all short-circuit conditions without damage.
4. To ensure maximum safety to personnel, the busbars shall be completely insulated at the front.
5. Two bus-bar sections in the distribution board is to be provided with a coupling switch in between, The bus-bar shall be supervised by an under voltage relay to be set at 80% of rated voltage with time delay between 0-5 seconds.
6. Switches of the outgoing Breakers shall be affected by two pole, manually operated miniature circuit breakers.
7. 100% MCB spare capacity of different ratings is required with a minimum of 20 MCB in total; rating for used breakers should meet the load requirement.
8. The two chargers should be connected in parallel sharing the load and charging batteries.
9. The miniature circuit breakers shall be equipped with an adjustable, temperature compensated thermal overload and an adjustable magnetic instantaneous over current release for automatic tripping. The short circuit rating shall be adequate to protect each circuit against the effects of a fault at the outgoing terminal of the unit.
10. Auxiliary contacts shall be provided on each circuit breaker for signalling circuits.
11. The Contractor shall submit a calculation of selectivity between all protective devices in a circuit for all 48 V DC. feeders to KAHRAMAA for approval. Time delayed releases shall be used wherever necessary in order to provide proper selectivity between circuit breakers of a circuit. Resetting shall also be provided.
12. The above-mentioned protective devices shall withstand the specified short currents. Auxiliary contacts shall be provided on each circuit breaker for signalling circuits.

1.10 240 V AC UNINTERRUPTIBLE POWER SUPPLY

A. General Design Requirements

1. The uninterruptible power supply (UPS) system shall supply continuously regulated AC power where indicated on the Tender drawings. The UPS system shall consist of dual independently operating units sharing the load necessary for the reliable operation of UPS system under all operating conditions of the substation.
2. Every UPS system shall have a minimum autonomy of 3 hours.
3. The UPS system shall comprise but not be limited to the following major items:

   a. Two thyristor controlled / GBT controlled 110V DC / 240V AC inverters.
   b. Two static interrupter and transfer switches.
   c. One 240/240V single phase isolating by-pass transformer.
   d. Two manual by-pass switches.

e. One UPS distribution board with control devices.
f. One external bypass.

4. Power supply for Security Management System (SMS) shall be distributed by separate distribution boards for access control and separate for CCTV. Each CCTV camera shall be supplied from separate MCB.
5. The output power shall be designed to provide uninterrupted power supply for DCS's, telecommunication security management systems, and online monitoring systems considering all actual loads, requirements for future expansion as described in Appendix A: Scope of Works, and 10% spare Power requirements considered in calculation for all components fed from UPS will be verified by original manufacturer data / catalogue.
6. Recommended power demand for Telecommunication System to be considered for sizing calculation of the UPS as per the design drawings.
7. However, it is Contractor obligation to verify UPS sizing for total load, including Security Management System, by calculation. The calculations shall be subject to KAHRAMAA approval and Contractor shall deliver UPS of adequate rating according to the same.
8. Rated input voltage is 110V DC and output 240V AC, 50Hz. However, the UPS shall function satisfactorily for variation in input voltage within ±10% of rated value. Allowed tolerances in output voltage are ±10% of rated value and ±5% of rated frequency.
9. The UPS system shall be fed from 110 V DC switchboard by two suitable rated MCCB connected to the separate bus sections.
10. All outgoing MCBs shall be two pole. 50% spare, or minimum two units, spare outgoing MCBs of each rating shall be provided.
11. Multiplication relays with three contacts for each alarm of the 240 V AC UPS system to be provided.
12. The enclosure of UPS shall be of similar construction and height, as the cubicles of LV AC and DC systems. The UPS cubicle shall be located in the LV AC & DC room. The cubicle shall be suitable for installation on false floor or above floor openings.
13. The system shall be isolated from the earth.
14. Complete UPS, bypass transformer and static switches shall be designed strictly with natural ventilation.
15. In the event of outage of air conditioning system in LVAC/DC room, UPS shall remain operational at full load without exceeding the permissible temperature rise of 65K, at an ambient temperature of 50°C.This requirement shall be validated by type tests. Additionally, a minimum of two fans with ratings as specified in the technical schedule and protected through MCB shall be provided in the panel to expel the hot air accumulated inside the cubicle.
16. Fan failure signals, preferably group alarm, shall be available locally and for remote signaling. It is required to have the fans installed at the bottom of the cubicle with exhaust grills at top for convenient maintenance. Dust filters shall be accessible from outside without opening the cubicle door.
17. Load Test shall be performed at site for various loading from 50% to 110%.
18. Audible sound level of the complete UPS system shall be controlled using appropriate noise level filters and shall be limited within the acceptable value.

B. Inverters

1. Two inverters with static switches shall be supplied and installed to provide the 240V single phase, 2 wire, 50 Hz, power supply. The output of the inverters shall be continuously synchronized to the input of the static switch.

2. The inverters shall furnish a constant output voltage to a varying AC load with a varying DC input voltage, as specified in 2.6.1 above and corresponding Technical Data Sheet. Regulation shall meet output voltage requirements under all load conditions. Voltage adjustment in the range ±5% of the rated voltage and frequency adjustment ±2Hz shall be possible.
3. The inverters shall have load switches for the input circuits, as well as the contactors locally/manually and automatically operated for the output circuits, located upstream the static switches.
4. The inverters shall have overload and short circuit protection. All internal circuits of the inverters shall be protected by HRC fuses or current limiting circuit beakers.
5. The electronic control modules printed circuit boards shall be equipped only with solid state equipment.
6. It shall be specified whether the transformers used are off the shelf equipment and easily replaceable.
7. Control sensors shall be included for detecting and signaling inverter failures (including internal faults).
8. Tolerances and overload ratings as specified in Technical Data Sheet are applicable for the load range 0-100%, power factor 0.5-1 (lag) and temperature range 0-50oC.

C. Static Transfer Switches

1. A static transfer switch shall be provided to bypass the critical load from the inverters directly to the main power source (240/240V, single phase bypass transformer), and vice versa, without interrupting or degrading computer operations. This operation shall occur in the event that the inverted system fails or an overload beyond the capabilities of the inverters develops either by load faults or inrush currents. The static transfer switch shall consist of static interrupters located on the output of each inverter and a static switch on the bypass transformer.
2. The static switch shall be capable to feed the output loads and shall be rated 30% above the nominal inverter rating.
3. Internal failures in an inverter unit shall cause the static interrupter to trip with minimum damage to the inverter and isolate only the inverter which failed. Failure of two inverters or overload conditions discussed above shall remove the inverters and bypass to the main supply. Necessary voltage, frequency and automatic synchronizing devices for synchronization of the inverter outputs with the main supply shall be provided.

D. Manual By-Pass Switches

1. This switch shall allow the load to be supplied from the AC distribution board, during periods when the UPS is being installed or repaired. The switch transfer shall be "make-before-break" to assure loads power continuity.

E. Isolating By-Pass Transformer

1. This transformer shall be 240/240V, single phase, 50 Hz and shall be oversized in order to accommodate overloading and to meet the performance required in the transient and short-circuit states, it shall be of the dry type with electrostatic screen.
2. Its regulation shall meet output voltage requirements under all load conditions (0% to 100% load at 0.8 power factor).

F. UPS Output Protection (Including Outgoing Lines)

1. The Contractor shall install the protection devices he deems necessary to protect the UPS from overloads and short-circuits at its output. The devices must not activate as a result of transient caused by connecting in a load drawing a heavy current.

EXECUTION

1.11 INSTALLATION

A. The installation of the dc distribution panelboards shall comply with the requirements of NEMA PB 1.1 or equivalent.

B. Substation Control Rooms:

1. The battery shall be mounted on a two-step, single row type racks. Maximum height of racks shall be 24-inches from floor.
2. The racks shall be bolted to the floor and wall, and shall satisfy the mounting requirements specified in the BART Seismic Design Criteria.
3. The racks shall be constructed of steel channels finished with at least two coats of acid and alkaline resistant gray paint.
4. The battery and rack assembly shall be arranged to provide easy access to each battery cell for maintenance and replacement.

C. Train Control Houses and Ventilation Structures:

1. Batteries, rectifier-chargers, and dc distribution panels shall be mounted in a standard EIA 19-inch cabinet.
2. Cabinet mounting shall meet the requirements of the BART Seismic Design Criteria.

1.12 TESTING

A. General

1. Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.
2. Testing shall comply with Section 2 - General Technical Requirements. All tests on material and equipment shall be made in accordance with IEC Standards if not otherwise specified.
3. The following lists of tests do not restrict KAHRAMAA's right to call for further tests if he considers these necessary.
4. High temperature operation tests shall be performed at the maximum ambient temperature of 50°C.

B. Workshop Test

1. Type Test

a. Type test shall be performed on each type and rating of the specified equipment with the purpose of proving its properties.
b. The following type tests shall be performed:

1) Testing of breaking and making capacity of circuit breaker and fuses(breaking capacity).
2) Testing of current-time characteristics of protective releases on circuit breakers and of fuses, verification of selectivity of different elements.
3) Temperature rise test(s).

C. Routine Tests

1. Routine tests shall be performed on each piece of equipment to be supplied for the purpose of revealing faults in material or construction. They shall not impair the properties and reliability of any part being tested or reduce its lifetime.
2. The following routine tests shall be performed:

a. Visual checking of all the equipment to verify conformity with the specifications.
b. Power frequency withstand voltage test for all LV AC equipment with 2500 V, 1 min. and for all DC equipment with 1500 V, 1 min.

c. Electrical test of charging rectifier to check the automatic current limitation, trickle and boost charging, ripple and manual control.
d. Operational test.

D. Site Tests
1. On arrival at the site and during and after completion of erection all items of equipment shall be inspected and tested in order to check quality, correct operation and correct installation of the equipment.
2. The following tests shall be performed:
a. Batteries:
1) Verification of proper and complete erection of the batteries.
2) Checking of intercell connections.
3) First filling with electrolyte and initial charging.
4) Checking of electrolyte level and density.
5) Checking of voltage of each cell after the charging.
6) Measuring of the insulation resistance to earth.
7) Charge and discharge tests.
b. Chargers:
1) Verification of proper and complete erection of chargers.
2) Verification of proper AC supply voltage, all connections.
3) Measuring of insulation resistance to earth.
4) Checking of operation of chargers in each mode.
5) Checking of control, signaling and tripping circuits.
6) Load voltage - characteristics.
c. LV AC and DC Switchgear:
1) Verification of proper and complete erection.
2) Checking of all connections.
3) Checking of labeling of the cubicles, fuses, circuit breakers, etc.
4) Measuring of insulation resistance.
5) Operation checking of different elements such as contactors, relays, circuit breakers, signaling devices, etc.
3. Commissioning tests shall be done according to a program agreed with KAHRAMAA.

7.4.27 26 3533 - Combined Power Factor Correction Capacitors and Harmonic Filtration

GENERAL

1.1 SUMMARY
A. This section specifies the requirements for Automatic Power Factor Correction and Harmonic Control Systems including but not limited to the following components:
1. Capacitors.
2. Power factor controllers.
3. Capacitor supports.
4. Harmonic filtration.

B. Related Sections:
1. Section 26 0500 – Common Work Results for Electrical

2. Section 26 0526 – Grounding and Bonding for Electrical Systems
3. Section 26 0529 – Hangers & Supports for Electrical Systems

1.2 REFERENCES

A. Regulations for the Installation of Electrical Wiring, Electrical Equipment and Air Conditioning Equipment, December 2010 (Updated with Amendments in June 2013), Qatar General Electricity and Water Corporation "Kahramaa".

B. Qatar Construction Specification 2010.

C. BS 5564:1978 - Specification for high-voltage fuses for the external protection of shunt power capacitors.

D. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

E. BS EN 50160:2010 - Voltage characteristics of electricity supplied by public electricity networks.

F. BS EN 60439 (series) - Low-voltage switchgear and controlgear assemblies.

G. BS EN 62208:2011 - Empty enclosures for low-voltage switchgear and controlgear assemblies. General requirements.

H. BS HB 10194:2001 - Code of Practice for In-service Inspection and Testing of Electrical Equipment. 2nd edition.

I. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; shipping, installed, and operating weights of multiple capacitor cells or elements; and data on features, ratings, and performance.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, method of field assembly, components, and location and size of each field connection. Show access and workspace requirements and required clearances.

C. Wiring Diagrams: Detail internal and interconnecting wiring and differentiate between manufacturer-installed and field-installed wiring.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

E. Factory Test Reports: Evidence of product's compliance with specified requirements.

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

G. Maintenance Data: For equipment to include in maintenance manuals specified in Division 1. Include the following:

1. Lists of spare parts and replacement components recommended for storage at Project site.
2. Detailed instructions covering operation under both normal and abnormal conditions.

H. Manufacturer's Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency.

I. Warranty: Sample of special warranty.

J. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

1.4 PERFORMANCE REQUIREMENTS

A. The overall power factor of the electrical installation shall be corrected to the strictest requirements stated in the "General Requirements and Scope of Works" and the Local Supply Authority Regulations.

B. The reactive power values indicated on the Consultant's drawings are nominal only. The Contractor shall be responsible for undertaking a comprehensive power factor study and assessing the final capacities of all power factor correction equipment.

C. The design is based on an assumed power factor and assumed equipment selection. The Contractor shall verify the design based on the actual equipment / vendor selected.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain power factor correction and harmonic filtering equipment from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

C. Manufacturer Qualifications: Minimum of 10 years manufacturing power factor correction and harmonic filtering equipment with references from at least 10 projects of a similar caliber in the Middle East.

D. Comply with BS 7671 (IEE Wiring Regulations) and the Local Supply Authority Regulations.

1.6 COORDINATION

A. Coordinate sensor-communication module package with data network and with monitoring equipment specified in Division 26 Section "Electrical Power Monitoring and Control" for successful transmission and remote readout of remote monitoring data specified in this Section.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

C. Coordinate features of accessory devices with remote pilot devices and control circuits to which they connect.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace capacitor-bank components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

1.8 SPARES

A. Furnish two of each size and type of capacitor fuse.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.9 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.10 CAPACITORS, GENERAL

A. Comply with UL 810.

B. Construction: Multiple capacitor cells or elements, factory wired in three-phase groups and mounted in metal enclosures.

C. Cells: Dry metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside plastic container.

D. Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

1.11 FIXED CAPACITORS

A. Description: Factory wired, ready for field connection to external circuits at a single set of pressure terminals. Comply with UL 810.

B. Fuses: Current-limiting, non-interchangeable type; factory installed in each phase and located within the equipment enclosure. Features include the following:

1. Interrupting Capacity: 100 kA
2. Fuse Ratings and Characteristics: As recommended by capacitor manufacturer.
3. Neon Indicator Lamp for Each Fuse: Connect to illuminate when fuse has opened, but is still in place, and locate so it is visible from outside the enclosure.

C. Discharge Resistors: Factory installed and wired.

D. Enclosure: IP 65, steel or aluminium, arranged to contain the fluid leakage from capacitor cells; factory equipped with mounting brackets suitable for type of mounting indicated.

1.12 AUTOMATIC POWER FACTOR CORRECTION UNITS

A. Description: Capacitors, contactors, controls, and accessories factory installed in independent enclosures complying with BS EN 62208.

B. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.9 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contactor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Provide multiple switching steps.

C. Current Transformer: Type, configuration, and ratio to suit sensing and mounting conditions.

D. Main Circuit Breaker:

1. Thermal-magnetic, inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
2. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Operable from outside the enclosure to disconnect the unit.
4. Operating handle can be padlocked.

E. Controls: Solid-state, microprocessor-based controls, including the following:

1. Undervoltage relay that interrupts capacitor switching and disconnects capacitors for power-supply interruptions longer than 15 minutes.
2. "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching.

F. Bus-bars: Hard-drawn copper of 98 percent conductivity.

G. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the capacitor application.

H. Fuses for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring and capacitors.

1. Spare-Fuse Cabinet: Identified and compartmented steel cabinet with hinged lockable door.

I. Discharge Resistors: Factory installed and wired.

J. Inductors: Air-core type, connected in capacitor circuits; rated to limit switching surges to within contactor ratings.

K. Precharge Capacitor Circuit: Resistive, precharge circuit to charge capacitors prior to switching and to limit switching surges to within contactor ratings.

L. Enclosure: IP 65, steel or aluminium, with hinged door and hand-operated catch. Door shall be interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.

1. Factory Finish: Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.

M. Mechanical Bracing for Current-Carrying Parts: Adequate to withstand the maximum fault current to which they may be exposed.

N. Local Display: LED or liquid-crystal digital type, mounted in door of enclosure, indicating the following:

1. Target and actual power factors accurate to plus or minus 1 percent of reading.
2. Steps energized.
3. Step reconnection delay.
4. Real and reactive currents.
5. Voltage total harmonic distortion.
6. Alarm codes.

O. System Alarms: Alarm relay and local display indication of the following conditions:

1. Low power factor.
2. Leading power factor.
3. Frequency not detected.
4. Overcurrent.
5. Overvoltage.
6. Overtemperature.
7. Excessive voltage total harmonic distortion.
8. Capacitor overload.
9. Loss of capacitance.

P. Remote Monitoring Components: Sensors, associated communication modules, and network interface units, matched to and compatible with electrical power monitoring and control network. Communication module shall have capability to transmit the following data to remote monitoring devices:

1. System in alarm.
2. Power factor set point.
3. Corrected power factor.
4. Number of capacitor steps activated.

1.13 POWER FACTOR REGULATORS :

A. The power factor regulator shall be microprocessor based, programmable at site with a full graphic display with customizable measurement overview. They shall be insensitive to harmonics and have an automatic no-volt release, suitable for operating in temperatures up to +70 degrees C.

B. The regulator should have a programmable protection thresh hold that will allow the capacitor bank to be protected against such events as over and under-voltage, over

temperature and excessive harmonic distortion. The regulator should be able to compute and display network information and capacitor bank information such as voltage, current, harmonics spectra etc. Day and night time power factors should be settable on the regulator along with the facility to log alarms by which the last 5 alarm messages can be recorded and may be consulted any time. The regulator should also have an event logging facility which records the maximum value logged between two resets of the selected measured parameters.

C. The regulator shall also automatically adapt itself to network phase rotation and CT terminals and have a maximum consumption of 15 VA. The regulator should have a power outage release which will result in automatic disconnection of all capacitors in case of a power outage longer than 20 secs.

1.14 SERIES REACTORS FOR HARMONIC CURRENT SUPPRESSION

A. The 3 phase series reactors to be connected in series with each capacitor stage for harmonic current suppression and to prevent resonance should be of iron cored type. The current rating of the reactors should be increased suitably to take into account the effect of harmonics in the network which could be generated by variable speed drives, dimmers, elevators, UPS systems, fax machines, computers, fluorescent discharge lamps etc. The offered reactors should undergo tests wherein the reactors should be subjected to harmonic currents generated by harmonic generating test equipment. The magnitude of these harmonic currents should correspond to the harmonic current magnitude in the network.

B. The combination of capacitors and the reactors should be tuned below the lowest harmonic present in the network. With the capacitors and suitable series reactors connected it should be proved through submission of relevant calculations that the Total Harmonic Voltage Distortion is within the limits as specified in G5/4 Engineering Recommendations on Planning levels for Harmonic Voltage Distortion and the connection of non-linear loads to Transmission Systems.

C. If the Total Harmonic Distortion limits are exceeded even with the use of the detuned harmonic suppression capacitor banks, then appropriately rated Active Filters should be proposed in conjunction with the detuned capacitor banks to limit the Total Harmonic Distortion to below the specified limits in G5/4 Engineering Recommendations. The specifications of Active Filters are furnished separately.

1.15 ACTIVE HARMONICS FILTER

A. The active filter should work on the principle of measurement of harmonic currents and generate actively a harmonic spectrum in opposite phase to the measured distorting harmonic current thereby cancelling the original harmonics. The rating of the Active Filters should be so selected that the Total Harmonic Voltage Distortion at the point of common coupling is below levels specified under G5/4 Engineering Recommendations on Planning levels for Harmonic Voltage Distortion.

B. The active filter shall be of parallel configuration and should filter with closed loop control. The active filter should not require special Current Transformers. The active filter shall monitor all three phases of the low voltage line current in real time by means of a Digital Signal Processor (DSP). The output of the DSP unit in combination with a micro-controller based system shall generate a pulse width modulated (PWM) signal to control power modules based on IGBT (Insulated Gate Bipolar Transistor) technology which act as a current source.

C. The PWM signal shall be of fixed switching frequency. The system shall be operated under closed loop control and shall have a maximum response time of not more than 40 milliseconds.

D. The control system shall be such that the active filter cannot be overloaded. Simultaneous filtering shall be provided for 20 individual harmonics that shall be individually programmable per harmonic up to the 50th harmonic. The filtering efficiency shall be typically better than 97%.

E. The operating power factor of the active filter shall be programmable over the range 0.7 inductive to 0.7 capacitive.

F. Both fixed and dynamic reactive power compensation shall be available for selection by the programmer.

G. The active filter shall be protected against over current, short-circuit, thermal overload and IGBT bridge abnormal operation.

H. The Active Filters should be suitable for an ambient temperature of 50 deg C.

I. The design of the active filters shall be such that the current rating of the filter system can be increased by the addition of extra power modules. Optional graphic monitoring of the wave shape shall be provided.

EXECUTION

1.16 INSTALLATION

A. Install capacitors in accordance with manufacturer's instructions.

B. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Division 03.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Maintain minimum workspace according to manufacturer's written instructions.

E. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.

F. Identify components according to Division 26 Section "Identification for Electrical Systems."

1.17 FIELD QUALITY CONTROL

A. Perform field inspection in accordance BS HB 10194:2001.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Inspections: Perform each visual and mechanical inspections stated in the following Contract Documents and Manufacturer's Documentation.

D. Testing: Perform the following tests and certify compliance with test parameters:

1. Use test voltages 500 V minimum, for equipment rated 250 V and less, and 1000 V minimum, for equipment rated more than 250 V.
2. Apply test voltage for 60 seconds.
3. Investigate, report, and resolve insulation resistance less than that stated by manufacturer's literature or less than allowable 25 mega-ohms for equipment rated 250 V and less and 100 mega-ohms for equipment rated more than 250 V.
4. Measure capacitance of pole-to-pole capacitor combinations and compare with manufacturer's published values. Report readings, and investigate and resolve discrepancies more than 10 percent of manufacturer's nominal values.
5. Energize circuits and demonstrate electrical operating features of automatic power factor correction units according to manufacturer's written instructions.
6. Verify accuracy of remotely monitored parameters transmitted from automatic power factor correction units by communication module.

E. Correct system deficiencies on-site where possible, and retest; otherwise, remove and replace with new units and retest.

1.18 ADJUSTING

A. Adjust for optimum automatic power factor correction.

B. Harmonic Analysis: After the commissioning of the detuned capacitor banks and active harmonic filters, the specialist supplier/vendor shall undertake harmonic measurements to confirm that the Harmonic Distortion is within the acceptable limits.

1.19 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean components internally, on completion of installation, according to manufacturer's written instructions.

1.20 STARTUP SERVICE

A. Engage a factory-authorized service representative to train perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions.

C. Connect and run installed motors and equipment to verify the automatic switching of the capacitors. Verification shall include automatic switching of the total capacity of installed capacitors.

1.21 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain automatic power factor correction units. Demonstrate method of determining optimum settings for system controls.

7.4.28 26 4300 - Transient Voltage Suppression

GENERAL

1.1 SUMMARY

A. Section includes field-mounted TVSS for low-voltage power distribution and control equipment.

B. Related Sections:

1. Section 26 0526 – Grounding and Bonding for Electrical Systems
2. Section 26 0913 – Electrical Power Monitoring and Control
3. Section 26 2413 – Switchboards
4. Section 26 2416 – Distribution Boards
5. Section 26 2726 – Wiring Devices
6. Section 26 4100 – Facility Lightning Protection

1.2 DEFINITIONS

A. MOV Metal-Oxide Varistors

B. SPD Surge Protective Device(s)

C. SVR Surge Voltage Rating

D. TVSS Transient voltage surge suppressor(s)

1.3 REFERENCES

A. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

B. BS EN 50160:2010 - Voltage characteristics of electricity supplied by public electricity networks.

C. BS EN 61643-11:2012 - Low-voltage surge protective devices. Surge protective devices connected to low-voltage power systems. Requirements and test methods.

D. DD CLC/TS 61643-12:2009 / IEC 61643-12:2008 - Low-voltage surge protective devices. Surge protective devices connected to low-voltage power distribution systems. Selection and application principles.

E. DIN EN 50022:1978-05 - Low voltage switchgear and control gear for industrial use; mounting rails for fixing terminal blocks.

F. IEC 60529 - Degrees of protection provided by enclosures (IP Code).

G. IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low Voltage (1000V and less) AC Power Circuits.

H. IEEE C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits.

I. IEEE C62.45-1992 - IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits

J. ISO 9001:2000 - International Quality Management System.

K. Local Electricity Supply Authority Regulations.

L. Local Telecommunications Authority Guidelines.

M. UL 1449, 3rd Edition - Transient Voltage Surge Suppressors.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.

B. Product Certificates: For TVSS devices, from manufacturer.

C. Field quality-control reports.

D. Operation and Maintenance Data: For TVSS devices to include in emergency, operation, and maintenance manuals.

E. Warranties: Sample of special warranties.

F. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

G. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify the Construction Manager no fewer than seven days in advance of proposed electrical service interruptions.
2. Do not proceed with interruption of electrical service without the Construction Manager's written permission.

B. Service Conditions: Rate TVSS devices for continuous operation under the following conditions unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.

2. Operating Temperature: 0 to 60 deg C.
3. Relative Humidity: 0 to 95 percent, non-condensing.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain TVSS, for use within a specific product or circuit from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE, UL, CSA and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

C. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

1.7 COORDINATION

A. Coordinate location of field-mounted TVSS devices to allow adequate clearances for maintenance.

B. Coordinate TVSS devices with Division 26 Section "Electrical Power Monitoring and Control."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors which fail in materials or workmanship within specified warranty period.

1. Warranty Period: ten (10) years for service entrance protection and five (5) years for all other areas, from date of Substantial Completion.

1.9 SPARES

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: One of each size and type installed.

B. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.10 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.11 SERVICE ENTRANCE SUPPRESSORS

A. Surge Protection Devices:

1. Modular design with field-replaceable modules.
2. Fuses, rated at 200 kA interrupting capacity.
3. Fabrication using bolted compression lugs for internal wiring.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

10. Four-digit transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 240 kA per mode / 480 kA per phase.

C. Minimum single impulse current ratings, using 8 by 20 µs waveform described in IEEE C62.41.2
   1. Line to Neutral: 70,000A.
   2. Line to Ground: 70,000A.
   3. Neutral to Ground: 50,000A.

1.12 DISTRIBUTION BOARD SUPPRESSORS

A. Surge Protection Devices:
   1. Modular design with field-replaceable modules.
   2. Short-circuit current rating complying with UL 1449, and matching or exceeding the distribution board short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
   3. Fuses, rated at 200-kA interrupting capacity.
   4. Fabrication using bolted compression lugs for internal wiring.
   5. Redundant suppression circuits.
   6. Redundant replaceable modules.
   7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   8. LED indicator lights for power and protection status.
   9. Audible alarm, with silencing switch, to indicate when protection has failed.
   10. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   11. Four-digit transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 120 kA per mode / 240 kA per phase.

C. Minimum single impulse current ratings, using 8 by 20 µs waveform described in IEEE C62.41.2:
   1. Line to Neutral: 70,000A.
   2. Line to Ground: 70,000A.
   3. Neutral to Ground: 50,000A.

1.13 MOUNTING

A. All SPD components shall have integral mounting brackets to attach to 35mm DIN rail conforming to DIN EN50022.

B. The SPD's may be pre-mounted on a rail or electrical enclosure. The DIN rail and enclosure will be electrically grounded.

C. The SPD's shall be mounted as close as possible to the equipment or service being protected.

D. Mounting guidelines will be followed as indicated in installation instruction provided by manufacturer.

1.14 WIRE CONNECTIONS

A. Wires shall be attached to the SPD by means of a cable-clamping terminal block activated by a screw. Connections shall be gas-tight, and the terminal block shall be fabricated of non-ferrous, non-corrosive materials.

B. All wiring points and plug connections shall be "touch-safe" with no live voltages that can make contact with a misplaced finger in accordance with IEC 529.

C. Both Service Entrance and Sub-Distribution protection devices shall be wired on the load side of the service or panel distribution box.

1.15 PROTECTION AGAINST LIGHTNING AND SWITCHING TRANSIENTS

A. The service entrance SPDs shall have protection in the L-N (GND) mode only as neutral to ground bonding is required at the service entrance by BS 7671 (IEE Wiring Regulations).

B. The SPD technology shall consist of coordinated two-stage protection to provide protection against IEEE C62.41.1-2002 defined Scenario II direct strike lightning events and Category C switching transients. The two-stage protection concept includes current limiting arc gap lightning arrestor components and MOV TVSS components defined below.

C. The lightning arrestor components shall provide the following:

1. The lightning arrester components shall have a protection level of 900 volts for systems with nominal voltage < 240VAC L-GND and 1.5kV for systems with nominal voltage > 240VAC L-GND.
2. The lightning arrester components shall have a maximum rated operating voltage of at least 330 VAC from line to ground
3. The lightning arrester components shall be tested to withstand at least 50 kA of lightning test current of a 10/350µs waveform described by IEC 1024/Application Guide A and by IEEE C62.41.2 Appendix A.
4. The lightning arrester components shall be able to quench 50 kA of follow (short circuit) current without properly sized over-current devices opening.
5. The lightning arrester components shall have a response time of 1 µs or faster.
6. The lightning arrester components shall have an operating temperature range of 40 degrees C to +85 degrees C.
7. The lightning arrester components shall be wired in series with a fuse capable of withstanding at least 100 kA 8/20 µs surge current and which has a 200 kAIC rating. This fuse shall be specifically designed for use with surge protection devices.

D. The TVSS components shall provide the following:

1. The TVSS component shall be designed to withstand a one time surge of up to a 40 kA test current of a 8/20 µs waveform according to IEC 1024 Application Guide A and ANSI/IEEE C62.41.1 Category C Area.
2. The TVSS components shall have a SPDT contact rated for 250 VAC, 1 Amp used for remote indication/visual indicator of circuit integrity.
3. The TVSS components shall have a rating of IP 20 according to IEC 529.
4. The TVSS components shall be modular with field replacement capability without the removal of any wires nor shall it interrupt the power to the protected. Bases shall have the ability to be coded to accept only the correct voltage plug.
5. The TVSS components shall have integral label holder to mark each terminal block
6. The TVSS components shall have an operating temperature range of at least 25 degrees C to +75 degrees C.

E. The SPD shall be UL listed or recognized to UL 1449, 3rd edition or bears mark of conformity applicable to the product, as stipulated on Section 26 0015.

F. The SPD shall have the following UL 1449 measured SVR's in the Line to Neutral (Ground) mode:

1. 1.2 kV for 480Y/277 systems
2. 800V for 208Y/120 systems
3. 1.8 kV for 480 DELTA systems

G. The SPD shall have the following Measured Limiting Voltage while discharging 50 kA of surge current:
   1. < 1.5 kV for 480Y/277 systems
   2. < 900V for 208Y/120 systems
   3. < 2.0 kV for 480 DELTA systems

H. The SPD shall have visual indication of TVSS component and fuse failure.

1.16 EQUIPMENT – DISTRIBUTION CIRCUIT AND PANEL SPD'S

A. The distribution circuit and panel SPD's shall have protection in the L-N and N-GND modes

B. The SPD's shall provide the following:
   1. The SPD component shall be designed to withstand a one-time surge of up to a 40 kA test current of a 8/20 µs waveform according to IEC 1024 Application Guide A and ANSI/IEEE C62.41.1 Category C Area.
   2. The SPD components shall have a SPDT contact rated for 250 VAC, 1 amp used for remote indication/visual indicator of circuit integrity.
   3. The SPD components shall have a rating of IP20 according to IEC 529.
   4. The SPD components shall be modular with field replacement capability without the removal of any wires nor shall it interrupt the power to the protected. Bases shall have the ability to be coded to accept only the correct voltage plug.
   5. The SPD components shall have integral label holder to mark each terminal block
   6. The SPD components shall have an operating temperature range of at least -25 degC to +75 degC.

C. The SPD shall be UL listed or recognized to UL 1449, 3rd edition.

D. The SPD shall have the following UL 1449 measured SVR's in the Line to Neutral mode:
   1. 1.2 kV for 480Y/277 systems
   2. 700V for 208Y/120 systems
   3. 700V for 240/120 Split Single Phase systems

E. The SPD shall have a response time < 25µs.

F. The SPD shall have a leakage current to ground of <1µA.

1.17 EQUIPMENT – POINT OF USE / ELECTRONIC EQUIPMENT SPD'S

A. For Protection of Single Phase Equipment
   1. SPDs for single phase equipment shall be designed to withstand up to a 10kA test current of a 8/20µS waveform according to IEC 1024 Application Guide A and IEEE C62.41.1-2002 Category C area.
   2. The SPD technology for single phase equipment protection shall be hybrid – MOV / Gas Discharge Tube.
   3. SPDs for single phase equipment shall have visual status indication and a dry contact rated for at least 250 VAC, 1 amp for remote status indication.
   4. SPDs for single phase equipment shall provide a method of landing both input and output wires using a feed-through terminal block. Maximum operating current through the block shall be no more than 20 amps.
   5. Operating temperature range shall be at least -25 degC to +75 degC
   6. SPDs for single phase equipment shall be modular with field replacement capability without the removal of any wires nor shall in interrupt the power to be protected. Bases shall have the ability to be coded to accept only the correct voltage plug.
   7. The SPD shall be UL Listed or Recognized to UL 1449, 3rd edition
   8. The SPD shall have the following UL 1449 measured SVR:

a. For 120VAC single phase: L-N = 500V, N-GND = 900V
b. For 24VAC (DC) single phase: L-N = 150, N-GND = 600V
c. The SPDs shall have a leakage current to ground of < 1µA

9. The SPDs shall have integral mounting brackets to attach to 35mm DIN rail conforming to DIN EN50022. The mounting bracket of the SPD shall make ground connection to the DIN rail; therefore, minimizing ground impedance connections.

B. For Protection of Single Phase Equipment with additional EMI/RFI noise filtering (sine wave tracking)

1. SPD's for single phase equipment shall be designed to withstand up to a 10kA test current of a 8/20µs waveform according to IEC 1024 Application Guide A and IEEE C62.41.1-2002 Category C area.
2. The SPD technology for single phase equipment protection with EMI / RFI noise filtering shall be sine wave tracking type with low pass filter circuit and MOV surge protection circuit.
3. SPD's for single phase equipment shall have visual status indication of MOV status on the input and output circuits and a dry contact rated for at least 250 VAC, 1 amp for remote status indication.
4. SPD's for single phase equipment shall provide a method of landing both input and output wires with a maximum operating current through the SPD of no more than 20 amps.
5. Operating temperature range shall be at least -40 degrees C to +85 degrees C
6. The SPD shall be UL Listed or Recognized to UL 1449, 3rd edition and UL 1283.
7. The SPD shall have the following UL 1449 measured SVR: L-N = 415V, N-GND = 415V
8. The SPDs shall have integral mounting brackets to attach to 35mm DIN rail conforming to DIN EN 50022.
9. The SPD shall be packaged in a metallic housing to shield the components from RFI therefore increasing the filter circuit performance.
10. The SPD shall have an attenuation of greater than -40 dB @ 100 kHz as determined by a standard 50-ohm insertion test.
11. The SPD shall exhibit sine wave tracking characteristics as described by the following IEEE C62.41 defined ringwave tests:

    a. Category A Ringwave: L-N = 100V, N-GND = 390VAC
    b. Category B Ringwave: L-N = 195 V, N-GND = 415VAC

C. For Protection of Three Phase Equipment

1. The Three Phase Equipment SPDs shall have protection in the L-N and N-GND modes
2. The SPD components shall provide the following:

    a. The SPD component shall be designed to withstand a one time surge of up to a 40 kA test current of a 8/20s waveform according to IEC 1024 Application Guide A and ANSI/IEEE C62.41.1 Category C Area.
    b. The SPD components shall have a SPDT contact rated for 250 VAC, 1 amp used for remote indication/visual indicator of circuit integrity.
    c. The SPD components shall have a rating of IP20 according to IEC 529.
    d. The SPD components shall be modular with field replacement capability without the removal of any wires nor shall it interrupt the power to the protected. Bases shall have the ability to be coded to accept only the correct voltage plug.

e. The SPD components shall have integral label holder to mark each terminal block
f. The SPD components shall have an operating temperature range of at least -25 degrees C to +75 degrees C.

3. The SPD shall be UL listed or recognized to UL 1449, 3rd edition.
4. The SPD shall have the following UL 1449 measured SVRs in the Line to Neutral mode:

   a. 1.2kV for 480Y/277 systems
   b. 700V for 208Y/120 systems
   c. 700V for 240/120 Split Single Phase systems

5. The SPD shall have a response time < 25µs.
6. The SPD shall have a leakage current to ground of <1µA.

1.18 EQUIPMENT – ACCESSORIES

A. Additional automated test equipment shall be provided for each job to perform verification testing on the modular SPDs. This testing equipment shall have the following capabilities:
   1. Bar code scanner and touch pad key entry for modular plug identification
   2. LCD display for diagnostics and test results display
   3. Reporting output capability with RS 232 interface

EXECUTION

1.19 INSTALLATION

A. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.

B. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

C. Comply with manufacturer's written recommendation for conductor and circuit-breaker size for connecting TVSS to distribution system.
   1. Match circuit breaker size to conductor size.
   2. Coordinate with drawings.

D. Installers shall follow manufacturer's installation instructions.

1.20 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
   1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. Tests and Inspections:
   1. Perform visual and mechanical inspections and electrical tests. Certify compliance with test parameters.
   2. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.
   3. Complete startup checks according to manufacturer's written instructions.

C. TVSS device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

1.21 STARTUP SERVICE

A. Do not energize or connect service entrance equipment, panelboards, control terminals or data terminals to their sources until TVSS devices are installed and connected.

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

1.22 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to maintain TVSS devices.

7.4.29 26 5000 - General Lighting

GENERAL

1.1 SUMMARY

A. This section specifies the requirements for interior lighting systems.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0923 – Lighting Control Devices
3. Section 26 0943 – Network Lighting Controls
4. Section 26 2726 – Wiring Devices

1.2 DEFINITIONS

A. BF: Ballast factor.

B. CCT: Correlated colour temperature.

C. CRI: Colour-rendering index.

D. HID: High-intensity discharge.

E. LER: Luminaire efficacy rating.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.3 REFERENCES

A. American National Standards Institute:

1. ANSI C78.1-91 – Fluorescent Lamps - Rapid-Start Types - Dimensional and Electrical Characteristics
2. ANSI C78.2-91 – Fluorescent Lamps - Preheat-Start Types - Dimensional and Electrical Characteristics
3. ANSI C78.3-91 – Fluorescent Lamps - Instart Start and Cold-Cathode Types - Dimensional and Electrical Characteristics
4. ANSI C78.376-91 – Chromaticity of Fluorescent Lamps (ANSI/NEMA C78/376-96)

B. Certified Ballast Manufacturers Association (CBM)

C. Institute of Electrical and Electronic Engineers:

1. IEEE C62.41-91 Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits

D. National Electrical Manufacturer's Association:

1. NEMA C82.1-97 – Ballasts for Fluorescent Lamps - Specifications
2. NEMA C82.2-02 – Method of Measurement of Fluorescent Lamp Ballasts

3. NEMA C82.4-02 – Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps
4. NEMA C82.11-02 – High Frequency Fluorescent Lamp Ballasts

E. Underwriters Laboratories:
1. UL 496-96 – Edison-Base Lampholders
2. UL 542-99 – Lampholders, Starters, and Starter Holders for Fluorescent Lamps
3. UL 844-95 – Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
4. UL 924-95 – Emergency Lighting and Power Equipment
5. UL 935-01 – Fluorescent-Lamp Ballasts
6. UL 1029-94 – High-Intensity-Discharge Lamp Ballasts
7. UL 1598-00 – Luminaires

F. CIBSE codes and guides as applicable.

G. IEC standards:
1. IEC 60598.
2. IEC 60529.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Ballast, including BF.
4. Energy-efficiency data.
5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
   a. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:
1. Lamps and ballasts, installed.
2. Cords and plugs.
3. Pendant support system.

D. Installation instructions.

E. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting fixtures.
2. Suspended ceiling components.
3. Structural members to which suspension systems for lighting fixtures will be attached.
4. Other items in finished ceiling including the following:
   a. Air outlets and inlets.
   b. Speakers.
   c. Sprinklers.
   d. Smoke and fire detectors.
   e. Occupancy sensors.
   f. Access panels.
   g. Jet fans.
5. Perimeter moldings.

F. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

G. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.

H. Operation and Maintenance Data: provide a list of all lamp types used on Project.

I. Warranty: Sample of special warranty.

J. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

K. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain lamps and ballasts through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

C. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labelled for indicated class and division of hazard by FM Global.

D. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.
   1. Obtain Architect's approval of fixtures for mockups before starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire detectors, fire-suppression system, and partition assemblies.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace lighting components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five (5) years from date of Substantial Completion.

PRODUCTS

1.8 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.9 LUMINAIRES

A. Ingress Protection: For the following types of areas only provide luminaires with the noted ingress protection:

1. Indoor (Dry Areas): IP4X.
2. Indoor (Plant and Wet Areas): IP65.
3. General External Areas: IP65.
4. Process Areas (where there is a chance of submersion in water – valve chambers, pump chambers etc.): IP68.

B. Lighting in Hazardous Areas:

1. All lighting in areas containing fuel storage shall be in accordance with Zone 0 requirements as defined by IEC/EN 60079-1.

C. Sheet Metal:

1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved) and parallel to each other as designed.
2. Wireways and fittings shall be free of burrs and sharp edges and shall accommodate internal and branch circuit wiring without damage to the wiring.
3. Where lighting fixtures are detailed with minimum 0.812 mm (20 gauge) housing, minimum 0.644 mm (22 gauge) housings will be acceptable provided they have strengthening embossed rib and break formations, which give the equivalent rigidity of a 0.812 mm(20 gauge) housing.
4. When installed, any exposed fixture housing surface, trim frame, door frame and lens frame shall be free of light leaks; lens doors shall close in a light tight manner.
5. Hinged door closure frames shall operate smoothly without binding when the fixture is in the installed position, and latches shall function easily by finger action without the use of tools.

D. Ballasts shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wire-way covers unless so specified.

E. Lamp Sockets:

1. Fluorescent:

   a. Lampholder contacts shall be the biting edge type or phosphorous-bronze with silver flash contact surface type and shall conform to the applicable requirements of UL 542.
   b. Contacts for recessed double contact lampholders and for slimline lampholders shall be silver plated.
   c. Lampholders for bi-pin lamps, with the exception of those for "U" type lamps, shall be of the telescoping compression type, or of the single slot entry type requiring a one-quarter turn of the lamp after insertion.

2. Incandescent:

   a. These shall not be used anywhere on the project.

3. High Intensity Discharge (H.I.D.):

a. Shall have porcelain enclosures.

F. Recessed incandescent fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.

G. Fluorescent fixtures with louvers or light transmitting panels shall have hinges, latches and safety catches to facilitate safe, convenient cleaning and relamping. Vapor tight fixtures shall have pressure clamping devices in lieu of the latches.

H. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

I. Metal Finishes:

1. The manufacturer shall apply his standard finish (unless otherwise specified) over a corrosion resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits.

a. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s).

b. Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking.

2. Interior light reflecting finishes shall be white with not less than 85 percent reflectance, except where otherwise shown on the drawing.

3. Exterior finishes shall be as shown on the drawings.

J. Provide all lighting fixtures with a specific means for grounding their metallic wireways and housings to an equipment grounding conductor.

K. Light Transmitting Components for Fluorescent Fixtures:

1. Shall be 100 percent virgin acrylic plastic or water white, annealed, crystal glass.

2. Flat lens panels shall have not less than 3.2 mm (1/8 inch) of average thickness. The average thickness shall be determined by adding the maximum thickness to the minimum unpenetrated thickness and dividing the sum by 2.

3. Unless otherwise specified, lenses, diffusers and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction of the lens without distortion or cracking.

L. Lighting Fixtures in Hazardous Areas: Fixtures shall be suitable for installation in flammable atmospheres (Class and Group) as defined in NFPA 70 and shall comply with UL 844.

M. Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Assemblies designed to retrofit incandescent fixtures are prohibited except when specifically indicated for renovation of existing fixtures. Fixtures shall be designed for lamps as specified.

1.10 FLUORESCENT LAMP BALLASTS

A. Where applicable, fluorescent lamps and ballasts shall comply with the National Energy Policy Act of 1992.

B. Ballasts shall comply with NEMA 82.1, 82.2 and 82.11, NFPA 70, and UL 935 unless otherwise specified.

C. Lamp types F32T8 and F32T8/U shall be operated by electronic, high frequency ballasts. All other fluorescent lamp types shall be operated by the standard energy saving electromagnetic core-and-coil ballasts. For these applications, the lamps shall be

operated by core-and-coil ballasts where specifically required on the drawings as "core-and-coil".

D. Electronic high-frequency ballasts:

1. Ballasts shall operate the lamps at a frequency between 20 and 50 KHz from an input frequency of 50Hz.
2. Ballast package:
   a. Size: The ballast case shall be sized to be physically inter-changeable with standard core-and-coil ballasts and suitable for standard mounting in new or existing lighting fixtures.
   b. Case marking: Mark the ballast to indicate the required supply voltage, frequency, RMS current, current surge during starting, input watts, and power factor at the design center voltage, open circuit voltage, crest factor and efficacy.
3. Performance:
   a. Light output:
   b. At the design voltage, the light output shall be at least equal to that obtained by a core-and-coil ballasted system meeting ANSI, NEMA and CBM standards.
   c. The comparison test shall be measured in the same fixture at 25 degrees C (plus or minus one degree) ambient room temperature.
   d. Tests shall be made in fixtures designed only for the number of lamps being tested.
   e. For other applications (higher ambients, etc.) the tests should be operated with equivalent lamp wall temperatures plus or minus 4 degrees C.
   f. Efficacy:
   g. The efficacy of the high-frequency, electronically ballasted system shall be at least 15 percent greater than the equivalent CBM core-and-coil ballasted system (see "Light output" above).
   h. Starting:
   i. The ballast shall be capable of starting and maintaining operation of lamps at an ambient temperature of 10 degrees C (50 degree F) or more for an input voltage of plus or minus 10 percent about the center design voltage unless otherwise indicated.
   j. The ballast shall never be started in the instant start mode at any temperature.
   k. Operation:
   l. The ballast shall safely and reliably operate in a room ambient temperature from 10 degrees C (50 degree F) to 40 degrees C (105 degree F).
   m. The light output shall not vary by more than plus or minus 5 percent for a plus or minus 10 percent variation of the input voltage about the center design voltage. Light output shall remain constant for a plus or minus 5 percent variation of the input voltage.
   n. The ballast shall operate the lamps in a manner that will not adversely curtail the normal life of the lamp.
   o. Transient protection:
   p. The ballast shall comply with IEEE C62.41, Cat. A.
   q. Flicker: The flicker shall be less than 5 percent and without visible flicker.
   r. Noise: The audible noise levels should be equivalent to or better than the Class A rating of CBM certified ballasts.
   s. Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI):

t. The EMI and RFI limits shall meet the requirements of the Federal Communications Commission Rules and Regulations (CFR 47 Part 18).
u. Rated life: The ballast shall have a rated life of 10 years or 30,000 hours (based on a 10 hour day).
v. The two-lamp ballast shall safely operate two F32T8 RS, 32- watt lamps or two F32T8/U lamps. The single lamp ballast shall safely operate one F32T8 RS, 32-watt lamp or one F32T8/U lamp.
w. Power factor: Not less than 95 percent.
x. Reliability: Labels: Ballasts must be labelled or listed by UL and CBM/ETL.
y. Submit, simultaneously with shop drawings, a certified test report by an independent testing laboratory showing that the electronic ballasts meet or exceed all the performance requirements in this specification.
z. Total harmonic distortion (THD) shall be less than 10 percent.

E. Core-and-coil ballasts (for lamps other than F32T8 and F32T8/U or where shown on drawings as "core-and-coil"):

1. Shall be rapid starting type.
2. Shall comply with NEMA 82.1 and UL 935.
3. Shall be UL Class P with automatic-resetting, internal, thermal protection.
4. Shall be CBM/ETL certified.
5. Power factor shall be not less than 95 percent.

a. Capacitors in ballasts shall not contain PCB (Polychlorinated Biphenyl) fluids or other fluids recognized as hazardous when discharged into the environment.

6. Sound ratings shall be Class A or better, except for ballast sizes which are not available with Class A ratings, as standard products from any manufacturer.

a. Ballasts which are not available with Class A ratings shall have the quietest ratings available.

7. Where core-and-coil ballasts are specified or detailed in lieu of the normally required electronic high-frequency types, two lamp ballasts shall be energy-saving type, UL listed to operate F40T12 rapid start lamps for both standard 40 watt lamps and the reduced wattage 35/34 watts energy-saving lamps.

a. Lamp output shall be within 5 percent of nominal rating.
b. Energy-saving type ballasts should not be used in ambient temperatures below or above manufacturer's recommendations.

F. Ballasts for lighting fixtures controlled by dimming devices shall be the electronic, high frequency type as specified herein, equipped for dimming and conform to the recommendations of the manufacturer of the associated dimming devices to assure satisfactory operation of the lighting system.

G. All ballasts serving straight or "U" type lamps shall be mounted by four non-turning studs (or captive bolts) equipped with lock washers and nuts or locking type nuts, or by four thread cutting (TC) sheet metal screws which are firmly secured against the fixture body (or wireway) to maximize dissipation of heat and minimize noise. Exception: electronic high-frequency ballasts may be mounted at a minimum of two points, one at each end of unit.

H. Ballasts shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.

I. To facilitate multi-level lamp switching, lamps within fixture shall be wired with the outermost lamp at both sides of the fixture on the same ballast, the next inward pair on

another ballast and so on to the innermost lamp (or pair of lamps). Within a given room, each switch shall uniformly control the same corresponding lamp (or lamp pairs) in all fixture units that are being controlled.

J. Where three-lamp fixtures are indicated, unless switching arrangements dictate otherwise, utilize a common two-lamp ballast to operate the center lamp in pairs of adjacent units that are mounted in a continuous row. The ballast fixture and slave-lamp fixture shall be factory wired with leads or plug devices to facilitate this circuiting. Individually mounted fixtures and the odd fixture in a row shall utilize a single-lamp ballast for operation of the center lamp.

1.11 BALLASTS FOR HIGH INTENSITY DISCHARGE FIXTURES

A. Shall comply with NEMA 82.4 and UL 1029.

B. Shall have individual overcurrent protection sized in accordance with the manufacturer's recommendations.

C. Shall have integral thermal protection where the fixture is recessed in an interior ceiling.

D. Shall be the constant wattage, high power factor type or the reactor high power factor type.

1. Capacitors shall not contain PCB (Polychlorinated Biphenyl) fluids or other fluids recognized as hazardous when discharged into the environment.

E. Shall have not less than Class B sound ratings for interior fixtures, when available.

1. Ballasts which are not available with Class B ratings shall be of the next standard rating.

1.12 LAMPS

A. Fluorescent Lamps:

1. Rapid start fluorescent lamps shall comply with ANSI C78.1; preheat-start type shall comply with ANSI C78.2; and instant-start and cold-cathode lamps shall comply with ANSI C78.3.
2. Chromacity of fluorescent lamps shall comply with ANSI C78.376.
3. The lamps shall include the F32T8, F32T8/U 32 watt energy saving type and EPACT approved F40T12 type if specifically required by contract drawings for special applications.
4. Except as indicated below, lamps shall be energy saving type, have a colour temperature between 3500 and 4100 degrees K, a Colour Rendering Index (CRI) of not less than 75, and an initial lumen output not less than 2800. "U" tube lamps shall have the same colour temperature and CRI limits as the above.

a. In utility areas (Electrical, Communication and Mechanical) Service rooms and closets), maintenance closets and non-medical storage spaces, utilize energy saving light-white lamps.
b. In areas with ambient temperatures below 60 degrees use the 40 watt version of the lamp above.
c. Other areas as indicated on the drawings.

B. Incandescent lamps shall be the general service, inside frosted type rated 130 volts except where otherwise shown on the drawings.

C. High Intensity Discharge Lamps:

1. Mercury vapor lamps shall be ANSI type "DX". Lamps in open or louvered fixtures mounted less than 4500 mm (15 feet) above the finished floor (or grade) shall be of the safety type in which the arc will automatically extinguish if the outer glass envelope becomes broken.

2. Multi-vapor lamps shall be as defined on the detail drawings.
3. High pressure sodium lamps shall be as defined on the detail drawings.

D. Compact Fluorescent Lamps: Shall be 3500 degrees K, 10,000 hours average rated life, and as follows:
1. T4, twin tube, rated 13 watts, 825 initial lumens (min) as indicated.
2. T4, double twin tube rated 26 watts, 1800 initial lumens (min), as indicated.

1.13 OCCUPANT SENSOR LIGHTING CONTROL SYSTEMS

A. General:
1. An active or passive sensor shall be utilized to control the "On-Off" actuation of fluorescent lighting loads.
2. It shall provide control of an isolated set of contacts on exposure to a perceived change in environmental conditions indicating the presence or absence of one or more persons.
3. It shall maintain the contacts closed in the presence of continued changes (due to human presence) at similar intensity and rate.
4. It shall open the contacts at a nominal time after the changes cease.

B. Passive Sensor System: Sensor(s) shall react to changes of radiated infrared energy, indicating the activity of one or more human bodies in the area covered:
1. Range of detection:
   a. The sensor(s) shall provide effective coverage of a room, sensing the presence of one or more people in the room in order to turn the lights on.
   b. The ceiling mounted sensor's area of coverage shall be approximately a 4200 mm (14 feet) diameter circle at 1800 mm (6 feet) away.
   c. Provide sufficient units to give full coverage as measured 750 mm (30 inches) above the floor.
   d. A field-of-view adjustment feature shall be provided to allow orientation to various room operating conditions.
2. Sensor placement:
   a. Locate the sensor(s) in accordance with the manufacturer's recommendations to maximize energy savings by avoiding nuisance activation due to sudden temperature or air flow changes.
   b. Locate the units within 1800 mm (6 feet) horizontally of work stations or major points of activity, including the center of room entrance doors.

C. Active Sensor System:
1. Sensor(s) shall react to reflective changes to generated ultrasonic radiation (crystal controlled, 24 to 42 kHz), indicating the activity of one or more persons in the area covered.
2. Range of detection:
   a. On ceilings below 3600 mm (twelve feet) in height, a single direction sensor shall cover approximately a 9 x 9 m (30 feet x 30 feet) area; a two directional unit a 18 x 9 m (60 feet x 30 feet) area; and a two-way corridor unit a total distance of 27 m (90 feet).
   b. The sensors shall be equipped with a concealed but accessible sensitivity control to tune the unit to specific room conditions.
3. Sensor placement:

a. Locate the sensor(s) in accordance with the manufacturer's recommendations to maximize energy savings by avoiding nuisance activation due to predictable non-human motion activities.
b. Give particular attention to work station or major areas of activity and the coverage of room entrance doors.

D. Timing/Function:
1. Shall not be user adjustable.
2. Lighting shall remain on with one or more persons within the covered area.
3. The system shall be factory set to maintain lights on for a minimum of 5 minutes and not longer than 15 minutes after the area of coverage is vacated.
4. For testing purposes, there shall be a means to change the pre-set time delay to 30 seconds or less.

E. Control Unit:
1. The system shall have a switching relay(s) capable of switching the fluorescent or incandescent loads as required.
2. Contacts shall be rated at a minimum of 15 Amps at voltages to 240, with expected cycles of operation in excess of 100 K.
   a. Power derived from a current limiting 24 volt transformer shall power the system and the unit must be packaged for installation on a standard 200 mm x 200 mm (4 inch x 4 inch) NEMA box enclosure.
   b. The unit shall be wired through a conventional wall switch to provide an over-ride system "Off" and active "Off-On" functioning.

F. Field Wiring:
1. The wiring between the control unit and sensor(s) shall be an insulated multi-conductor, 0.50 sq. mm (#22 gauge) Poly Vinyl Chloride (PVC) jacketed cable.

1.14 REMOTE CONTROL SWITCHING FOR INDOOR LIGHTING SYSTEMS

A. Shall be rated for continuous-duty service.

B. Electric contacts shall be precious metal surface.

C. Magnetic contactors and relays shall be electrically-operated and mechanically-held.

D. Characteristics of the components and the total resistances of the circuits throughout the systems shall be such that the systems will operate satisfactorily in every respect while the branch circuit power supply voltage to each system is within a 105-130 volt range at 50 Hz.

E. Wall switches shall be the momentary contact type suitable for mounting in a single gang outlet box space and compatible with the standard design wall plates as specified.

F. Where shown on the drawings, incorporate the components in panelboards behind separate doors and mount them on sound absorbing materials.

G. Install circuit breaker or fuse protection for the control circuits.

H. Low voltage remote control system shall be DC type, operating at not greater than 30 volts, and meeting the requirements for Class 2 circuits in Article 725 of the NEC.

1.15 RADIO-INTERFERENCE-FREE FLUORESCENT FIXTURES

A. Shall be specially designed for suppressing radio-frequency energy produced within the fixtures. The Rules and Regulations of FCC (CFR 47, Part 18) shall apply.

B. Lenses shall have a light-transparent layer of metal permanently bonded to them, and in positive contact with the steel housing or equal to prevent the radio-frequency

interferences from passing through the lenses. The effective light transmittance of the lenses shall be not less than 75 percent.

C. Install line filters within the body of the fixtures and wired in series with the supply circuit conductors to eliminate the transmission of radio frequency energy into the supply circuit.

1.16 FLUORESCENT BEDLIGHT FIXTURES

A. Requirements:

1. Fixed or movable arms are not acceptable.
2. Exposed surfaces shall remain cool to the touch.
3. Major portion of the light shall be directed upwards and outwards through lenses. Balance of the light shall be directed downwards through lenses to produce low brightness surfaces with minimum contrast as viewed by the patients from their normal viewing angles in bed.
4. Shall provide not less than 110 lx (10 foot-candles) (average) of general room illumination measured 750 mm (30 inches) above the floor.
5. Shall provide 330 lx (30 foot-candles) on the reading surfaces for the patients while in a normal prone or normal sit-up position in bed.

B. Provide 4-position, pull cord switch on the fluorescent bedlight within easy reach of the patient while in a normal prone position in bed.

1. The switches shall enable the patient to control the upward and downward portion of the light separately and simultaneously, to include an off position, except in single bed rooms where the switch shall enable the patient to energize and de-energize the downward light only.
2. In the single bed rooms, provide a 2-position pull cord switch for "on-off" control of the downward lamps.

C. Bedlight fixtures shall be rated for 120 volt operation.

EXECUTION

1.17 INSTALLATION

A. Align, mount and level the lighting fixtures uniformly.

B. Avoid interference with and provide clearance for equipment. Where the indicated locations for the lighting fixtures conflict with the locations for equipment, change the locations for the lighting fixtures by the minimum distances necessary as approved by the Resident Engineer.

C. For suspended lighting fixtures, the mounting heights shall provide the clearances between the bottoms of the fixtures and the finished floors as shown on the drawings.

D. Fluorescent bed light fixtures shall be attached to the studs in the walls. Attachment to gypsum board only is not acceptable.

E. Lighting Fixture Supports:

1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
2. Shall maintain the fixture positions after cleaning and re-lamping.
3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
4. Hardware for recessed fluorescent fixtures:

a. Where the suspended ceiling system is supported at the four corners of the fixture opening, hardware devices shall clamp the fixture to the ceiling system structural members, or plaster frame at not less than four points in such a

manner as to resist spreading of the support members and safely lock the fixture into the ceiling system.

b. Where the suspended ceiling system is not supported at the four corners of the fixture opening, hardware devices shall independently support the fixture from the building structure at four points.

5. Hardware for surface mounting fluorescent fixtures to suspended ceilings:

a. In addition to being secured to any required outlet box, fixtures shall be bolted to a grid ceiling system at four points spaced near the corners of each fixture.
b. The bolts shall be not less than 6 mm (1/4 inch) secured to channel members attached to and spanning the tops of the ceiling structural grid members.
c. Non-turning studs may be attached to the ceiling structural grid members or spanning channels by special clips designed for the purpose, provided they lock into place and require simple tools for removal.
d. In addition to being secured to any required outlet box, fixtures shall be bolted to a plaster ceiling at four points spaced near the corners of each fixture.
e. Pre-positioned 6 mm (1/4 inch) studs or threaded plaster inserts secured to ceiling structural members shall be used to bolt the fixtures to the ceiling.
f. In lieu of the above, 6 mm (1/4 inch) toggle bolts may be used on new or existing ceiling provided the plaster and lath can safely support the fixtures without sagging or cracking

6. Hardware for recessed lighting fixtures:

a. All fixture mounting devices connecting fixtures to the ceiling system or building structure shall have a capacity for a horizontal force of 100 percent of the fixture weight and a vertical force of 400 percent of the fixture weight.
b. Mounting devices shall clamp the fixture to the ceiling system structure (main grid runners or fixture framing cross runners) at four points in such a manner as to resist spreading of these supporting members.
c. Each support point device shall utilize a screw or approved hardware to "lock" the fixture housing to the ceiling system, restraining the fixture from movement in any direction relative to the ceiling.
d. The screw (size No. 10 minimum) or approved hardware shall pass through the ceiling member (T-bar, channel or spline), or it may extend over the inside of the flange of the channel (or spline) that faces away from the fixture, in a manner that prevents any fixture movement.
e. In addition to the above, the following is required for fixtures exceeding 9 kg (20 pounds) in weight. Note: Ceiling types are defined in ASTM Standard C635-69.
f. Where fixtures mounted in "Intermediate" and "Heavy Duty" ceilings weigh between 9 kg and 25 kg (20 pounds and 56 pounds) provide two 12 gauge safety hangers hung slack between diagonal corners of the fixture and the building structure.
g. Where fixtures weigh over 25 kg (56 pounds) they shall be independently supported from the building structure by approved hangers. Two-way angular bracing of hangers shall be provided to prevent lateral motion.
h. Where ceiling cross runners are installed for support of lighting fixtures, they must have a carrying capacity equal to that of the main ceiling runners and be rigidly secured to the main runners.

7. Surface mounted lighting fixtures:

a. Fixtures shall be bolted against the ceiling independent of the outlet box at four points spaced near the corners of each unit.
b. The bolts (or stud-clips) shall be minimum 6 mm (1/4-20) bolt, secured to main ceiling runners and/or secured to cross runners.
c. Non-turning studs may be attached to the main ceiling runners and cross runners with special non-friction clip devices designed for the purpose, provided they bolt through the runner, or are also secured to the building structure by 12 gauge safety hangers.
d. Studs or bolts securing fixtures weighing in excess of 25 kg (56 pounds) shall be supported directly from the building structure.
e. Where ceiling cross runners are installed for support of lighting fixtures they must have a carrying capacity equal to that of the main ceiling runners and be rigidly secured to the main runners.
f. Fixtures less than 6.8 kg (15 pounds) in weight and occupying less than 600 mm x 600 mm (two square feet) of ceiling area may, (when designed for the purpose) be supported directly from the outlet box when all the following conditions are met.
g. Screws attaching the fixture to the outlet box pass through round holes (not key-hole slots) in the fixture body.
h. The outlet box is attached to a main ceiling runner (or cross runner) with approved hardware.
i. The outlet box is supported vertically from the building structure.
j. Fixtures mounted in open construction shall be secured directly to the building structure with approved bolting and clamping devices.

8. Single or double pendent-mounted lighting fixtures:

a. Each stem shall be supported by an approved outlet box, mounted swivel joint and canopy which holds the stem captive and provides spring load (or approved equivalent) dampening of fixture oscillations.
b. Outlet box shall be supported vertically from the building structure.

9. Outlet boxes for support of lighting fixtures (where permitted) shall be secured directly to the building structure with approved devices or supported vertically in a hung ceiling from the building structure with a nine gauge wire hanger, and be secured by an approved device to a main ceiling runner or cross runner to prevent any horizontal movement relative to the ceiling.

F. Furnish and install the specified lamps for all lighting fixtures installed and all existing lighting fixtures reinstalled under this project.

G. Coordinate between the electrical and ceiling trades to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.

H. Bond lighting fixtures and metal accessories to the grounding system as specified in Section 26 0526, Grounding and Bonding for Electrical Systems.

I. At completion of project, re-lamp all fixtures which have failed/burned-out lamps. Clean all fixtures, lenses, diffusers and louvers that have accumulated dust/dirt during construction.

1.18 REFLECTORS, LENSES & CLEANING

A. All glassware, diffusers, reflectors, etc, shall be left in a clean condition. Allowance shall be made for all plastic surfaces which reflect or transmit light or are visible to view to be treated with an anti-static solution to prevent static electricity.

B. Reflectors, reflector cones and visible trim of all luminaires shall not be installed (or otherwise protected in an approved manner) until completion of plastering, ceiling tile

work, painting and general clean-up. They shall be carefully handled to avoid scratching or finger printing and shall be completely clean at the time of handover by methods as recommended by the manufacturers.

C. All broken parts shall have been replaced and all lamps shall be operative.

D. Allow, to ensure that at handover all luminaires and lamps provided are in pristine condition.

1.19 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1.20 FIELD QUALITY CONTROL

A. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

1.21 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

1.22 ADJUSTING

A. All adjustable luminaires shall be aimed, focused, locked etc, by the Contractor to the requirements of the Engineer. This shall be carried out once the installation is complete. All necessary ladders, scaffolds etc. shall be provided by the Contractor.

B. Where possible units shall be focused during the normal working day. However, where daylight interferes with viewing or proper adjustments, aiming shall be accomplished at night.

7.4.30 26 5200 - Emergency Lighting

GENERAL

1.1 SUMMARY

A. This section specifies the requirements for the following emergency lighting systems:

1. AC inverter type Central Battery system.
2. Self-contained emergency light fittings
3. Central Maintenance and Automatic Test Facility

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 5000 – General Lighting
3. Section 27 1000 – Telecommunications Cabling Systems

1.2 REFERENCES

A. Qatar Civil Defence Department requirements.

B. Qatar Construction Specification 2010.

C. BS 5266-1:2011 - Emergency lighting. Code of practice for the emergency escape lighting of premises.

D. BS 5499-4:2000 - Safety signs, including fire safety signs. Code of practice for escape route signing.

E. BS 6387:1994 - Specification for performance requirements for cables required to maintain circuit integrity under fire conditions.

F. BS 7629-1:2008 - Electric cables. Specification for 300/500 V fire resistant screened cables having low emission of smoke and corrosive gases when affected by fire. Multicore and multipair cables.

G. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

H. BS 7846:2009 - Electric cables. Thermosetting insulated, armoured, fire-resistant cables of rated voltage 600/1000 V, having low emission of smoke and corrosive gases when affected by fire. Specification.

I. BS 8519:2010 - Selection and installation of fire-resistant power and control cable systems for life safety and fire-fighting applications. Code of practice.

J. BS EN 1838:1999, BS 5266-7:1999 - Lighting applications. Emergency lighting.

K. BS EN 50171:2001 - Central power supply systems.

L. BS EN 50172:2004, BS 5266-8:2004 - Emergency escape lighting systems.

M. BS EN 60598-2-22:1998+A2:2008 - Luminaires. Particular requirements. Luminaires for emergency lighting.

N. BS EN 60622:2003 - Secondary cells and batteries containing alkaline or other non-acid electrolytes. Sealed nickel-cadmium prismatic rechargeable single cells.

O. BS EN 60623:2001, IEC 60623:2001 - Secondary cells and batteries containing alkaline or other non-acid electrolytes. Vented nickel-cadmium prismatic rechargeable single cells.

P. BS EN 60702-1:2002, IEC 60702-1:2002 - Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Cables.

Q. BS EN 60896-11:2003 - Stationary lead-acid batteries. General requirements and methods of test. Vented types. General requirements and methods of tests.

R. BS EN 60896-22:2004 - Stationary lead-acid batteries. Valve regulated types. Requirements.

S. BS EN ISO 7010:2012. Graphical symbols. Safety colours and safety signs. Registered safety signs.

T. CIBSE, LG12 SLL Lighting Guide 12: Emergency Lighting

U. NFPA 101 – Life Safety Code®

1.3 DEFINITIONS

A. AC: Alternating Current

B. DC: Direct Current

C. LED: Light-emitting diode.

D. LSF: Low Smoke and Fume

1.4 PERFORMANCE REQUIREMENTS

A. The system shall be configured to ensure that the emergency lighting within a designated areas operates upon sensing a loss of mains power at the nearest local lighting sub-circuit.

B. Emergency Power Source: Batteries with a minimum autonomy of three (3) hours.

C. Central Battery Systems: incorporate AC inverter(s), to distribute emergency power at 240V 50Hz AC throughout the building.

1. Provide emergency power distribution system including sub-mains and distribution boards located within electrical cupboards.

2. All emergency power supplies shall utilise fire-retardant cables with LSF/LSOH outer sheaths.
3. Central Battery systems shall be sized to provide additional capacity over the calculated equipment power load; unless otherwise required additional capacity shall be 50 percent.

D. Central Maintenance and Automatic Test Facility:
1. All Emergency Luminaires and Exit Signs (both self-contained and those supplied from central batteries) shall be automatically tested via a Computerised Maintenance System.
2. Provide a communications network including data cabling and fully addressable network interfaces at all emergency light fittings.

E. Exit Signage shall incorporate pictograms in accordance with European signs directive "Running Man symbols".

F. All products shall bear CE certification for electromagnetic compatibility.

1.5 SUBMITTALS

A. General Submittal Requirements:
1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.

B. Product Data: For each type of product indicated.

C. Manufacturer's Installation Instructions:
1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product. Include equipment installation outline, connection diagram for external cabling, internal wiring diagram, and written instruction for installation.

D. Calculations: Central Battery and AC inverter sizing calculations.

E. Shop Drawings:
1. Show installation details for emergency luminaires and exit signs.
2. Electrical Schematic diagrams for emergency power distribution.
3. Emergency Lighting Distribution Board schedules.

F. Maintenance data for products for inclusion in Operating and Maintenance Manual.

G. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

1.6 QUALITY ASSURANCE

A. Engage a specialist vendor/supplier to undertake the detailed design, installation, testing and commissioning of a lighting control system.

B. Installers Qualifications:
1. Company specializing in supplying the products specified in this section with minimum three years documented experience and with service facilities within 100 miles (160 km) of Project.
2. Firms experienced in manufacturing and servicing equipment of the types and capacities indicated that have a record of successful in-service performance.
3. Qualifications include ability to provide training and emergency repairs at the Project Site within a 24-hour response time.

C. Source Limitations: All products specified shall be supplied and produced by a single manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be protected from deterioration and damage while awaiting installation.

B. Storage procedure shall be as recommended by manufacturer.

1.8 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.9 WARRANTY

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Central Batteries: 10 years from date of Substantial Completion.
2. Warranty Period for emergency fittings with Self-contained Batteries: 7 years from date of Substantial Completion.

1.10 SPARES

A. Contractor shall provide a list of spares required for each installed item of equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the corresponding equipment.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

C. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.11 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

1.12 EMERGENCY LUMINAIRES

A. Comply with BS EN 60598-2-22

B. Energy saving cold 6W T2 lamp bases shall be used for emergency purposes.

C. Luminaires shall be constructed with high impact polycarbonate and shall be suitable for wall, ceiling or semi-recessed mounting.

D. Where emergency conversion kits are specified for normal light fittings, luminaires, these shall be factory fitted and provided with a Manufacturer's Warranty.

E. Emergency luminaires shall incorporate integral hold off relays / change-over modules and addressable network interface units.

F. Include a Red LED to indicate standby battery availability.

1.13 EXIT SIGNS

A. Comply with QCS i.e. exit signs in Arabic and English.

B. Utilise LED or Cold Cathode Lamps.

1. LED lamps shall be rated minimum 25 years life.

C. Include a Red LED to indicate standby battery availability.

D. Housing and Canopy:
   1. Shall be made of cast or extruded aluminium, or rolled steel.
   2. Optional steel housing shall be a minimum 0.812 mm (20 gauge) thick or equivalent strength aluminium.
   3. Steel housing shall have baked enamel over corrosion resistant, matte black or ivory white primer.

E. There shall be no radioactive material used in the fixtures.

F. Fixtures:
   1. Inscription panels shall be cast or stamped aluminium a minimum of 2.25 mm (0.090 inch) thick, stenciled with 150 mm (6 inch) high letters, baked with green colour stable plastic or fiberglass.
   2. Double-Faced Fixtures: Provide double-faced fixtures where required or as shown on drawings.
   3. Directional Arrows: Provide directional arrows where required or as shown on drawings as part of the inscription panel where required or as shown on drawings.

G. Operating Voltage: Fixtures shall be wired for 240 V AC operation.

1.14 BATTERIES FOR SELF-CONTAINED FITTINGS

A. Batteries shall be maintenance free, sealed nickel cadmium type, with a minimum design life of 7 years when operating at an average temperature of 35 deg. C.

1.15 BATTERIES FOR CENTRAL SYSTEMS

A. Batteries shall be maintenance free, sealed lead acid, gas recombination type with a minimum design life of 10 years when operating at an average temperature of 25 deg. C.

B. Batteries shall be low gas generation, low self-discharge and have permanently sealed pressure valve.

C. Store and install batteries in areas which are not subject to extreme changes in temperature.

1.16 CENTRAL BATTERY – INVERTER SYSTEMS

A. Comply with BS 5266 (CENELEC 62/8).

B. The Central Battery Inverter cabinet shall be sheet steel, powder coated paintwork RAL 9002, Grey in colour.

C. The cabinet shall be IP21 with hinged front door for complete access.

D. The display panel shall be mounted flush in the cabinet fascia. If the batteries cannot be accommodated in the inverter enclosure then they shall be installed in a separate adjacent enclosure to the same specification at the inverter cabinet.

E. Control equipment including mains failure relays, contactors, battery charger, inverter protection fuses, control switches, instruments and indicators shall be contained in suitable enclosures.

F. Battery Chargers: shall be capable of recharging the batteries after they have been discharged for the specified duration of the system so that within 14 hours the batteries can again support the load for the specified duration period. This requirement shall be achieved without exceeding the maximum design charging characteristics of the batteries. The charger and controls shall possess the following characteristics:
   1. Mains Supply: 240 + 10 percent V AC single phase 50 Hz
   2. Input Control: MCB to BS3871 Pt. 1, or BS4752 Part 1.
   3. Fuse gear: HRC type BS88.
   4. Terminals: DIN rail mounted near to cable entry
   5. Transformer: Double wound with earth screen to BS171.

6. Contactor: Standard contactors comply with the requirements of BS 5424
7. Charger: Constant voltage, current-limited type with electronic solid state controller. Voltage to be controlled to within 2 per cent setting at up to 10 percent supply variations.
8. Temp Compensation: The charger voltage to be automatically adjusted with reference to ambient temperature
9. Test Push-button: Push button or switch facility to simulate mains failure.

G. Static Inverters: shall be provided and arranged on a one per area basis and possess the following characteristics:

1. Output voltage: 220-240VAC. Voltage tolerance is 2 percent on loads of 0-100 percent of system rating.
2. Frequency: 50 or 60 Hz. + 0.01 percent sinusoidal waveform
3. Voltage Regulation: Static 2 percent, dynamic 6 percent.
4. Isolation: 2 kV RMS between input and output terminals.
5. Total Harmonic Distortion: Less than 3 percent HD
6. Start-up Time: Standard 30mS. Soft start up to 10 seconds if required.
7. Noise Level: Less than 55dBA at 1 metre.
8. Efficiency: 85-89 percent.
9. Protection: DC input and AC output MCB's, DC input reverse polarity protection, short circuit protection, pre-charge protection fuse, reverse-fed mains proof.
10. Low voltage shut down:
    a. The inverter module(s) shall automatically shut down when the battery discharges to a pre-set level.
    b. Re-set allowable following a combination of the restoration of the mains supply and an increase in battery voltage above the disconnect threshold level.
    c. Residual current drain when the disconnect circuit has operated is less than 1mA per module.
11. Inhibit Switch: an inhibit switch shall be fitted on a user control PCB in the cubicle to control the inverter.
12. Technology: Pulse width modulation with high frequency switching.
13. Environmental Conditions: Ambient temperature (nominal) 15 – 20 deg C
14. Humidity: 40 – 60 per cent RH
15. Instruments shall provide indication of battery voltage, trickle charge and boost charge currents, indication shall be provided of battery charger functioning and battery charger failure.
    a. Instruments for monitoring the current drawn by the emergency luminaire ballast and for causing alarm on failure shall be provided.
    b. Other instruments, alarms and provision for remote display of alarms shall be provided as indicated.
16. Simulation of central mains failure shall be on electronic switching device or a 2 position type tamper-proof switch operated by a removable key.

EXECUTION

1.17 INSTALLATION

A. The overall system shall be installed to the manufacturers recommendations and comply with BS 5266.

B. Coordinate the installation with all aspects of the general lighting installation.

1.18 EMERGENCY POWER DISTRIBUTION

A. Emergency lighting wiring shall not be drawn into the same conduit, trunking compartment or ducting compartment as cables of other Category 3 circuits (BS 7671). The cores of emergency lighting circuits shall not be contained within the same multi-core cable, flexible cable or flexible cord as cores of any other circuits.

B. Wiring for emergency lighting circuits shall be carried out using fire resistant cables to BS 6387 Category CWZ, with white oversheath. This includes all mains wiring between Central Battery systems and output distribution boards and final circuit wiring.

C. Outgoing circuits from the final distribution boards shall not exceed 200 metres in length. A power line transmitter is required for each final distribution board. This should not contain more than 40 luminaires and consist of more than 4 circuits.

D. Distribution cables from the output of the Central Battery system to the sub-circuit and final circuit emergency lighting distribution boards shall all be Fire Rated with steel wire armoured protection (as FP400).

1.19 CENTRAL BATTERY INSTALLATION

A. Central Batteries shall be contained in an enclosure or rack mounted as indicated and colour coded.

B. Where batteries are not in an enclosure, insulating covers shall be provided over all cell terminals and inter-connections. All leads shall be insulated and colour coded.

C. Batteries shall be maintained in a good condition on site with all necessary precautions being taken to prevent deterioration; they shall be handed over at the completion of the works, fully charged.

D. The unit shall usually operate in a normal ambient of 25 deg C.

1.20 COMMUNICATIONS NETWORK

A. Provide communications network cabling system in accordance with the Division 27 Communications Specifications.

1.21 RECORD INFORMATION

A. Provide detailed Record drawings showing location and type of all emergency lighting luminaries throughout the project.

B. Provide detailed operating and maintenance manuals and demonstration and training of staff in the operation of the system as indicated in Section 26 0710, Quality requirements for electrical installations.

7.4.31 26 5600 - Exterior Lighting

GENERAL

1.1 SUMMARY

A. This section specifies the requirements for exterior lighting systems including:

1. Exterior luminaires with lamps and ballasts.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.
4. Luminaire lowering devices.

B. Related Sections:

1. Section 26 0500 – Common Work Results for Electrical
2. Section 26 0923 – Lighting Control Devices
3. Section 26 2726 – Wiring Devices
4. Section 26 5000 – General Lighting

1.2 DEFINITIONS

A. CCT: Correlated colour temperature.

B. CRI: Colour-rendering index.

C. HID: High-intensity discharge.

D. IESNA: Illuminating Engineering Society of North America.

E. LER: Luminaire efficacy rating.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

G. Pole: Luminaire support structure, including tower used for large area illumination.

1.3 REFERENCES

A. American Association of State Highway and Transportation Officials:

B. AASHTO LTS-4-2003, Structural Supports for Highway Signs, Luminaries and Traffic Signals

C. American National Standards Institute:

1. ANSI C57.12-2000 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers C81.61-2005 Electrical Lamp Bases

D. American Society for Testing and Materials:

1. ASTM A123/A123M-2002, Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2. ASTM A153/A153M-2001, Zinc Coating (Hot-Dip) on Iron and Steel Hardware – AASHTO No.: M232 B108-03a -2003, Aluminium-Alloy Permanent Mold Castings D3487-2000, Mineral Insulating Oil Used in Electrical Apparatus

E. BS 5489-1:2003, Code of practice for the design of road lighting. Lighting of roads and public amenity areas.

F. BS 7671:2008+A1:2011 - Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition.

G. CIBSE LG6, the Outdoor environment

H. IEC standards:

1. IEC 60598.
2. IEC 60529.
3. IEC 60662.
4. IEC 62035.

I. Illuminating Engineering Society of North America (IESNA) HB-9-2000, Lighting Handbook RP-8-2000 (R-2005), Roadway Lighting

J. National Electrical Manufacturers Association:

1. NEMA C78.41-2001, Electric Lamps – Guidelines for Low-Pressure Sodium Lamps
2. NEMA C78.42-2004, Electric Lamps – Guidelines for High-Pressure Sodium Lamps C78.43-2005, Electric Lamps – Single-Ended Metal-Halide Lamps
3. NEMA C78.1381-1998,R 1997) Electric Lamps – 70-Watt M85 Metal- Halide Lamps
4. NEMA C82.4-2002, Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
5. NEMA C136.17-2005, Roadway Lighting Equipment – Enclosed Side- Mounted Luminaries for Horizontal-Burning High- Intensity-Discharge Lamps
6. NEMA ICS 2-2005, Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts
7. NEMA ICS 6-2001, Industrial Control and Systems Enclosures

K. Underwriters Laboratories, Inc. (UL):
   1. UL 496-2004, Edison-Base Lamp holders
   2. UL 773-1995, Plug-in, Locking Type Photo controls, for Use with Area Lighting
   3. UL 773A-2006, Non-industrial Photoelectric Switches for Lighting Control
   4. UL 1029-1994, High-Intensity-Discharge Lamp Ballasts
   5. UL 1598-2004, Luminaries

1.4 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
   2. Details of attaching luminaires and accessories.
   3. Details of installation and construction.
   4. Luminaire materials.
   5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
      a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
      b. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
   6. Photoelectric relays.
   7. Ballasts, including energy-efficiency data.
   8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
   9. Materials, dimensions, and finishes of poles.
   10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
   11. Anchor bolts for poles.
   12. Manufactured pole foundations.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
   3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
   4. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.

D. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

E. Field quality-control reports.

F. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

G. Warranty: Sample of special warranty.

H. Point-wise compliance statement to the specifications duty signed by the manufacturer / manufacturer's authorized representative and by the Contractor.

I. The Contractor shall follow the submittal procedures outlined in the "General Requirements and Scope of Works".

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain lamps and ballasts through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labelled as defined in the BS, CE, UL, CSA and other equivalent recognized independent laboratories acceptable to authorities having jurisdiction, and marked for intended location and application.

1.6 COORDINATION

A. The Contractor shall thoroughly coordinate with locations of all lighting columns, bollards and poles with the road-way, pavement, landscape, podium and roof-design layouts.

B. Coordinate the location of concrete footing and anchors with the services within the pavement and roads.

C. Coordinate with underground services.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store poles on ground. Store poles Store poles on decay-resistant-treated skids at least 300 mm above ground level and vegetation. Support poles to prevent distortion and arrange to provide free air circulation

B. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five (5) years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: Five (5) years from date of Substantial Completion.
3. Warranty Period for Colour Retention Five (5) years from date of Substantial Completion.
4. Warranty Period for Poles: Repair or replace lighting poles that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than five (5) years from date of Substantial Completion.

1.9 SPARES

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: One for every 10 of each type and rating installed. Furnish at least one of each type.
2. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.

4. Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

B. Contractor shall provide all required spares as specified in the "General Requirements and Scope of Works".

PRODUCTS

1.10 MANUFACTURERS

A. Materials and products proposed by the Contractor shall be compliant with the Specification. All material submittals shall be approved by the Engineer prior to procurement.

B. Refer the Approved Suppliers List in the "General Requirements and Scope of Works".

C. The Contractor may propose LED street lighting luminaires if they are certified to operate correctly and without fault in Qatar for a minimum of 100,000 hours. Any failures within this time shall be replaced at the Contractor's cost.

1.11 LIGHTING POLES

A. General:

1. Poles shall be as shown on the drawings, lighting fixture/luminaire schedule and as specified.
2. Finish shall be as specified on the drawings and, or the lighting fixture/luminaire schedule.
3. The pole and arm assembly shall be designed for wind loading of 161 km/hr (100 miles per hour), with an additional 30 percent gust factor, supporting luminaire(s) having the effective projected areas indicated.
   a. The effective projected area of the pole shall be applied at the height of the pole base as shown on the drawings.
4. Unless otherwise indicated, poles shall be anchor-bolt type designed for use with underground supply conductors.
   a. Poles shall have oval-shaped handhole having a minimum clear opening of 65 by 125 mm.
   b. Handhole cover shall be secured by stainless steel captive screws.
5. Provide a steel-grounding stud opposite handhole openings.
6. Provide a base cover matching the pole in material and colour to conceal the mounting hardware pole-base welds and anchor bolts.
7. Hardware: All necessary hardware shall be 300 series stainless steel.
8. UV radiation levels are high therefore all GRP and other plastics subject to direct sunlight shall contain a UV barrier.

B. Material: All lighting poles shall be hot dip galvanized mild steel in accordance with BS 4360 grade 43 C or equivalent with minimum 87 microns of galvanized cover. Aluminium lighting poles are not permitted.

C. Base Covers:

1. Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 36,000 psi.

D. Foundation for Poles:

1. Foundations shall be precast concrete.
2. Foundations shall support the effective projected area of the specified pole, arm(s), and luminaire(s) under wind conditions previously specified in this section.
3. Rub-finish and round all above-grade concrete edges to approximately 6 mm radius.

4. Concrete shall have 3000 psi minimum 28 day compressive strength.
5. Anchor bolt assemblies and reinforcing of concrete foundations shall be as shown on the drawings and meet ACI 318. Anchor bolts shall be in a welded cage or properly positioned by the tie wire to stirrups.

1.12 COLUMNS AND BOLLARDS

1. Provide bollards as shown on the drawings and, or luminaire schedule.
2. Provide bollards complete with column, bracket, spigot, doors, wooden backboards, column root, earthing terminal, cable entry slots, luminaires, control gear and HRC fused cut-out.
3. In addition, allow for the provision of a proprietary manufactured double pole lockable isolator within the service compartment of each lighting column complete with minimum IP65 intermediate safety protection barrier to accord with the requirement of Part 611 of BS7671 (IEE Wiring Regulations).

1.13 INTERNAL WIRING

A. Cutouts in columns shall be phenolic moulded, three phase, and suitable for looping two 4 Core 25 mm XLPE/SWA/PVC cables.

B. Cutouts shall:

1. Incorporate miniature circuit breakers complying to BS EN 60898 with a minimum breaking capacity of 4kA.
2. Be of the combined single phase and neutral type.
3. Incorporate an earth terminal.
4. Be suitable for concentric or PVC armoured cables of up to 25mm2 cross-sectional area with capacity for looping in and out.
5. ave all metal parts tinned.
6. Be provided with a minimum of 2 fixing screws.
7. Be manufactured from material which is non-hygroscopic and non-tracking.

C. Terminals and contacts shall have a rating of not less than 40 Amp and be suitable for the use of miniature circuit breakers 6 A, 10A or16 A ratings, selected from the Table 12.1 below:

D. Ratings of Miniature Circuit Breakers:

Wattage	50W	70W	100W	150W	250 W	400 W
For 1 Lamp	6	6	6	6	10	10
For 2 Lamps	6	6	6	10	16	16

E. The cutouts shall comply with the 16th Edition of the IEE Wiring Regulations.

F. A cutout used as a means of isolation shall have the facility for padlocking.

G. The service cutout shall have a moulded enclosure, offering a minimum protection of IP22, capable of withstanding severe impact.

H. Separate terminals shall be provided for live, neutral and earth conductors complete with terminal shields to prevent accidental contact with all live conductors.

I. Cutouts shall be sized to accommodate the designated cables, but with a minimum of 25mm2 cables.

J. Cable armouring shall be bonded as an integral part of the cutout, and complete with cable armour clamp shrouds.

K. The cutout shall be suitable for mounting on a wooden backboard or DIN rails.

L. Where there is a requirement for the use of an isolator they shall incorporate in-built fused loop terminals for the feeds to signs, bollards etc.

M. All isolating devices shall be double pole for single-phase systems and four poles for three phase systems.

N. All isolators shall be rated to suit the local environmental conditions of Qatar where these differ from those stated in BS EN 60947-3.

1.14 LUMINAIRES

A. General

1. UL 1598 and NEMA C136.17. Luminaries shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat and safe cleaning and relamping.
2. IESNA HB-9 and RP-8 light distribution pattern types shall be as shown on the drawings.
3. Incorporate ballasts in the luminaire housing except where otherwise shown on the drawings.
4. Lenses shall be frame-mounted heat-resistant, borosilicate glass, prismatic refractors. Attach the frame to the luminaire housing by hinges or chain. Use heat and aging resistant resilient gaskets to seal and cushion lenses and refractors in luminary doors.
5. Lamp sockets for high intensity discharge (H.I.D) fixture shall have locking type porcelain enclosures in conformance to the applicable requirements of ANSI C81.61 and UL 496.
6. Pre-wire internal components to terminal strips at the factory.
7. Bracket mounted luminaries shall have leveling provisions and clamp type adjustable slip-fitters with locking screws.
8. Materials shall be rustproof.
9. Latches and fittings shall be nonferrous metal.
10. IESNA Cutoff Category shall as specified on the lighting fixture/luminaire schedule.

B. Ingress Protection: IP68 for all luminaires.

C. Floodlighting Luminaires

1. Floodlighting luminaires shall be enclosed and gasketed vapor-tight fixtures in accordance with IESNA HB-9.

D. Sign Lighting Luminaires:

1. The sign lighting luminaires shall be mounted where shown in the drawings and in accordance with the manufacturer's instructions.
2. The lamps shall be 150 watt high pressure sodium or as shown in the lighting fixture schedule.
3. All conductors shall be copper and shall be installed in conduit unless otherwise indicated on drawing.
4. The feeder cable shall be a minimum 10 sq.mm. (No. 8 AWG) XLPE/PVC with a 30 ampere circuit breaker at the service entrance.
5. Each sign structure shall be controlled by a 15 ampere, 2 pole circuit breaker, equivalent to NEMA 3R at a location convenient for luminaire maintenance.
6. Each sign structure shall have a photoelectric control mounted near the sign unless the sign luminaires are tied into the lighting control system photocells.
7. The relays for switching the line current to the lighting fixtures shall be mounted near the circuit breaker or as directed by the Consultant.

E. Wall Mounted, Underdeck or Overhead Luminaires:

1. Wall mounted/under deck/overhead luminaires shall be installed as shown on the drawings.
2. Each luminaire shall be grounded per Section 266 0526.

3. Fuses shall be installed in each hot leg using approved in-line fuse holders located inside the units or in a junction box when so indicated in the drawings.
4. Luminaires shall be adjusted for optimum light distribution as directed by the Consultant.

F. High-Intensity-Discharge (HID) Luminaires

1. The HID luminaire shall be a complete, coordinated assembly of ballast, igniter if any, ballast housing, reflector, diffuser or lens, heat removal louver or shield as required, wiring compartment, mounting device and hardware (unless remote mounted ballast is specified).
   a. All components shall be connected by secure mechanical means to reduce vibration noise and to prevent detachment of any components due to shock or vibration.
   b. HID luminaires with base-down vertical-lamp burning positions shall include a housing with glass lens and cover, reflector, lamp holder, ballast compartment, terminal block, fuses, fuse holders, and fixture mounting devices in a completely sealed optical system.
   c. Housing shall be cast aluminium with hinged cast-aluminium cover, heat-resistant clear plain glass lens not less than 5 millimeter thick, gasket, and cover clamps.
      1) Housing shall provide a weatherproof seal against moisture and foreign material.
      2) Housing shall include an integral cast-aluminium ballast compartment with built-in ballast and terminal block.
   d. Reflector shall be detachable, formed anodized sheet aluminium with diffuse or specular finish designed for a rectangular wide-beam spread.
   e. Fixture mounting devices shall include a galvanized-steel trunnion adaptable to pole, wall, pipe, or cross arm mounting as indicated and required, with fixture positioning devices that will permit horizontal and vertical adjustment over a 180-degree range.
   f. Fixture shall have lamp focusing adjustments, fixture aiming and leveling devices, fuses, and fuse holders accessible from the outside of the fixture.
2. Lamps shall be replaceable from the top or front.

G. Quartz-Iodine Luminaires, Special Purpose

1. Quartz-iodine lamp luminaires, Class HD, with horizontal lamp-burning position shall include housing with glass lens and cover, reflector, lamp holders, fuses, fuse holders, lamp, and fixture mounting devices in a completely sealed optical system for pole-top mounting.
2. Wiring shall be concealed in floodlighting luminaires.
3. Housing shall be cast aluminium with hinged cast-aluminium cover, heat-resistant plain glass lens, gasket, and cover clamps.
4. Housing shall seal against moisture and foreign material.
5. Reflectors shall be formed anodized sheet aluminium in a [parabolic] [elliptical] shape with diffuse or specular finish for a rectangular beam spread with narrow, medium, or wide light distribution. Beam spread shall be not less than 10 percent of the maximum luminance candlepower.
6. Fixture shall have lamp focusing, positioning, and leveling adjustments that will permit horizontal and vertical adjustment over a 180-degree range, fixture leveling and aiming devices, and fuses with fuse holders accessible from the outside of the fixture.

7. Lamps shall be replaceable from the front and rear.
8. Fixture shall be designed to accommodate the appropriate lamp.

H. Substation-Yard Lighting Luminaires

1. Substation-yard lighting luminaires shall be enclosed and casketed vapor tight fixtures especially designed for substations to illuminate overhead vertical and horizontal surfaces of the substation structure.
2. Luminaires shall include cast-aluminium fittings with pole-top slip fitters and supports for lamp holder and reflector assemblies.
3. Lamp holder shall be porcelain with mogul base and shall support the lamp in a vertical base-down burning position. Slip fitter shall secure the fixture to the pole with corrosion-resistant steel setscrews.
4. Collar of the reflector assembly shall engage threads in the cast-aluminium fitting with corrosion-resistant steel setscrews that will prevent rotation of the luminaire after beam adjustment.
5. Reflector assembly shall include a reflector with cast-aluminium threaded collar, refractor, and top access cover. Reflector and refractor shall be sealed at the joint with a clamping band formed from sheet aluminium or corrosion-resistant steel.
6. Refractor and access cover shall be sealed with a heat-resistant weatherproof gasket and secured with spring-loaded corrosion-resistant steel latches.
7. Reflector and access cover shall be formed from anodized sheet aluminium.
8. Reflecting surfaces shall have a secular finish. Refractor shall be moulded prismatic heat-resistant borosilicate glass designed to provide not less than 60 percent of the total lamp lumens in the upward direction.
9. Maximum illuminance candlepower of the lighting-distribution curve shall be adjustable plus or minus 5 degrees.
10. Wiring shall be concealed in lighting poles and luminaires.

I. Lay-in, Recessed, or Surface-Mounted Low-Bay Type Fixtures

1. Luminaires for recessed or surface ceiling mounting shall include on the submittal:
   a. Complete dimensions
   b. The details of mounting and hardware to include seismic protective features, door construction and access if any, suspensions and latching, lens type and thickness if any, ballast and lamp location, and heat removal provisions or heat shield if required.
2. Lay-in type fixtures shall have seismic clips to secure them to T-bars.
3. Where a plastic lens is specified, the lens shall be 10 mm thick acrylic and shall be mounted in the door in such a manner that the lens cannot fall due to vibration or sudden opening of the door.
4. In addition, the plastic lens shall be protected against, and shall offer protection against, catastrophic lamp failure.
5. The door shall have a positive hinge and latch with a light-leak gasket.

J. High-bay Type Fixtures

1. Luminaires for suspended mounting shall include in its submittal:
   a. Overall dimensions
   b. Details of mounting and hardware to include seismic protective features, lens type and thickness if any, remote ballast provisions if any,
   c. Power conductor type and connections.

d. The preferred power conductor connection method is by NEMA L5 or L7 series twist-lock plug-and-cord, with mating receptacle mounted on structure or the fixture anchor point.

2. High bay fixtures shall be mounted from cast wiring boxes with hangers.
   a. Unless otherwise indicated, the fixture mounting device shall be of the compression 20mm conduit type with set screw.
   b. Gravity type hanger hubs on fixture are not acceptable.

3. High bay fixtures shall have a partially-reflective, tempered glass, acrylic, or polycarbonate reflector with approximately 20 percent uplight.
   a. The reflector shall have an opening at the top to allow heat removal by convection.
   b. A similar glass, acrylic, or polycarbonate lens shall enclose the lower opening of the reflector bell, and shall be rated as protection against catastrophic failure of the lamp.

1.15 LAMPS

A. Install the proper lamps in every luminaire installed.

B. Lamps to be general-service, outdoor lighting types.

C. High-Pressure Sodium (HPS) Lamps: NEMA C78.42, wattage as indicated. Lamps shall have average rated life of 16,000 hours minimum for 35 watt lamps and 24,000 hours minimum for all higher wattages.

D. Low-Pressure Sodium (LPS) Lamps: NEMA C78.41.

E. Metal-Halide Lamps: NEMA C78.43 or NEMA C78.1381

F. Mercury vapor lamps shall not be used.

1.16 HIGH INTENSITY DISCHARGE BALLASTS

A. General

1. For low voltage systems, the ballasts shall be the high efficiency, high power factor, copper-wound constant wattage type and shall meet the requirements of UL 1029 and NEMA C82.4.
   a. Ballasts shall operate the discharge lamp of the type, wattage, and voltage shown on the drawings.
   b. Ballasts shall have individual overcurrent protection (inline fuse holder) as recommended by the ballast manufacturer.
   c. Ballasts shall be capable of providing reliable starting of the lamps at minus 30 degrees C.
   d. Open-circuit operation shall not reduce the average life.

2. Provide each ballast with a film type lamp failure protector to prevent excessive secondary voltage.

3. Provide ballasts to operate the discharge lamp of the type, wattage, and voltage shown on the drawings.

4. Ballasts shall be capable of providing reliable starting of the lamps at minus 30 degrees C.

B. Locate protective devices for ballasts to be accessible if the devices are not integral with ballasts.

C. Each ballast shall operate not more than one lamp except where otherwise shown on the drawings.

1.17 CONTROLS

A. Each Lighting System shall be controlled by one of the following methods as shown for each system on the drawings:
   1. Photocell
      a. Photocells shall have the following features:
         1) Quick-response, cadmium-sulfide type.
         2) A 15 to 30 second, built-in time delay to prevent response to momentary lightning flashes, car headlights or cloud movements.
         3) Energizes the system when the north sky light decreases to approximately 1.5 footcandles, and maintains the system energized until the north sky light increases to approximately 3 to 5 foot candles.
      b. A photocell to act as the pilot device.
      c. The photocell shall be the type which fails safe to the closed position meeting UL 773 or 773A.
      d. Mount and connect photocells and time clocks as shown on the drawings.
   2. A time clock to act as the pilot device.
   3. A combination, photocell-time clock to act as dual pilot devices connected in series. The photocell shall provide the "on" function at dusk and the time clock(s) shall control specific circuit "off" functions during dark hours.
   4. A time clock to act as the pilot device for a circuit (or circuits) when luminaries are individually photocell controlled.

B. The pilot devices shall control the power circuit through the contractor or relay as shown on the drawings.
   1. Contactors:
      a. Contactors shall be NEMA ICS 2 or its equivalent or better, electrically held.
      b. Contactor rating shall be as indicated on the drawings.
      c. Provide contactors with enclosure suitable for the environment where installed and, or as indicated on drawings.
      d. Contactors shall have silver alloy double-break contacts and coil clearing contacts for mechanically held contactor] and shall require no arcing contacts.
      e. Provide contactors with hand-off automatic selector switch or as indicated on drawings.

C. The arrangement and method of control and the control devices shall be as shown on the drawings.

EXECUTION

1.18 INSTALLATION

A. Install lighting in accordance with the applicable standards references indicated on Paragraph 1.2 above, as shown on the drawings, and in accordance with manufacturer's recommendations.

B. Poles:
   1. Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad 90 degrees at the bottom end.
      a. Provide galvanized nuts, washers, and ornamental covers for anchor bolts.
      b. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit.
      c. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.

2. After the poles have been installed, shimmed and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material. Provide a plastic or copper tube, of not less than 10 mm inside diameter, through the grout tight to the top of the concrete base for moisture weeping.

C. Foundation Excavation:

1. Depth shall be as indicated. Dig holes large enough to permit the proper use of tampers to the full depth of the hole.
2. Place backfill in the hole in 150 mm maximum layers and thoroughly tamp.
3. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

D. Photocell Switch Aiming:

1. Aim switch according to manufacturer's recommendations.

1.19 GROUNDING

A. Ground noncurrent-carrying parts of equipment including metal poles, luminaries, mounting arms, brackets, and metallic enclosures as specified in Section 26 0526, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

1. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable and listed for this purpose.

1.20 INSTALLATION OF LUMINAIRES IN TALL STRUCTURES

A. This paragraph applies where there are tall structures required to be illuminated such as smoke stacks, water towers, cooling towers and similar structures:

1. Mount the lighting fixtures at the extreme top of structure.
2. Mount the lighting fixtures at uniform intervals in a horizontal plane around the stack at each elevation, in accordance with the manufacturer's instruction, so not less than two lighting fixtures at each elevation will be visible from any direction.
3. Securely attach the lighting fixtures to permanent structures including bracing on each side and upwards for each fixture.
4. Install an individual winch and cable for each lighting fixture in accordance with manufacturer's recommendations:

   a. Anchor the guide lines to eyes in the stack foundation and maintain tension with turnbuckles.
   b. Install conduit protection for the winch lines.

B. At each elevation, divide the lighting fixtures between three phases.

C. Coordinate works against the requirements of Section 26 5536, Obstruction Lighting.

1.21 FIELD TESTING

A. Installation shall be demonstrated to operate to the satisfaction of the Consultant.

B. Operational Tests shall be performed in accordance with referenced standards in this section.

7.4.32 26 9999 - Schedule of Guarantees, Warranties and Spares for Electrical Services

GENERAL

1.1 SUMMARY

Where there are any discrepancies between the spare parts and warranties listed in the Electrical General Requirements and Scope of Works / Electrical Standard Material and

Workmanship Specifications and the table below then the following table shall take precedence.

In addition to the items identified in the table below the Contractor shall also provide a list of spares required for ALL installed equipment as recommended by the manufacturer(s) and/or its authorized installer/representative of the equipment. The contractor shall also deliver all spare parts to site in protective containers where practicable.

The Contractor shall provide a written confirmation from each supplier used, confirming the recommended spares to be provided with each item of equipment supplied and/or installed under this contract.

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
Division 26 - Electrical		
26 0509 - Fire Barriers and Cable Transitions	N/A	2 years
26 0513 - Conductors and Cables	N/A	2 years
26 0523 - Extra Low Voltage Control Cables	N/A	2 years
26 0526 - Grounding and Bonding for Electrical Systems	N/A	2 years
26 0529 - Hangers and Supports for Electrical Systems	N/A	2 years
26 0533 - Raceway and Boxes for Electrical Systems	N/A	2 years
26 0536 - Cable Trays for Electrical Systems	N/A	2 years
26 0539 - Underfloor Raceways for Electrical Systems	N/A	2 years
26 0543 - Underground Ducts and Raceways for Electrical Systems	N/A	2 years
26 0548 - Vibration and Seismic Controls for Electrical Systems	N/A	2 years
26 0553 - Identification for Electrical Systems	N/A	2 years
26 0573 - Overcurrent Protective Device Coordination	N/A	2 years
26 0800 - Commissioning of Electrical Systems	N/A	N/A

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
26 0923 - Lighting Control Devices	Provide the following: a. Occupancy Sensors and Daylight Sensors: One for every 100 of each type and rating installed. Furnish at least one of each type.	2 years
26 1300 - Medium Voltage Switchgear	Refer to Fuses and Enclosed Switches and Circuit Breakers.	5 years
26 2200 - Low Voltage Transformers		5 years
26 2413 - Low Voltage Switchgear	Refer to Fuses and Enclosed Switches and Circuit Breakers.	5 years
26 2416 - Distribution Boards	Refer to Fuses and Enclosed Switches and Circuit Breakers.	2 years
26 2419 - Motor Control Centres	Refer to Enclosed Motor Controllers.	5 years
26 2500 - Enclosed Bus Assemblies	Tap-off Boxes: Two (2) of each type and rating installed.	2 years
26 2713 - Metering	Provide the following: a. Meters and Gauges: Five (5) of each type installed. b. Fuses: Equal to 1-percent of amount installed for each size indicated, but no fewer than 20 of each size.	2 years
26 2726 - Wiring Devices	Provide the following: a. Socket Outlets: Equal to 1-percent of amount installed, but no fewer than 20 of each type, rating and colour installed. b. Light Switches: Equal to 1-percent of amount installed, but no fewer than 10 of each type, rating and colour installed.	2 years
26 2813 - Fuses	Fuses: Equal to 1-percent of amount installed for each size indicated, but no fewer than 20 of each type and rating.	2 years
26 2816 - Enclosed Switches and Circuit Breakers	Provide the following: a. Miniature Circuit Breakers: Equal to 1-percent of amount installed for each size indicated, but no fewer than 20 of each type and rating. b. Moulded Case Circuit Breakers: Equal to 1-percent of amount installed for each size indicated, but no fewer than one (1) of each type and rating.	2 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
26 2913 - Enclosed Motor Controllers	Equal to 1-percent of amount installed for each size indicated, but no fewer than one (1) of each type and size.	2 years
26 2923 - Variable Frequency Motor Controllers	N/A	2 years
26 3213 - Packaged Engine Generators	Keys and Tools: One extra set for access to locked and tamper proofed components. Oil, Oil Filters and Air Filters: 3 complete sets per generator.	5 years
26 3301 - DC Battery Systems	Keys and Tools: One extra set for access to locked and tamper proofed components.	2 years
26 3353 - Static Uninterruptible Power Supplies	Keys and Tools: One extra set for access to locked and tamper proofed components.	5 years
26 3533 - Combined Power Factor Correction Capacitors and Harmonic Filtration	Provide the following: a. Capacitor fuses: two of each size and type installed. b. Keys and Tools: One extra set for access to locked and tamper proofed components.	3 years
26 4100 - Facility Lightning Protection 26 4300 - Transient Voltage Suppression	Replaceable Protection Modules: One of each size and type installed.	2 years 10 years
26 5000 - General Lighting 26 5200 - Emergency Lighting 26 5600 - Exterior Lighting	Provide the following: a. Lamps: One for every 10 of each type and rating installed. Furnish at least one of each type and rating installed. b. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type and size installed. c. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type and rating installed. d. Guards: One for every 20 of each type and rating installed. Furnish at least one of each type and size installed.	General: 2 years Central Batteries: 10 years Self-Contained Luminaires: 7 years Exterior Luminaires: 5 years
Division 28 - Electronic Safety and Security		
28 0513 - Conductors and Cables for Electronic Safety and Security	N/A	2 years

Specification Number and Title	Spare Parts / Extra Materials	Warranty Period
28 3111 - Digital, Addressable Fire-Alarm Systems	Provide the following: a. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit. b. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit. c. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type. d. Detector Bases: Quantity equal to 2-percent of amount of each type installed, but no fewer than 1 unit of each type. e. Keys and Tools: One extra set for access to locked and tamper proofed components. f. Audible and Visual Notification Appliances: Two (2) of each type installed. g. Fuses: Two of each type and rating installed in the system.	5 years

ELECTRIC WATER HEATER SCHEDULE		All sites					Rev 1
MARK NO.	SERVICE	LOCATION	QUANTITY	UNIT	CAPACITY (LITERS)	POWER (kW)	REMARKS
TFS GUARD HOUSE							
EWH-1	HOT WATER	KITCHEN	1	EACH	76	1	STORAGE TYPE, WALL HUNG
EWH-2	HOT WATER	T&B	1	EACH	258	2	STORAGE TYPE, WALL HUNG
MAIN GUARD HOUSE							
EWH-1	HOT WATER	KITCHEN	1	EACH	76	1	STORAGE TYPE, WALL HUNG
EWH-2	HOT WATER	T&B	1	EACH	258	2	STORAGE TYPE, WALL HUNG
CHLORINATION BUILDING							
EWH-3	HOT WATER	T&B	1	EACH	122	3	STORAGE TYPE, WALL HUNG
MAINTENANCE, CLEANERS & WORKSHOP							
EWH-2	HOT WATER	KITCHEN	1	EACH	76	2	STORAGE TYPE, WALL HUNG
EWH-4	HOT WATER	STORE 2	1	EACH	228	5	STORAGE TYPE, WALL HUNG
EWH-4	HOT WATER	FEMALE TOILET	1	EACH	243	5	STORAGE TYPE, WALL HUNG
EWH-5	HOT WATER	MALE TOILET	1	EACH	441	7	STORAGE TYPE, WALL HUNG
MAIN PUMPING STATION							
EWH-1	HOT WATER	HC & COMMON TOILET	2	EACH	8	0.5	STORAGE TYPE, WALL HUNG
EWH-2	HOT WATER	COMMON ROOM	1	EACH	76	1.5	STORAGE TYPE, WALL HUNG
EWH-2	HOT WATER	FIRST AID ROOM	1	EACH	76	1.5	STORAGE TYPE, WALL HUNG
EWH-3	HOT WATER	F. CHANGING ROOM	1	EACH	129	3	STORAGE TYPE, WALL HUNG
EWH-4	HOT WATER	M. CHANGING ROOM	1	EACH	251	5	STORAGE TYPE, WALL HUNG
WATER TESTING FACILITY							
EWH-2	HOT WATER	LABORATORY 2	1	EACH	152	2	STORAGE TYPE, WALL HUNG
EWH-4	HOT WATER	CLEANERS ROOM	1	EACH	488	4	STORAGE TYPE, WALL HUNG

Hyder Consulting

SUMP PUMP SCHEDULE

PROJECT TITLE

Kahramaa Mega Reservoir (PRPS1)

EQUIPMENT REFERENCE	SERVICE	LOCATION	QTY.	UNIT	CAPACITY	HEAD	POWER DATA				REMARKS
					(LPS)	(M)	KW	Volts	Phase	Hz	
MAIN PUMP STATION BUILDING											
SUMP PUMP 1 & 2	WASTE WATER	Valve Chamber 1	2	EACH	0.315	8.9	0.19	230	1	50	CONSTANT SPEED SUBMERSIBLE PUMP (Duty/Standby)
SUMP PUMP 3 & 4	WASTE WATER	Valve Chamber 2	2	EACH	0.379	8.9	0.19	230	1	50	CONSTANT SPEED SUBMERSIBLE PUMP (Duty/Standby)
SUMP PUMP 5 & 6	WASTE WATER	Valve Chamber 3	2	EACH	0.315	8.9	0.19	230	1	50	CONSTANT SPEED SUBMERSIBLE PUMP (Duty/Standby)
SUMP PUMP 7 & 8	WASTE WATER	Valve Chamber 4	2	EACH	0.315	8.9	0.19	230	1	50	CONSTANT SPEED SUBMERSIBLE PUMP (Duty/Standby)
MV & GENERATOR BUILDING											
SUMP PUMP 1 & 2	WASTE WATER	SUMP PIT	2	EACH	0.063	9.75	0.19	230	1	50	CONSTANT SPEED SUBMERSIBLE PUMP (Duty/Standby)
GALLERY CABLE TUNNEL											
SUMP PUMP 1 & 2	WASTE WATER	SUMP PIT	2	EACH	0.41	7.7	0.6	400	3	50	CONSTANT SPEED SUBMERSIBLE PUMP (Duty/Standby)

SB - REMOTE SUBSTATION BUILDING 1 & 2

VRF A/C UNIT SCHEDULE

NAME NO.	LOCATION	SERVICE	EVAPORATOR										OUTDOOR UNIT		COMPRESSOR					REMARKS
			TYPE	SUPPLY FAN				MAIN COOLING COIL					FAN QUANTITY	ENTERING AIR TEMP. °C	TYPE	TOTAL LOAD kW	TOTAL MOTOR			
				CAPACITY L/S	EXT STATIC PRESSURE Pa	MOTOR				COOLING CAPACITY										
						kW	RPM	V/PH/HZ	ENTERING AIR DB/WB °C/°C	LEAVING AIR DB/WB °C/°C	TOTAL kW	SENSIBLE kW					kW	RPM	V/PH/HZ	
INDOOR / OUTDOOR UNIT																				
FC-B1-1 / VR-B1-1	ELECTRICAL	ELECTRICAL	WALL MOUNTED	150	60	0.14	1650	240/1/50	27/19.5	12/11.3	3.2	1.87	1	46	SCROLL	4.0	19.2	1650	L15/1/50	
FC-B1-1 / VR-B1-1	ELECTRICAL STORE	ELECTRICAL STORE	WALL MOUNTED	150	60	0.14	1650	240/1/50	27/19.5	12/11.3	3.2	1.87	1							
FC-B1-1 / VR-B1-1	STORE 1	STORE 1	WALL MOUNTED	150	60	0.14	1650	240/1/50	27/19.5	12/11.3	3.2	1.87	1							
FC-B1-1 / VR-B1-1	STORE 2	STORE 2	WALL MOUNTED	150	60	0.14	1650	240/1/50	27/19.5	12/11.3	3.2	1.87	1							
FC-B1-1 / VR-B1-1	STORE 3	STORE 3	WALL MOUNTED	150	60	0.14	1650	240/1/50	27/19.5	12/11.3	3.2	1.87	1							
FC-B1-3 / VR-B1-1	OFFICE	OFFICE	DUCTED	194	60	0.14	1650	240/1/50	23/17	12/10.7	3.8	2.36	1							
FC-B1-4 / VR-B1-1	PRAYER ROOM	PRAYER ROOM	DUCTED	250	60	0.145	1650	240/1/50	23/17	12/10.7	5.0	3.34	1							
FC-B1-7 / VR-B1-1	WORKSHOP 1	WORKSHOP 1	WALL MOUNTED	254	30	0.037	1650	240/1/50	27/19.5	12/10.7	5.6	4.78	1							
FC-B1-7 / VR-B1-1	WORKSHOP 2	WORKSHOP 2	WALL MOUNTED	254	30	0.037	1650	240/1/50	27/19.5	12/10.7	5.6	4.78	1							
FC-B1-7 / VR-B1-1	WORKSHOP 3	WORKSHOP 3	WALL MOUNTED	254	30	0.037	1650	240/1/50	27/19.5	12/10.7	5.6	4.78	1							
FC-B1-4 / VR-B1-2	CORRIDOR	CORRIDOR	DUCTED	254	60	0.143	1650	240/1/50	27/19.5	12/10.7	5.6	4.78	1	50	SCROLL	5.0	22.1	1650	L15/1/50	
FC-B1-4 / VR-B1-2	CLEANERS	CLEANERS	DUCTED	254	60	0.143	1650	240/1/50	23/17	12/10.7	5.6	4.78	1							
FC-B1-3 / VR-B1-2	ACCOMMODATION	ACCOMMODATION	DUCTED	191	60	0.107	1650	240/1/50	23/17	12/10.7	4.3	3.615	1							
FC-B1-4 / VR-B1-2	MAINTENANCE	MAINTENANCE	DUCTED	250	60	0.143	1650	240/1/50	23/17	12/10.7	5.0	4.75	1							
FC-B1-5 / VR-B1-2	TRAINING ROOM	TRAINING ROOM	DUCTED	446	60	0.343	1650	240/1/50	23/17	12/10.7	11.2	9.52	1							
FC-B1-6 / VR-B1-2	KITCHEN	KITCHEN	DUCTED	630	60	0.524	1650	240/1/50	23/17	12/10.7	14	11.9	1							

GRILLE DIFFUSER SCHEDULE

NAME NO.	SIZE mm x mm	FLOW RATE lps	TYPE	REMARKS
SG-1	150x150	63	4-WAY	SUPPLY
SG-2	210x201	75	4-WAY	SUPPLY
SG-3	300x200	95	4-WAY	SUPPLY
SG-4	250x250	125	4-WAY	SUPPLY
SG-5	250x254	151	4-WAY	SUPPLY
SG-6	300x304	212	4-WAY	SUPPLY
SG-7	250x250	60	4-WAY	MAKE-UP AIR
RG-1	150x150	63	4-WAY	RETURN
RG-2	200x200	75	4-WAY	RETURN
RG-3	200x200	95	4-WAY	RETURN
RG-4	250x250	125	4-WAY	RETURN
RG-5	250x250	155	4-WAY	RETURN
RG-6	300x300	211	4-WAY	RETURN

NOTE: GRILLES AND DIFFUSERS SHALL BE PROVIDED WITH VOLUME DAMPER

GRILLE DIFFUSER SCHEDULE

NAME NO.	SIZE mm x mm	FLOW RATE lps	TYPE	REMARKS
EG-1	300x204	95	4-WAY	EXHAUST
EG-2	300x300	61	GRILLE	EXHAUST
EG-3	350x350	188	GRILLE	EXHAUST

NOTE: GRILLES AND DIFFUSERS SHALL BE PROVIDED WITH VOLUME DAMPER

FAN SCHEDULE

NAME NO.	LOCATION	SERVICE	TYPE	CAPACITY lps	EXT STATIC PRESSURE Pa	MOTOR DATA			REMARKS
						kW	RPM	V/PH/HZ	
REF-B1B-1	GROUND FLOOR	KITCHEN EXTRACT	CONT. IN-LINE	65	250	0.1	1650	240/1/50	
TEF-B1B-1	GROUND FLOOR	TOILET EXTRACT	CONT. IN-LINE	101	250	0.25	1650	240/1/50	
EF-B1B-1	GROUND FLOOR	WORKSHOP EXTRACT	CONT. IN-LINE	189	250	0.75	1650	240/1/50	

PACKAGED ROOFTOP FRESH AIR HANDLING UNIT SCHEDULE

NAME NO.	LOCATION	SERVICE	TYPE	SUPPLY FAN			COOLING COIL				HEAT PIPE				ELECTRICAL DATA			V/PH/Hz	REMARKS
				CAPACITY L/S		EXT STATIC PRESSURE Pa					PRE - COOL		RE - HEAT						
				SUPPLY AIR	FRESH AIR		ENTERING AIR DB/WB °C/°C	LEAVING AIR DB/WB °C/°C	COOLING CAPACITY SENSIBLE kW	COOLING CAPACITY TOTAL kW	ENTERING AIR DB/WB °C/°C	LEAVING AIR DB/WB °C/°C	ENTERING AIR DB/WB °C/°C	LEAVING AIR DB/WB °C/°C	COMPRESSOR MOTOR kW	CONDENSER FAN MOTOR kW	SUPPLY FAN MOTOR kW		
PAHU-B1B-01	ROOF	WORKSHOP	PACKAGED ROOFTOP UNIT	990	990	500	43/26.7	12/11.3	36.6	56.3	30/23	43/26.7	12/11.3	22/10	22.1	6.3 x 6 nos	0	415/3/50	CAPABLE OF 100% OUTDOOR AIR OPERATION AT 30°C AMBIENT

Rev	Date	Revision Details	Drn	Chkd	Appd
B	23JUL14	RE-ISSUED FOR TENDER	MJ	AH	AH
A	20FEB14	ISSUED FOR TENDER	BS	RC	AH

Status: TENDER

		Current Issue Signatures	
Scales	NTS	Drawn	B.SANTOS
Original Size	A1	Checker	R.CRUZ
Datum	QNHD	Approver	A.HARRIS
Projection	UTM - 39N	Date	FEB 2014

Filename: MQ174-R2-DH-BM-6091_Rev B.dwg

Client: Qatar General Electricity & Water Corporation

Project Code: GTC 626/2014

Project: WATER SECURITY MEGA RESERVOIRS PACKAGE B PRPS 2 - UMM SLAL

Title: MAINTENANCE CLEANERS & WORKSHOP MECHANICAL EQUIPMENT SCHEDULES

Drawing No.: MQ174-R2 - DH - BM - 6091 | Rev: B