

SECTION 26 24 00

LOW VOLTAGE SWITCHGEARS, SWITCHBOARDS AND PANELBOARDS

1. GENERAL

This section covers the minimum requirements for the Low Voltage Switchgears, Switchboards, and Panel Boards. The LV Panels and Switch Boards shall include, but not limited to, all equipment, materials, labor, documentation, and services necessary to furnish and install a complete, operational system.

1.01 SUMMARY

A. General:

1. This Section shall be read in conjunction with other related sections, Scope of Works & employer General requirements, the design drawings and the contract conditions.
2. Refer to the Quality Control Requirements document for requirements related to samples, mock-ups, prototypes and quality benchmarks.
3. Refer to the Spares Requirements document for requirements related to spares and extra material requirements.
4. Refer to the Warranty Requirements document for requirements related to warranties.
5. Refer to the Training Requirements document for requirements related to demonstration and training.

B. Section Includes:

1. This section includes the minimum requirements to supply, install, test, and operate the Low Voltage (LV) Switchboards and switchgears.
2. Factory assembled main or sub-main Low Voltage (LV) switchgear / distribution boards and associated equipment including, but not limited to, the following:
 - a) Switchgear/distribution board assembly.
 - b) Switchgear/distribution board components.
 - c) Labelling and identification.
 - d) Miscellaneous accessories.
 - e) Factory tests.

C. Related Sections:

1. The electrical services particular specification, drawings and schedules.
2. Other related divisions/sections including but not limited to:
 - a) Other sections of division 26
 - b) Other divisions produced to describe elements of the overall project.
 - c) The contract documents (including contract, conditions, specifications, drawings, schedules etc.).
3. The Governing Codes for the Kingdom of Saudi Arabia (KSA) and the relevant international codes and references within this document.

1.02 REFERENCES

A. References Standards:

1. SASO Saudi Arabian Standards Organization.
2. SBC 401 Saudi Electrical Code.
3. SEC Saudi Electricity Company.
4. IEC 60044-1 Current Transformers.
5. IEC 60051 Direct acting Indicating Analogue Electrical Measuring Instruments and their Accessories.
6. IEC 60073 Basic and Safety Principles for Man-Machine Interface, Marking and Identification.
7. IEC 60114 Indicating Instruments.
8. IEC 60269 Low Voltage Fuses.
9. IEC 60335 Safety of Household and similar Electrical Appliances.
10. IEC 60364 Electrical Installations of Buildings.
11. IEC 60408 LV Air Break Switches, Air Break Disconnectors, Air Break Switch Disconnectors and Fuse Combination Units.
12. IEC 61439 LV Switchgear and Control gear Assemblies.
13. IEC 60529 Degrees of Protection provided by Enclosures (IP Code).
14. IEC 60947 Standards for LV Switchgear and Control gear (Various Parts).
15. IEC 61643 Surge Protective Devices connected to LV Power Distribution Systems.
16. BS 7671 Requirements for Electrical Installations (IEE Wiring Regulations).
17. BS HD 60269 Low Voltage Fuses.
18. BS EN 60898 Electrical Accessories, Circuit Breakers for Over-current Protection for Household and similar Installations.

B. ABBREVIATIONS AND DEFINITIONS:

1. The Following abbreviations used throughout this document shall have the meanings ascribed to them below:

AC	Alternating current.
ACB	Air circuit breaker.
ASTA	Association of Short circuit Testing Authorities.
AWA	Aluminum Wire Armour.
BEAMA	British Electro-technical and Allied Manufacturers.
BS	Association BS British Standard.
CT	Current transformer.
DB	Distribution board.
DC	Direct current.
EN	European standard (EN).

HRC	High rupturing current.
Hz	Frequency.
IEC	International Electro-technical Commission.
IEE	Institute of Electrical Engineers or Institute of Engineering Technology.
IPnn	Ingress protection rating to BS EN 60529.
ISO	International Organization for Standardization.
kA	Kilo amperes.
KEMA	Keuring van Elektrotechnische Materialen in Arnhem LED Light emitting diode.
LOVAG	Low Voltage Agreement Group.
LV	Low voltage.
MCB	Miniature circuit breaker.
MCC	Motor control centre.
MCCB	Moulded Case Circuit breaker.
MDB	Main distribution board – main switch panel.
MLV	Main low voltage switch panel
O+M	Operating and maintenance manual
PDU	Power distribution unit
PVC	Polyvinylchloride
RAL	Reichs-Ausschuss für Lieferbedingungen colour space system.
RCBO	Residual Current Circuit Breaker with Overcurrent Protection.
RCCB	Residual current circuit breaker
REF	Restricted earth fault protection or earth fault protection.
RMS	Root Mean Square.
SDB	Sub-Main Distribution Board – Sub-Main Switch Panel.
SWA	Steel Wire Armour.
TIA	Telecommunications Industry Association.
TTA	Type Tested Assembly.
UL	Underwriters Laboratory – United States.
V	Voltage.
VCB	Vacuum Circuit Breaker.
VT	Voltage Transformer.
XLPE	Cross-linked Polyethylene.
PMS	Power Management System

2. Post contract shall mean prior to ordering of the materials or equipment and prior to commencement of those elements of the installation that may change if the

submission is rejected.

3. Switchboard shall generically mean main distribution boards (MDB's), sub-main distribution boards (SDB's), motor control centers (MCC's), power distribution Units, (PDU's) final circuit distribution boards (DB's) , feeder pillars and all factory-built assemblies of switchgear (FBA's).
4. Inclusive of both mains only supplied (SDB. MCC etc.) and generator backed essential (ESMDB, EMCC etc.) switchgear.
5. A full schedule of abbreviations is included in the particular specification, drawings and schedules.

1.03 SUBMITTALS

- A. Submit manufacturer's catalogues and data including schematic drawings, dimensioned layout of equipment and accessories, technical specifications, installation instruction and general recommendations. Include data substantiating that the proposed units comply with the project requirements.
- B. Submit a dimensioned outline drawing of each switchgear/distribution board showing all leading dimensions and the estimated weight of the equipment.
- C. Submit manufacturer's fabrication, builders work and installation drawings showing all significant details of each main and sub-main LV switchgear/distribution board including the following:
 1. All components.
 2. Fuse, circuit-breaker and switch ratings.
 3. Current and voltage transformer ratios, class, terminal markings and output.
 4. Instruments including scale details.
 5. Relay types and characteristics.
 6. Indicating lamps including color.
 7. Position of switches and details of function.
 8. All internal connections with terminal markings.
 9. Arrangement of terminal blocks.
 10. Wire numbers.
 11. Size, type and color of secondary wiring.
 12. Principal physical dimensions, including clearances required for removing covers, opening doors, operating handles, withdrawing equipment, etc.
 13. Position of all panel face equipment.
 14. Identification of all equipment, and appropriate label inscriptions.
 15. Foundation details, including weights and fixing points.
 16. Cable entry details including gland and gland plate provisions.
- D. Submit manufacturer's short circuit and protection coordination study showing correct selection of all components as per actual site conditions and recommended protection settings for all protective devices to achieve proper discrimination as per referenced standards and recognized industry practices.
- E. Submit list of tools, test equipment, spare parts and ancillary equipment.

- F. Submit factory test reports verifying that LV switchgear/distribution boards have successfully passed all routine tests. Type tests results shall be submitted, when required by the Engineer.
- G. Submit operation and maintenance manuals including data / catalogues pertaining to model nos., type, serial nos., capacities, controls, operation / maintenance instructions, etc. of each major item / component and each LV switchgear/distribution board by itself.
- H. Post contract submittals:
 - 1. Shop drawings: Drawings shall have the following information:
 - a) Fully dimensioned drawings showing outlines of the switchboards, and arrangement/ position of important external features:
 - 1) Mass, hoisting positions, crane lifts necessary for unloading and moving and the size of lifting lugs or eyes.
 - b) Front and side views of enclosures.
 - c) Top and bottom plans showing space available for conduits, cables, bus-bars, etc.
 - d) Nameplate legends
 - e) 3-Line schematic diagram
 - f) Size and number of bars per phase and neutral in each bus run including main, section and branch buses plus equipment ground buses.
 - g) Electrical characteristics of equipment, including ampere ratings of buses, temperature rise, and maximum short circuit withstand ratings and control voltages.
 - h) Features, characteristics and ratings of overcurrent protective devices
 - i) Internal wiring diagrams.
 - j) Foundation plan, including foundation loading.
 - 2. Product Data: Provide manufacturer's specifications and technical data including performance, construction and fabrication. Submit product data for each manufactured component.
 - a) Service voltage, number of phases and frequency
 - b) Main bus-bars capacity (Ampere Rating) and short circuit rating
 - c) Overcurrent protective device types with short circuit, frame and trip ratings, features and characteristics.
 - d) Metering equipment types and functions
 - e) Time-current coordination curves for each circuit breaker.
 - 3. Supplementary product literature: Include a statement from the manufacturer for the design life of the system.
 - 4. Test reports: Provide test reports prepared in accordance with requirements of the Supply Authority Having Jurisdiction and to the Engineer's approval. Provide other test reports to establish the adequacy, quality, safety, complete status and suitable operation of each system. The test reports to include the 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.

5. Certified test data.
6. Calculations
7. Forward the following calculations and data:
 - a) Calculations and charts proving that discrimination of the breaker characteristics is achieved.
 - b) Detailed short circuit calculation to select the short circuit rating of the various switchboards.
 - c) Bus-bar sizing calculations for such switchboard
 - d) Calculations for temperature rise inside switchboard.
8. Outline technical specifications reflecting proposed materials and systems.
9. A list of proposed suppliers and Subcontractors intended to be used.
10. Preliminary method statement
11. Preliminary quality plan
12. Summary of deviations from the Performance Specification

1.04 CLOSEOUT SUBMITTALS

- A. General: Comply with the requirements of this document and those noted in the summary above and submit the following:
 1. Warranties:
 - a) The Contractor shall provide a full One-year warranty from TOC (Taking-over certificate) covering the LV switchboards and LV panels, to include routine and preventive maintenance, periodic checks and replacement of defective parts.
 2. Operation and Maintenance (O+M) Manuals: Include component list with manufacturer's reference numbers, descriptions of materials and procedures for repairing and cleaning of finishes and cleaning frequency.
 3. Recorded documents including accurate site test report and system scheme.
 4. As-built drawings: At project close-out, submit record drawings of meters and instruments, in accordance with requirements comply with the requirements of this document and those noted in the summary above.
- B. Tools and Testing Equipment:
 1. Special tools and equipment required for erection, commissioning, maintenance and testing LV panels and switchboards shall form part of the order and be shipped together with the assembly.
 2. Voltage detection and phasing-sequencing equipment shall be offered as a separate item in the quotation.
 3. A suitable wall-mounting cabinet shall be provided for all such portable tools and equipment.
 4. Testing equipment for motor starting units shall be provided with local-on control facility.
- C. Spare Parts:
 1. Spare parts shall be adequate for start-up procedures and for 2 years of operation.

Spare parts shall be adequately identified and packed.

2. Main low voltage panel (MDB)
 - a) 2% spare moulded case circuit breakers of all different frame sizes, but in any case, not less than 2 nos. circuit breakers of each size.
 - b) 5% spare indicating lamps for each indicating lamp in the switchgear.
 - c) One set of tools required for switchgear maintenance.
 - d) Provide 2-complete sets of spare parts as recommended by the manufacturer for each different size of ACB.
 - e) 5% of multi-function meter, ammeter, voltmeter and selector switch.
 3. Other Switch gear including sub-main distribution boards, motor control centers and distribution boards etc.:
 - a) 5% spare combination magnetic motor starters.
 - b) 5% of multi-function meter, ammeter, voltmeter and selector switch.
 - c) 5% spare circuit breakers for each rating of each MCCB.
 - d) 5% spare circuit breakers for each rating of each MCB.
 - e) 5% spare HRC fuses for each rating.
 - f) 5% spare of load break switch (isolators) of each size.
 - g) 5% spare of Residual Current Devices (RCDs), ELCBs and RCBO.
 - h) 2% spare of Variable Frequency drives of each type, Rating etc., but in any case, not less than two circuit breakers of each type, size etc.
 4. Disconnecting switches (Isolators) and switch Fuses:
 - a) 5% spare switch of each size.
 5. Where circuit breakers are supplied as spare the overall requirement includes the provision of both the base circuit breakers and the utilized trip units.
- D. Extra materials:
1. Furnish extra materials as required by this section and the documents noted in the summary above.

1.05 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of main or sub-main switchgear/ distribution boards of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years. Preference shall be given to local manufacturers and agents/suppliers.
- B. Installer: Firms regularly engaged and qualified with at least 5 years of successful installation experience on projects with electrical installation work similar to that required for the project.
- C. Except where detailed in the specification, all components and equipment in LV switchgear/ distribution boards shall preferably be from the same manufacturer. These shall comply with the requirements of SASO, IEC and BS.
- D. The design, manufacture, testing and method of installation of all apparatus and materials furnished under the requirements of this specification shall conform to the latest publications or standard rules of the following:
 1. British standards, in particular BS 7671 (IET Wiring Regulations)

2. International Electro-technical Commission (IEC).
- E. Contractor to submit letter to the Employer's Representative and Assistants, signed by a suitably qualified Structural Employer's Representative and Assistants (on behalf of the Contractor) performing seismic load calculations in conformance with paragraph entitled QUALITY ASSURANCE, confirming that the Contractor has:
1. Testing and Inspection: Provide as indicated under Site Quality Control within Part 3 of this Section.
 2. Performed calculations for reaction loads to the building structure for all seismic restraints, including those covered by referenced Guidelines.
 3. Coordinated his bracing layout, reaction loads and details of structural attachments with work of other trades confirmed that proposed system of seismic bracing is fully compatible with building structure.
 4. A copy of calculations and layout drawings for seismic bracing to be maintained on jobsite.
- F. Standards and other Codes of Practice: In addition to the requirements indicated on the Design Drawings or specified in the Performance Specification, the Work shall be in accordance with provisions of the following standards and codes. The current editions of publications listed in the References Sub-Section a part of this section.
- G. The work shall be in accordance with recommendations and requirements of the following bodies: The current editions of their publications being those applicable:
5. The requirements of the local authority having jurisdiction.
 6. The requirements of the Telecoms services provider.
 7. The requirements of the electrical supply authority.
- H. The quality control/assurance duties shall be performed by the Contractor. The system of quality control verification shall be in accordance with ISO 9000 standards of quality control/assurance.
- I. Product selection for restricted space: Design drawings indicating maximum dimensions for the equipment, including clearance between the equipment and adjacent surfaces and items. Only switchgear having equal performance characteristics and complying with indicated maximum dimensions may be considered.
- J. Equipment supplied under this contract shall be new and selected specifically for this project by manufacturers having at least 10 years' experience in the production of specific items or equipment supplied.
- K. All LV switchgear shall be designed, manufactured, tested and installed in accordance with the latest editions and amendments of IEE, IEC and BS.
- L. The main switchboard manufacturer, assembler and supplier shall be independently certified to BSENISO9001:2000 Quality standard. A copy of this certification shall be submitted to the Employer's Representative and Assistants for approval.
- M. The system of quality control verification shall be in accordance with ISO 9000 standards of Quality Control/Assurance.
- N. Preconstruction Testing/Reports:
- O. Submit reports of independent tests demonstrating that the products and systems comply with the specified performance requirements.
- P. The provision of testing data or carrying out of tests does not relieve the Contractor of his responsibilities regarding the performance requirements, durability or service life

requirements.

Q. Switch board testing:

1. All Switch boards (MDB'S, SDB's MCC's and FDB's) shall undergo the following routine factory tests before dispatching and a test certificate shall be forwarded for the same.
 - a) Mechanical test
 - b) Voltage test
 - c) Primary injection test for all circuit breakers and meters
 - d) Secondary test for all protective relays
 - e) Millivolt drop test.
 - f) Insulation test
 - g) Function test.
2. Tests shall be witnessed by the Employer's Representative and Assistants as noted previously.
3. The Contractor is responsible for complying with all codes/standards, which apply to the equipment. Any special certification requirements or inspection by other authorities arising from the above shall be arranged by the Contractor and the costs for the same included in this quotation.
4. Switchgear and panel boards shall be type tested by ASTA or KEMA.

R. The components and cables, design, material and performance shall conform except where otherwise indicated, with the latest issues and amendments of the following codes and standards.

S. Where conflicts exist between the requirements of this Performance Specification and other drawings, standards, codes and specifications, the most stringent shall be applied.

T. ASTA or KEMA or LOVAG Total type test certificate shall be submitted to prove the assembly performance and design and as per the requirements of the supply authority having jurisdiction.

U. Factory witness testing:

1. Include witnessing of factory acceptance testing:
 - a) of:
 - 1) all Power switchgear and control gear assemblies of switchgear with Current Ratings over 250A
 - 2) Other units as noted in the particular specification drawings and schedules.
 - b) By the:
 - 1) Contractor – minimum 1 person
 - 2) Employer's Representative and Assistants – 1 person
 - 3) Employer and/or Client's representative (2-persons)
2. Include for:
 - a) Minimum business class travel and 4-star hotel accommodation including meals and other incidentals for the above the Engineers and Employer.
3. Testing shall be scheduled at times approved by the Employer and the Employer's

Representative and Assistants.

4. Notify the Employer's Representative and Assistants 4 weeks in advance of proposed final factory tests of the switchboards.
5. Submit:
 - a) Detailed method statements for each test
 - b) Copies of all certified test results after the tests

1.06 DELIVERY AND HANDLING

- A. Comply with section 1.07 (Product Conditions).
- B. Handle packaged cubicles of LV switchgear/distribution boards carefully to prevent breakage, denting or scoring the finish. Store equipment at an indoor location and protect from weather. When outdoor storage is necessary, elevate well above ground and enclose with durable, waterproof wrapping.
- C. Shipping splits: Modules shall be not wider than 1 vertical section or as per the manufacturer recommendation, maximum 2400mm, individually wrapped and mounted on shipping skids.

1.07 PROJECT CONDITIONS

- A. Project Climatic Conditions:
 1. Refer to the particular specification, schedules and drawings for details of the expected climatic conditions.
 2. All components of the installation shall be suitable for continuous operation in the expected climatic conditions.
- B. Civil Work Coordination
 1. Take into account all of the Civil/ mechanical work performed by other Sub-Contractors associated with installation of electrical, mechanical, plumbing and other facilities.

1.08 WARRANTY

- A. Comply with section 1.04 (Closeout Submittals).

1.09 SPARE PARTS

- A. Supply as maintenance stock, additional circuit breakers, fuses, control relays, lamps and other components of LV switchgear/distribution boards, amounting to one unit for every 10 units, but not less than 2 units of each type and rating.

1.10 SCOPE OF WORKS

- A. The Contractor shall supply, install, connect, test and commission LV switchgear and LV Boards and accessories as described in the particular specification and project documents and design drawings and schedules.
- B. The Contractor shall supply all materials, skilled workmanship, equipment, working plans, procedure, method statements for installations to provide complete and fully operational Low voltage switchgear equipment as described herein and indicated in the particular specification, contract documents, project drawings and schedules including but are not limited to the following:
 1. Switchboards

2. Change-over circuit breakers
3. Disconnect Switches (Isolators or isolating switches).
4. Motor Starters
5. Circuit breakers
6. Metering
7. Current Transformers
8. Voltage Transformers
9. Control and control wiring
10. Protection Relays

2. PRODUCTS

2.01 ACCEPTED MANUFACTURERS

- A. Refer to the approved Manufacturer list, Section 26 00 01:
 1. Manufacturers: Provide systems and products from the list of approved manufacturers included in section 26 00 01, drawings and schedules.

2.02 GENERAL

- A. All materials used in the manufacture and installation of LV switchgear/boards shall be of high quality and of proven suitability for the functions they will perform and the conditions they will meet in service.
- B. All materials shall be suitable for the climatic conditions to work and operated in KSA. Provide and apply any current de-rating due to ambient temperature, if required.
- C. All materials shall be suitably selected and installed for use seismically active area on which they are to be used and as noted in the particular specification schedules and drawings.
- D. Manufacturers: Provide systems and products from one of the listed manufacturers within the approved manufacturer list.
- E. All switching and protection components (Switches, Isolators, circuit breakers etc.) within a single switch board (MDB, SDB, MCC, FDB etc.) shall originate from a single reputable manufacturer from the schedule of acceptable manufacturers.
- F. Allow for witnessed tests to be carried out in factory and give at least 14 days' notice before the tests are to be carried out.
- G. The LV switchgear/distribution boards and associated equipment shall be suitable for 400/230 Volts, 3-phase, 4-wire, 60 Hz system or as shown on the drawings.
- H. All main and sub-main LV switchgear/distribution boards shall be type tested assemblies in compliance with IEC 61439-1.
- I. All new switching and protection components (Switches, isolators, circuit breakers etc.) within a single distribution system shall originate from a single reputable manufacturer from the schedule of acceptable manufacturers.

2.03 PMS CONTROL

- A. The switchgear assembly shall include all necessary marshalling, signal processing equipment and distribution wiring or bus-wiring to enable each functional unit to communicate with the remote PMS over dual redundant communication. Vendor shall be responsible for providing all addressing information necessary to enable the communication system software to be configured. All device and software configuration, including the communications interface, shall be completed and tested at the manufacturer's factory before shipping.
- B. Loop communication from feeders over digital communication link shall be arranged so as to avoid common mode failure. Similarly, communication bus-wiring shall be to enable control unit / relay / complete starter to be withdrawn without breaking the loop.
- C. Software supporting the configuration and interrogation of the intelligent motor starters and protection relays shall be provided. The software shall include the ability to monitor variables, trending, alarms, and time stamping of events, configuring of starter control units and communications integrity monitoring.
- D. A laptop PC complete with pre-loaded software shall be provided for communication and control with the switchboard communications processor as a minimum the Manufacturer shall provide support to any specified microprocessor control units for ten years.
- E. Switchgear/panels shall be provided with control and indication facilities as per PMS I/O List.
- F. Vendor shall develop a remotely operated scheme via PMS. The scheme shall permit manual switching to remove an incomer from service or return an incomer to service with no break in supply. This shall involve momentary paralleling of supplies.
- G. Communication protocol of PMS shall be IEC 61850 (GOOSE) All panels shall be provided with suitable interface point through relay/panel for PMS system connection. Suitable communication port shall be provided in each panel to connect it with PMS system. All relays in the switchgear shall be connected in ring fashion and single point interface shall be provided to transfer all monitoring & control signals from equipment to PMS system. Vendor shall coordinate with the PMS system provider for details and all requirements to be incorporated in the PMS system.
- H. The Vendor shall coordinate with the PMS Vendor to define the equipment and software requirement to enable the seamless communication between the switchgear and the PMS system.
- I. The vendor shall incorporate intelligent electronic device (IED) All I/Os as per PMS list shall be connected internally to the IED. The IED shall have minimum 2 ports for this interface. Looping cable from PMS shall be either FO patch cord or CAT6 cable.
- J. All motorized breakers indicated in the SLD shall be control and monitor by the PMS system. Vendor shall refer to the PMS I/O list and he shall provide all provisions in the panels which can be monitored and controlled by the PMS.

2.04 DESIGN CRITERIA

- A. The components and systems shall be suitable for the system voltage, frequency, phasing, supply arrangement and fault level noted in the particular specification, drawings and schedules.
- B. The components and systems shall be to the approval of the Authorities Having Jurisdiction and the Engineers. Details of the Authorities Having Jurisdiction are noted in the particular specification, drawings and schedules.

- C. All control and monitoring systems in the MDB and other panels with motorized breakers shall be fed from UPS based power supply.

2.05 LABELLING AND IDENTIFICATION

A. Identification:

1. Allocate each Switchboard and each item of switchgear a unique identification reference that reflects its purpose, physical Location and position in the electrical distribution systems.
2. Agree a method of allocating references and format of them with the Supply authority, Engineers and Employer
3. Agree the final allocated references with the Supply authority, Engineers and Employer.
4. Each label is to give the required information in both English and Arabic

B. Labelling:

1. Provide identification labels:
 - a) On all:
 - 1) Switchboards, and all Functional units of switchboards and to all collections of functional units.
 - 2) Circuit breakers and switches
 - 3) Control elements
 - 4) Indicators
 - 5) Bus-bar chambers and covers for bare conductors
 - 6) Cable chambers
 - 7) Earth bars
 - b) to identify:
 - 1) Purpose
 - 2) Physical Location
 - 3) Position in the electrical distribution system.
 - 4) Origin of supply
 - c) Comprising:
 - 1) Red background with white lettering for all Life safety functional units.
 - 2) White Background with black lettering for all other elements
 - 3) Engraved lettering on thermoplastic material.
 - 4) Minimum 10mm characters for incoming and Bus section devices and minimum 6mm characters on all other devices.
2. Labels to be screw fixed in place.
3. Provide warning labels on all removable covers access panels behind which bare conductors or terminals are located.
4. Agree labels with Supply Authority, Engineers and Employer.

5. Labels shall be engraved on traffolite sheet, with white letters on black background.
6. Nameplates for main breaker, tie breaker, section and outgoing modules identification and for the entire switchboard shall have letters not smaller than 13mm high. Nameplates for branch breakers, switches, push buttons, control devices, pilot lights and metering shall have letters not less than 3mm high. All nameplates shall be mechanically fixed with non-ferrous metal screws.
7. Warning signs on doors and access panels shall be engraved traffolite with white letters on red background.
8. Engraved traffolite/ aluminum mimic of the SLD shall be provided on the front face of the switchboard. The same shall be mechanically fixed with non-ferrous metal screws.

2.06 MAIN DISTRIBUTION BOARDS (MDB) AND MAIN SWITCHBOARDS (MSWBD)

A. General:

1. LV switchgear/distribution boards shall be designed and constructed to withstand for one (1) second without damage, thermal and mechanical stresses which might arise under short circuit conditions up to the prospective bus-bar short circuit current.
2. Switchgear/distribution boards shall provide a degree of protection against contact with live or moving parts and against the entry of solid foreign bodies and liquid, at least to IP-31 for indoor applications and IP-54 for wet areas and outdoor use in accordance with the definitions contained in relevant standards.
3. Switchgear/distribution boards shall be self-contained, free-standing, floor mounted, flush-fronted, multi-cubicle Form-4b type as called for on the drawings and shall be constructed in sections where necessary to facilitate transport and erection.
4. The overall height of each switchgear/distribution board shall not exceed 2200 mm unless otherwise shown on the drawings.
5. Each switchgear/distribution board shall be designed for front access and top or bottom entry as shown on the drawings or approved by the Engineer. Cable terminations and space for terminations shall be suitable for the sizes of cable. All switchgear/distribution boards shall be capable of extension at both ends and bus-bar chambers shall be fitted with removable end covers.
6. Individual cubicles from which cubicle type switchgear/distribution boards are built shall be rigidly constructed from folded steel panels and sections firmly welded together and the required number of cubicles shall be bolted or welded together. Switchgear/distribution boards constructed from flat steel plates on a framework of rolled steel angle shall not be accepted. All distribution boards shall be provided with adequate lifting eyes, which shall be removed after the boards are in place and replaced by screw-in plugs. When a switchgear/ distribution board is sectionalized for assembly on site, the sections shall be provided with adequate means of locating adjacent sections to ensure accurate alignment.
7. Each switchgear/distribution board shall be supplied with removable undrilled steel plates for cable glands and conduit entry. Where single core cables are used, the gland plates shall be brass or non-conducting. All conduits, trunking and cables as shown on the drawings shall be accurately located and drilled, cut and threaded on site.

8. LV switchgear/distribution boards shall be enclosed with lockable doors. All live metal shall be insulated and the operator shall not be able to accidentally come into contact with live connections or bus-bars when energized. All cable terminations shall be fully shrouded and shall permit connections to be made with adjacent circuits live.
9. All equipment mounted in switchgear/distribution boards shall be fully accessible for maintenance. The compartments shall be fitted with hinged doors, neoprene or foam rubber gasketed, and doors shall be provided with lever type locking handles having integral cylinder locks. All locks shall be operable with a common key, the number of keys supplied being two per lock up to a maximum of 10 per distribution board.
10. Bus-bars shall be four-pole, air insulated of uniform cross-section throughout their length, with a continuous current rating not less than that shown on the drawings and shall be arranged horizontally and vertically through each switchgear/distribution board. Current ratings shall take account of reduction in section caused by drilling for connections and supports.
11. Bus-bars and their connections / branches to the various items of switchgear/distribution board shall be manufactured from hard drawn high conductivity 99.9 % pure electrolytic copper with silver plated contact surface. Identification of phase, neutral and earth bus-bars shall be done by color coding as per IEC.
12. Bus-bars shall be supported on non-hygroscopic, non-tracking insulators of sufficient strength to withstand, without damage, the forces set up, either by thermal effects during normal operation or by electromagnetic effects under short circuit fault conditions. The spacing between bus-bar supports shall be maintained according to required short circuit withstand capacity of the switchgear/distribution board as recommended by the manufacturer and applicable standards.
13. Bus-bars shall be housed in separate compartments, which shall not contain any wiring or
14. apparatus other than that for connecting to the bus-bars.
15. Access to bus-bars and bus-bar connections shall be possible only after the removal of covers secured by bolts or studs. Such covers shall be identified externally by "Formica" engraving laminate labels bearing the inscription "BUS-BARS" in black lettering not less than 10 mm high, on a white background.
16. The cross-sectional area of the neutral bus-bar shall be equal to the phase bus-bars.
17. Each cubicle or box section shall be provided with sufficient bus-bar links to enable cubicle sections to be easily joined. Facilities shall also be provided for extending the bus-bars to extra cubicle sections, if required at some future date.
18. Requirements overview:
 - a) Factory Built and Type Tested Assemblies (FBA and TTA) of switchgear in accordance with BS EN 61439-1.
 - b) Power switchgear and control gear assemblies (PSC-ASSEMBLY's) in Accordance with BS 61439-2.
 - c) 'Cubicle' type or 'multi-cubicle' type assemblies in accordance with BS EN 61439-1.
 - d) Equipped with all of the functional units, meters, bus-bars controls relay etc.

necessary to fulfil the requirements of the particular specification drawings and schedules.

19. Electrical characteristics:
 - a) Rated operating voltage and frequency: as the particular specification schedules and drawings
 - b) Rated insulation voltage: 1000V for rated operating voltages up to 415V.
 - c) Rated impulse withstand voltages shall be as Table G1 in Appendix G of BS EN 61439-1 unless noted otherwise in the particular specification drawings and Schedules.
 - d) Rated Impulse withstand Voltage:
 - e) Rated current: as the particular specification, schedules and drawings.
 - f) Rated peak withstand current: 105KA.
20. Rated short-time withstand current shall be as noted in the Particular specification, drawings and Schedules or alternately as per requirements of the supply authority having jurisdiction.
 - a) Where this is not given, the rated short time withstand current shall be:
 - 1) 50kA for 1 sec where provided with incoming devices up to 2500A rating
 - 2) 65kA for 1 sec where incoming devices are greater than 2500A ratings
21. Circuit Breakers, switches, bus-bars, meters, CT's, VT's, contactors, time switches, control relays selector switches and other accessories used in conjunction with MDB's shall accord with the requirements of this section of the specification.
22. Other components used in conjunction with MDB's shall accord with the requirements and recommendations of the applicable IEC and BS EN standards.
23. Clause not used.
24. Meters shall be mounted in separate compartments in each section. Meters shall be as described hereinafter.
25. CTs and VT's for the metering, control and protection functions shall be provided as required. CT.s and VT's shall be as described hereinafter.
26. The Contractor shall provide fault level calculations to substantiate Proper selection of all devices.
27. The Contractor shall carry out routine tests at their work with valid testing equipment calibrated by a reputed laboratory.
28. Air circuit breakers used in MDB'S shall be of the 'withdrawable' or draw-out type in accordance with BS EN 61439-2. They shall be capable of being padlocked in the isolated position.
29. Moulded case circuit breakers used in MDB's shall be of the plug-in type unless noted otherwise in the particular specification, drawings and schedules. Plug-in MCCB's shall be 'removable' as defined in BS EN 61439-1.
30. Withdrawable compartments and plug-in units or breakers shall be indicated clearly in the Design Drawings and single line diagram. The switchgear shall be completely compartmentalized and metal enclosed.
31. All equipment and materials shall be new.
32. MDB's shall be free standing unless noted otherwise in the particular drawings,

specifications and schedules.

33. Special Tools:
 - a) The Contractor shall provide a complete set of all special tools and devices necessary for the operation and maintenance of the complete assembly.
 - b) The Contractor shall provide a wall mounted panel to accommodate these tools and devices.
 - c) Include an integral roll-along lifting device for any switchgear equipped with draw-out or "withdrawable" devices. Mount lifting device on top of switchgear.
34. MDB's shall have been type tested for internal arc withstand as per AS/ NZS 3439.1 and IEC TR 6164 and as the following:
 - a) Arc testing shall have been carried out:
 - 1) On the Supply side of incoming devices.
 - 2) On the Load side of incoming devices.
 - 3) Along the main bus-bars.
 - 4) Along distribution and/or riser bus-bars.
 - 5) On the Supply side of output units
 - 6) On the load side of output units
 - b) Personal protection is to be achieved by fulfilment of the following criteria during the arc testing:
 - 1) Correctly secured doors, covers, etc., do not open.
 - 2) Parts of the assembly, which may cause a hazard, do not fly off. (This includes large parts or those with sharp edges, for example inspection windows, pressure relief flaps, cover plates, etc.)
 - 3) Arcing does not cause holes to develop in the freely accessible external parts of the enclosure as a result of burning or other effects.
 - 4) The indicators arranged vertically do not ignite (indicators ignited as a result of paint or stickers burning are excluded from this assessment)
 - 5) The protective circuit for accessible parts of the enclosure is still effective.
 - 6) The assembly is capable of confining the arc to the defined area where it ignited, and there is no propagation of the arc to other areas within the assembly.
 - 7) Hot gases are not discharged at or towards operators standing in front of the panel.
 - c) In addition, the assembly is to be suitable for limited continued operation following the arc and after:
 - 1) Clearing of the fault or after isolation or disassembly of the affected functional units in the defined area, emergency operation of the remaining ASSEMBLY is to be possible. This is to have been verified by a dielectric test with a value of 1,5 times the rated operational voltage during 1 min.
35. The Contractor shall submit valid test certificates such from ASTA or KEMA to the Employer's Representative and Assistants for acceptance. Test certificates will be required to demonstrate compliance with the Current, Voltage and Arcing requirements noted above.

36. Control contacts, auxiliary contacts, relays and small or light mechanisms shall be enclosed and protected and shall be accessible for repair or adjustment.

B. Construction:

1. The MDB's shall meet the requirements noted in the particular drawings, specifications and schedules for the following:
 - a) Ingress protection rating to BS EN 60529
 - b) Form of construction to BS EN 61439.
 - c) Front or rear access.
 - d) Top and/or Bottom entry of cables
 - e) Top and/or bottom exit of cables.
2. Basic protection against direct contact with live parts shall be achieved by appropriate constructional measures: enclosures.
3. The assembly, including the framework, wiring, earth bar, etc., shall be suitable in all respects for extension at both ends such that only the minimum of work shall be required to make such extensions.
4. The switchgear shall be painted inside and out. Unpainted galvanized coating of internal metal work shall not be acceptable.
5. A plinth/space of 100mm shall be provided at the bottom of each panel. Functional units, controls bus-bars shall not be located in the plinth space.
6. All doors shall be provided with concealed type hinges and captive screws.
7. Vertical cable chambers:
 - a) shall be provided for the installation of the outgoing cable/cores and their connections to the functional units. These chambers shall run the full height of the switchboard and shall be sized for the greater of;
 - 1) To accommodate all of the cables used for the project and a minimum of 20% spare space for future use/changes.
 - 2) A minimum 200mm wide and as deep as the largest functional unit adjacent to it.
 - b) Shall be provided with suitable hinged doors. The cable termination shall be completely shrouded. It shall be possible to safely carry out maintenance work on cable connections to all circuit with the bus bars and adjacent circuits live. Adequate number of slotted cable support arms shall be provided for clearing the cables.
8. The MDB's shall be of uniform height of not more than 2200mm.
9. Permanent lifting means shall be provided on top of shipping sections.
10. The MDB shall be built-up of individual freestanding cubicles to allow easy installation on Site. The cubicles shall be made of electro-zinc coated sheet metal of 2mm thickness. The sheet metal shall be coated with a thermosetting powder of an epoxy resin base modified by polyester resin, which provide perfect finish and excellent protection against corrosion (standard "all climate" protection). The color shall be to RAL 7032/ 9002 and to the Engineer's acceptance.
11. The switchboard shall be:
 - a) Provided with a metal sill frame made of structural steel channels section properly drilled for mounting the switchgear along with necessary mounting

- hardware. Hardware shall be zinc plated and passivized to deter chemical changes.
- b) Provided with cable entry facilities with 3mm thick removable gland plates and necessary cable glands. For single core cables these plates shall be nonmagnetic.
 - c) Provided with gaskets all-round the perimeter of adjacent panels and base frame, removable covers and doors.
 - d) Provided with bus bars running at the top all along the Switchgear in a separate sheet steel enclosure.
12. Operating devices shall be incorporated only in the front of the switchgear with a hinged door.
- a) Only the handles of control and selector switches, push buttons, knobs and cut-outs for lamps and meters shall be arranged on the front doors of the respective compartments to permit operation without opening the door. Protective relays shall be mounted on the front door of the compartment. All other equipment pertaining to a circuit shall be mounted on the withdrawable chassis. All cut-outs shall be provided with gaskets for the purpose of dust proofing.
13. Current transformers shall not be directly mounted on the buses but shall be mounted on the fixed portion of the compartment using removable CT links for easy access and maintenance.
14. Suitable barriers shall be placed between circuit breakers and all control, protective and indication circuit equipment including instrument transformers. External cable connections shall be carried in separate cable compartments for power and control cables.
15. After isolation of the power and control connections of a circuit, it shall be possible to safely carry out maintenance in a compartment with the bus bars and adjacent circuits live.
16. The withdrawable chassis shall move on suitable guides and on stainless steel rollers or balls to facilitate easy withdrawal.
17. The switchgear shall be divided into distinct vertical sections each comprising:
- a) A completely metal enclosed bus bar compartment running horizontally.
 - b) Individual feeder modules arranged in multi-tier formation. It is essential that the modules are integral multiples of the basic unit size to provide for flexibility in changes, if any, at Site.
 - c) Enclosed vertical bus bars serving all modules in the vertical section for safety isolation of the vertical bus bars, insulating barrier with cut outs shall be provided to allow the power stab contacts to engage with vertical bus bars.
 - d) A horizontal separate enclosure for all auxiliary power and control buses, as required, shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap off connections from these buses shall be arranged separately for each vertical section.
18. Each vertical section shall be equipped with thermostatically controlled ante-condensation space heaters. The heaters shall be provided within the assembly and shall be controlled by a panel-mounted hygostat with a 50% to 100% setting range.
19. Open metal sheet shall be provided between 2 No. adjacent vertical sections

running to the full height of the switchgear except for the horizontal bus-bar compartment. However, each shipping section shall have metal sheets at both ends.

20. All equipment associated with a single circuit shall be housed in a separate module compartment of the vertical section. The compartment shall be sheet steel enclosed at the sides and the rear with the withdrawable units in the position or removed. However, for front cable entry type switchboards, a plate cover with a slot to permit wiring connections shall be provided on the side corresponding to the cable chambers.
21. All withdrawable chassis mounting circuit breakers shall be of the fully draw out type:
 - a) It shall be possible to draw out the withdrawable chassis without having to unscrew or unbolt any connections to the equipment mounted on the withdrawable chassis. The power and control draw out type connections shall be of the slab-in or sliding type. All draw out contacts including for auxiliary and control wiring shall be of self-aligning type.
 - b) Automatic shutters shall be employed to ensure live parts cannot be reached when withdrawable units are removed.
22. All identical equipment and corresponding parts including chassis of draw out modules of the same size shall be fully interchangeable, without having to carry out modifications. For trouble free interchangeability, the draw out arrangement shall be designed such that normal dimensional variations are taken care of by self-aligning feature of the modules.
23. Fixed circuit breakers shall be:
 - a) Be fitted on prefabricated appropriate mounting plates and access to their operating toggles shall be provided through an appropriate front cover, fixed to the front frame.
 - b) Have their cable connections made in a separate compartment. The access shall be possible through hinged covers.
24. Removable outgoing circuit breakers shall have
 - a) Their base frame fitted on prefabricated appropriate mounting plates. Access to their operating toggles shall be provided through an appropriate front cover, fixed to the front frame.
 - b) Connections made in a separate compartment. The access shall be possible through hinged covers.
25. The cubicle shall be divided into modules with a minimum of 20% of empty modules for extension.
26. Compartments for future breakers shall be complete with bus connections, plug-in bases and mounting plates, ready for the insertion of a breaker.
27. No cast iron or cast aluminum shall be used in any part of the assembly, which is subjected to mechanical stress.
28. All incoming and outgoing switching devices shall have provision for locking in the 'off position.'
29. Where the MDB's are required to bridge one or more civil work expansion joints in the substation construction, this requirement shall be detailed on the civil drawings.

30. Where the MDB's are required to bridge cable trenches then the Contractor shall ensure:
 - a) Support steelwork is suitably recessed across the top of the cable trench at centers to suit the sections of the MDB's.
 - b) The steel work can safely carry the weight of the MDB's.
- C. Incoming and sectionalizing units (Bus-section devices):
 1. Incoming and sectionalizing units shall be air circuit breakers and shall be mounted in separate panels.
 2. Air circuit breakers shall be four-pole or three-pole type as indicated in the single line diagram for three phase and neutral systems. They shall be provided with "In Service/ Out of Service/ Test Point" positions and suitable locking devices shall be provided for the "Out of Service" and "Test Point" positions.
 3. A dedicated compartment shall be included for metering on the incomers.
 4. The supplier shall supply details for incoming units and bus-bar standard earthing arrangements.
- D. Outgoing functional units
 1. They shall be ACB or MCCB with type and ratings as indicated in the particular specification, schedules and drawings and as indicated in the relevant section of this Performance Specification.
 2. ACB's and MCCB's of 630A frame size and above shall be withdrawable.
 3. All other MCCB's below 630A shall be plug-in unless noted otherwise in the particular specification, schedules and drawings.
 4. There shall be a minimum 300mm space between the base of the switchgear and the underside of the lowest functional unit.
 5. All incoming and outgoing circuit breakers shall be provided with short circuit and overload release to trip the breaker, instantaneously if closed onto a fault.
 6. All compartments shall occupy the full cubicle width; a semi module compartment or vertical division between compartments is not acceptable.
 7. Supplier shall ensure that the number of outgoing feeders in any vertical section of switchboard shall be such that there is adequate space in the cable alley for all power and all control cables entering the panel.
- E. Cable and Wire Terminations and Terminals:
 1. All internal control and auxiliary wiring shall terminate in suitable spring loaded, clamp type terminals and shall be provided with a permanent, easily read numbering system at both ends in accordance with the wiring diagram. Wires shall be identified by means of numbered and or lettered sleeves.
 2. Formal blocks shall be arranged and positioned to afford easy access for carrying out external cabling, testing, inspection and maintenance.
 3. Cable Glands shall be of the double sealed compression type with position armour bond suitable for XLPE and PVC insulated cables.
- F. Mechanical Indications
 1. All functional units other than contactors shall be provided with mechanically operated "on" and "off" indicators, which shall be positively driven in both directions and shall be visible from the front of the assembly.

G. Safety Shutters

1. Where shutters are provided to maintain IP 20(minimum), they shall automatically cover all bus bar and cable spouts or isolating contacts whenever removable or withdrawable units are removed.
2. The safety shutters shall be automatically opened and closed by action of the removable or withdrawable unit movement. A positive drive to the shutters shall be provided in both directions.
3. They shall be capable of being padlocked in the closed position.

H. Interlocks and transfer functions

1. Where multiple incoming supplies are provided then the incoming functional units and bus-section devices shall be provided with interlocks and controls including:
 - a) Those noted in the particular specification schedules and drawings.
 - b) a complete set of electrical and mechanical interlocks to prevent incorrect operation and to provide safety for personnel in addition to any external interlocks specified for operational reasons. This shall be taken to include:
 - 1) such interlocks as required to prevent parallel operation of sources where such paralleling has not been agreed with the supply authority.
 - 2) Check sync Controls that automatically prevent parallel operation of two supplies that are not synchronized.
2. Where other interlocking, intertrip or transfer functions are required these arrangements shall be as outlined in the particular specification, schedules and drawings.
3. The contractor shall submit logic and interlocking line diagrams to the Employer's Representative and Assistants for acceptance for all Interlocking, intertripping and transfer functions.
4. On removal of withdrawable units, mechanical interlocks shall be provided to prevent the following operations and any other operations which could cause danger or damage:
 - a) The unit being closed unless it is correctly located in the service, isolated or earthed positions or unless it is removed from the fixed part of the assembly.
 - b) The unit being withdrawn from or inserted into the feeder spouts or isolating device when it is in the closed position.
 - c) The unit being moved to any position other than that selected by means of the mechanical selector.
 - d) The unit being withdrawn or inserted into the fixed part unless it is in the correct state for withdrawal or insertion.
 - e) The unit being closed in the service position unless all auxiliary circuits between fixed and removable parts have been completed.
 - f) Means shall be provided to prevent opening of cubicle doors or covers before disconnection of supply to exposed live parts within.

I. MDB Bus Bars:

1. The bus bars shall be three phase Neutral and Earth (TPN+E). The phase, neutral and earth bus bars shall each be 100% rated and shall have the same cross-sectional area.

2. The Bus-bars shall be sized and supported for the Rated Peak Withstand and the Rated Short-Time Withstand currents noted earlier. Additionally, Bus bars shall be rated for the following full-time operational currents:
 - a) Supply Side of incoming devices, Load side of incoming devices and the main Bus- bars: 100% rating equal to the frame size of the largest incoming device.
 - b) Supply and load side of outgoing devices: 100% rating equal to the frame size of the individual outgoing devices.
 - c) Connections to Bus-couplers: 100% rating equal to the frame size of the largest incoming device.
 - d) Distribution and riser bars shall be sized to the smaller of:
 - 1) 150% of the arithmetic sum of the functional unit frame sizes connected to them.
 - 2) The same as the Main Bus bars.
3. Earth bars shall run through the entire length of the switchboard. The metal frames and all components shall be connected to the earth bar.
4. Bus bar current density shall not be more than 64A/cm² and shall also be in accordance with the local authority regulations/requirements.
5. The configuration and size of bus bars used should have been type tested by the panel manufacturer.
6. Bus bar supports shall be supplied by the original manufacturer of the enclosure with components provided at the distances as recommended by the original manufacturer.
7. All the bus bars used in the panel shall be high grade electrolytic tinned copper of 99% conductivity. The main bus bars shall be epoxy powder coated throughout their length and colored for phase, Neutral and Earth identification.
8. Bus bars shall be provided with at least the minimum clearances in air as per applicable standards for the system operating voltage identified in the particular specification, schedules and drawings.
9. The complete bus-bar system shall be certified by ASTA or KEMA for a fault level as indicated in the particular specification, schedules and drawings, Test certificates for a typical bus-bar system assembled by the switchgear assembler shall be submitted to the Employer's Representative and Assistants for acceptance. Components provided by Contractor shall comply with Coordination and Fault study, unless drawings indicate larger value.
10. Bus bars shall be totally enclosed within sheet steel compartments to provide optimum safety against accidental contact. The bus-bar compartments shall be properly marked with danger signs.
11. The vertical bus bars shall be accessible through hinged doors.
- J. Digital Multifunction Metering Systems
 1. A digital multifunction metering system complete with all CTs and VTs for customer's use shall be installed and factory wired in locations in each switchboard as indicated herein and as indicated in the particular specification, drawings and schedules.
 2. All VT secondary's shall be for LV and all CT secondary's shall be 5A.
 3. The Metering system shall be an integrated micro-processor-based multifunction

metering package, capable of displaying:

- a) Line and phase volts (V).
 - b) Line Current (A).
 - c) Power factor (Cos F).
 - d) Frequency (Hz).
 - e) Kilovolt amperes (KVA).
 - f) Kilovolt amperes reactive (KVAR).
 - g) Kilowatt hours (KWH).
 - h) Neutral current (A).
4. A standard banana jack test block shall allow testing of the meters by injecting 230V and 5A while the phase display indicates T. 3
 5. Set point N/O and N/C Contacts shall be provided for the purpose of load shedding or alarm with each being field programmable to suit the Employer requirements.
 6. The meter shall be designed to include provisions for communication with external monitoring devices via an RS 232F port.
 7. The digital metering system and associated software shall be supplied by the switchboard manufacturer.
 8. The Contractor shall include for all hardware and software as required and recommended by the digital meter manufacturer for remote monitoring at the PMS terminals.
- K. Design verification will be required for the following in accordance with BSEN 61439-1 :
1. Construction:
 - a) Strength of materials and parts;
 - b) Degree of protection of enclosures;
 - c) Clearances and creepage distances;
 - d) Protection against electric shock and integrity of protective circuits;
 - e) Incorporation of switching devices and components;
 - f) Internal electrical circuits and connections;
 - g) Terminals for external conductors.
 2. Performance:
 - a) Dielectric properties;
 - b) Verification of temperature rise;
 - c) Short-circuit withstand strength;
 - d) Electromagnetic compatibility;
 - e) Mechanical operation.
 3. Verification shall be submitted to the Engineers

2.07 SUB MAIN DISTRIBUTION BOARDS (SDB)

- A. SBD's with Air Circuit Breaker (ACB) Incomers shall be as described above for Main distribution Boards.

B. SDB's with Moulded Case Circuit Breaker (MCCB) incomers shall be as follows:

1. General:
 - a) Requirements overview:
 - 1) Factory Built and Type Tested Assemblies (FBA and TTA) of switchgear in accordance with BS EN 60439-1.
 - 2) Power switchgear and control gear assemblies (PSC - ASSEMBLY's) in Accordance with BS 61439-2.
 - 3) 'Cubicle' type or 'Multi-cubicle' type assemblies in accordance with BS EN 61439-1.
 - 4) Equipped with all of the functional units, meters, bus-bars controls relays etc. necessary to fulfil the requirements of the particular specification drawings and schedules.
 - b) Electrical characteristics:
 - 1) Rated operating voltage and frequency: as the particular specification schedules and drawings.
 - 2) Rated insulation voltage: 1000V for rated operating voltages up to 415V.
 - 3) Rated impulse withstand voltages shall be as Table G1 in Appendix G of BS EN 61439-1 unless noted otherwise in the particular specification drawings and Schedules.
 - 4) Rated Impulse withstand Voltage:
 - 5) Rated current: as the particular specification, schedules and drawings.
 - 6) Rated peak withstand current: 105KA.
 - 7) Rated short-time withstand current shall be as noted in the Particular specification, drawings and Schedules. Where this is not given, the rated short time withstand current shall be:
 - a. 35kA/25kA for 1 sec. were provided with incoming devices up to and including 800A rating as indicated in LV schematics.
 - b. 50kA for 1 sec. where incoming devices greater ratings of 800A.
2. Circuit Breakers, switches, bus-bars, meters, CT's, VT's contactors, time switches, control relays selector switches and other accessories used in conjunction with SDB's shall accord with the requirements of this section of the specification.
3. Other components used in conjunction with SDB's shall accord with the requirements and recommendations of the applicable BS and BS EN standards.
 - a) The switchgear system and devices shall originate from a single reputable manufacturer from the schedule of acceptable manufacturers.
 - b) Digital Multifunction meter systems shall be provided where indicated on the Particular specification, drawings and schedules. Meters shall be mounted in separate compartments in each section. Meters shall be as described hereinafter.
 - c) CTs and VT's for the metering, control and protection functions shall be provided as required. CT.s and VT's shall be as described hereinafter.
 - d) The Contractor shall provide fault level calculations to substantiate Proper selection of all devices.

- e) The Contractor shall carry out routine tests at their work with valid testing equipment calibrated by a reputed laboratory.
4. Moulded case circuit breakers used in SDB's shall be:
 - a) Free standing SDB's: plug-in type unless noted otherwise in the particular specification, drawings and schedules. Plug-in MCCB's shall be 'removable' as defined in BS EN 61439-1.
 - b) Wall Mounted SDB's: Fixed pattern
5. Withdrawable compartments and plug-in units or breakers shall be indicated clearly in the Design Drawings and single line diagram. The switchgear shall be completely compartmentalized and metal enclosed.
6. All equipment and materials shall be new.
7. SDB's shall be free standing unless noted otherwise in the particular drawings, specifications and schedules.
8. Special Tools:
 - a) The Contractor shall provide a complete set of all special tools and devices necessary for the operation and maintenance of the complete assembly.
 - b) The Contractor shall provide a wall mounted panel to accommodate these tools and devices.
 - c) Include an integral roll-along lifting device for any switchgear equipped with draw-out or "withdrawable" devices. Mount lifting device on top of switchgear
9. The Contractor shall submit valid test certificates such from ASTA or KEMA to the Employer's Representative and Assistants for acceptance. Test certificates will be required to demonstrate compliance with the Current, Voltage and Arcing requirements noted above.
10. Control contacts, auxiliary contacts, relays and small or light mechanisms shall be enclosed and protected and shall be accessible for repair or adjustment.
11. The manufacturer of the SDB's shall be the same as the MDB's and Circuit Breakers to ensure consistency and discrimination.
12. Enclosures:
 - a) Distribution boards shall be totally enclosed.
 - b) The degree of ingress protection according to IEC 60529 shall be as noted in the particular specification, drawings or schedules, or where no details are given shall be IP 42 for indoor installation.
 - c) The enclosure shall be manufactured from minimum 1.5mm thick electro-zinc coated sheet steel with Epoxy polyester powder finish.
 - d) Color to be RAL 7032 as standard unless otherwise agreed in writing by the Employer's Representative and Assistants.
 - e) A hinged door fitted with lock and key has to be opened for operating the switchgear. Access to the cabling space and to the switchgear shall be obtained by removing a front cover bolted fastener.
 - f) Ample-wiring space shall be provided. Detachable blank gland plates shall be provided at the top and bottom.
 - g) Unless otherwise specified on the drawings, the construction form shall be:
 - 1) Form 2b, for ratings up to and including 630A.

- 2) Form 4, for ratings of 800A and above.
13. Pan Assembly:
 - a) The pan assembly shall be completely independent unit that can be taken out of the enclosure for maintenance purpose.
 - b) All components are mounted on a strong chassis consisting of 2mm thick electro- zinc coated folded sheet steel.
 - c) Bus bars shall run in separate compartment fully shrouded by 2 No. layers of high impact polypropylene materials isolating the main bus bar from branch bus bars with IP20 minimum degree of protection and shall be made of hard drawn high conductivity tinned copper, air insulated c/ w earth and neutral bars sized the same as the phase bars.
14. Breakers:
 - a) Incoming and out-going breakers shall be MCCBs of fixed type with adjustable short circuit and overload releases.
 - b) Breaking capacity of the MCCBs shall be in line with the prospective fault level of the installation but shall not be less than fault level calculation. Ratings and capacity shall be as given elsewhere in this Performance Specification.
 - c) Short circuit calculations shall be submitted to the Employer's Representative and Assistants for acceptance.
 - d) Breaker selection shall be made to achieve maximum discrimination between the upstream and downstream breakers.
15. Auxiliaries and Accessories:
 - a) In addition, the incomer shall be provided with ammeter and voltmeter and selector switches.

2.08 POWER DISTRIBUTION UNITS (PDU)

- A. General:
 1. Requirements overview:
 - a) Factory Built and Type Tested Assemblies (FBA and TTA) of switchgear in accordance with BS EN 60439-1.
 - b) Power switchgear and control gear assemblies (PSC - ASSEMBLY's) in Accordance with BS 61439-2.
 - c) 'Cubicle' type or 'Multi-cubicle' type assemblies in accordance with BS EN 61439-1.
 - d) Equipped with all of the functional units, meters, bus-bars controls relays etc. necessary to fulfil the requirements of the particular specification drawings and schedules.
 2. Electrical characteristics:
 - a) Rated operating voltage and frequency: as the particular specification schedules and drawings
 - b) Rated insulation voltage : 1000V for rated operating voltages up to 415V.
 - c) Rated impulse withstand voltages shall be as Table G1 in Appendix G of BS EN 61439-1 unless noted otherwise in the particular specification drawings and Schedules.

- d) Rated Impulse withstand Voltage:
- e) Rated current: as the particular specification, schedules and drawings
- f) Rated peak withstand current: 105KA.
- g) Rated short-time withstand current shall be as noted in the Particular specification, drawings and Schedules. Where this is not given, the rated short time withstand current shall be:
 - 1) 35kA/2kA for 1 sec. were provided with incoming devices up to and including 800A rating as indicated in LV schematic.
 - 2) 50kA for 1 sec. where incoming devices greater rating of 800A.
3. Circuit Breakers, switches, bus-bars, meters, CT's, VT's, contactors, time switches, control relays selector switches and other accessories used in conjunction with MDB's shall accord with the requirements of this section of the specification.
4. Other components used in conjunction with MDB's shall accord with the requirements and recommendations of the applicable BS and BS EN standards.
5. The switchgear system and devices shall originate from a single reputable manufacturer from the schedule of acceptable manufacturers.
6. Meters shall be mounted in separate compartments in each section. Meters shall be as described hereinafter.
7. CTs and VT's for the metering, control and protection functions shall be provided as required. CT's and VT's shall be as described hereinafter.
8. The Contractor shall provide fault level calculations to substantiate Proper selection of all devices.
9. The Contractor shall carry out routine tests at their work with valid testing equipment calibrated by a reputed laboratory.
10. Air circuit breakers used in MDB'S shall be of the 'withdrawable' or draw-out type in accordance with BS EN 61439-2. They shall be capable of being padlocked in the isolated position.
11. Moulded case circuit breakers used in MDB's shall be of the plug-in type unless noted otherwise in the particular specification, drawings and schedules. Plug-in MCCB's shall be 'removable' as defined in BS EN 61439-1.
12. Withdrawable compartments and plug-in units or breakers shall be indicated clearly in the Design Drawings and single line diagram. The switchgear shall be completely compartmentalized and metal enclosed.
13. All equipment and materials shall be new.
14. MDB's shall be free standing unless noted otherwise in the particular drawings, specifications and schedules.
15. Special Tools:
 - a) The Contractor shall provide a complete set of all special tools and devices necessary for the operation and maintenance of the complete assembly.
 - b) The Contractor shall provide a wall mounted panel to accommodate these tools and devices.
 - c) Include an integral roll-along lifting device for any switchgear equipped with draw-out or "withdrawable" devices. Mount lifting device on top of switchgear.
16. MDB's shall have been type tested for internal arc withstand as per AS/ NZS 3439.1

and IEC TR 6164 and as the following:

- a) Arc testing shall have been carried out:
 - 1) On the Supply side of incoming devices
 - 2) On the Load side of incoming devices.
 - 3) Along the main bus-bars
 - 4) Along distribution and/or riser bus-bars.
 - 5) On the Supply side of output units
 - 6) On the load side of output units
- b) Personal protection is to be achieved by fulfilment of the following criteria during the arc testing:
 - 1) Correctly secured doors, covers, etc., do not open.
 - 2) Parts of the assembly, which may cause a hazard, do not fly off. (This includes large parts or those with sharp edges, for example inspection windows, pressure relief flaps, cover plates, etc.)
 - 3) Arcing does not cause holes to develop in the freely accessible external parts of the enclosure as a result of burning or other effects.
 - 4) The indicators arranged vertically do not ignite (indicators ignited as a result of paint or stickers burning are excluded from this assessment)
 - 5) The protective circuit for accessible parts of the enclosure is still effective.
 - 6) The assembly is capable of confining the arc to the defined area where it ignited, and there is no propagation of the arc to other areas within the assembly.
 - 7) Hot gases are not discharged at or towards operators standing in front of the panel.
- c) In addition, the assembly is to be suitable for limited continued operation following the arc and after:
 - 1) Clearing of the fault or after isolation or disassembly of the affected functional units in the defined area, emergency operation of the remaining ASSEMBLY is to be possible. This is to have been verified by a dielectric test with a value of 1,5 times the rated operational voltage during 1 min.
17. The Contractor shall submit valid test certificates such from ASTA or KEMA to the Employer's Representative and Assistants for acceptance. Test certificates will be required to demonstrate compliance with the Current, Voltage and Arcing requirements noted above.
18. Control contacts, auxiliary contacts, relays and small or light mechanisms shall be enclosed and protected and shall be accessible for repair or adjustment.
19. The manufacturer of the panel boards shall be the same as the MDB's, SDB's and Circuit Breakers to ensure consistency and discrimination.

B. PDU Construction/details:

1. Incorporate isolation transformers, surge protection, input and output breakers as required to meet the particular specification, Drawings and schedules and this section of the specification.
2. Conform to the:

- a) Requirements of BS EN 61439
- b) Form 4 type 6 Requirements of BS EN 61439 unless specifically noted otherwise in the particular specification, drawings and Schedules.
- c) IP54 requirements of IEC 60529.
3. Be Suitable for floor standing or complete with wall mounting frame as befits the required installations.
4. Digital Multifunction meter systems shall be provided where indicated on the Particular specification, drawings and schedules. Meters shall be mounted in separate compartments in each section. Meters shall be as described hereinafter.
5. PDU's shall:
 - a) Have enclosure manufactured from minimum 1.5mm thick electro-zinc coated sheet steel with Epoxy polyester powder finish.
 - b) Be Colored to RAL 7032 as standard unless otherwise agreed in writing by the Employer's Representative and Assistants.
 - c) Have hinged access doors fitted with lock and key which have to be opened for operating the switchgear. Access to the cabling space and to the switchgear shall be obtained by removing a front cover bolted fastener.
 - d) Have ample-wiring space provided with detachable blank gland plates provided at the top and bottom.
 - e) Be capable of thermographic examination and voltage and current analysis without the need for isolation.
 - f) Be complete with:
 - 1) 200% neutral busbars and have
 - 2) All spare outgoing ways fitted with circuit breakers
 - 3) Fully insulated busbars
 - 4) Complete with clean and functional earth bars
 - 5) Complete with pre drilled gland plates suitable for top and bottom cable entry
 - g) be mechanically ventilated.
 - h) be fitted with Type "D" outgoing MCB's rated at the minimum to minimize nuisance tripping.
 - i) be capable of MCB replacement without the need for total PDU isolation.
 - j) be complete with single and three phase MCB's and no blanks.
 - k) Have 20% spare breaker capacity on each PDU.
 - l) Equipped with an isolation transformer where required by the particular specification, drawings and schedules. The isolation transformers shall:
 - 1) Be capable of supplying their full load continuously in the environment (Enclosure) in which they are fitted have a minimum UL 1561 'K' Rating of 20.
 - 2) Have the 'K' Rating displayed on the transformer nameplate.
 - 3) Be contained in a separate enclosure within the PDU.
 - 4) Be equipped with a bypass switch to enable the transformer to be taken

off-line for testing/maintenance.

C. PDU Auxiliaries and accessories shall include:

1. power meters to record and display current, voltage and power (kW), together with KWh, power supplies healthy, EPO buttons, and harmonics.
2. Emergency Power Off buttons to trip the main incoming circuit breaker shunt trip mechanism. EPO's must be installed on a failsafe circuit, i.e. "close to make circuit" type of configuration and must use a shunt trip device, not contactors.
3. Full labelling with permanent white, black, white traffolyte labels indicating all functions and outgoing circuits.
4. PMS systems outputs and interfaces for:-
 - a) Power demand metering
 - b) warning output for 'Isolating Transformer off-line' conditions.
 - c) Alarm outputs for 'power output failed' to each outgoing circuit.
5. Have Key lockable access doors. Keys are to be provided in Triplicate.

2.09 MOTOR CONTROL CENTERS (MCC)

A. Motor control centres shall be of similar construction to the main distribution boards (MDB's) and in addition, shall be in accordance with the following specification.

1. The construction of the MCC panel shall be Form 4b type 4, with a degree of protection of:
 - a) IP41 Construction for internal use.
 - b) IP 54 (Minimum) for external use and wet areas (mechanical room, pump room, etc.).
2. The short circuit withstand rating shall be as noted in the particular specification, schedules and drawings or where this is not given, the rated short time withstand current shall be:
 - a) 35kA for 1 sec. were provided with incoming devices up to and including 800A rating.
 - b) 50kA for 1 sec. where incoming devices are greater rating of 800A.
3. Motor control centers shall be in accordance with IEC 60947-4-1 with type-2 coordination.
4. All power and control devices shall be mounted in separate compartments. All power and control wiring shall be segregated.
5. Separate color-coded wires shall be used for power and control wiring, the same shall be properly ferruled.
6. Control wires shall be of flexible copper not less than 1.5mm².
7. Chiller sequence controllers shall be provided for chiller plant.
8. Automatic controls for pump duty standby, duty selection, interlocking with chillers shall be provided.
9. All motors shall be provided with phase failure, under voltage, phase sequence over current and earth fault protection.
10. Run/ Trip/ Off indication shall be provided for all pump with lamp test facility.

11. On/ Off switch for chiller's control panel shall be provided.
12. Hand/ Off/ Auto selector switch and On/ Off push buttons shall be provided for all motors.
13. Phase healthy indicator lights shall be provided for each phase of the incoming supply.

B. Outgoing units

1. Motor starters and contactors shall have a utilization category of AC-3 (starting of squirrel-cage motors, switching off motors during running) and AC-4 for motors with inching or reversing duties.
2. Motor starter components i.e., breakers, contactors, relays, etc. shall be selected in accordance with IEC 60947-4-1 type 2 coordination.
3. Ammeters shall be fitted to all starters for motors greater than 3.0kW.
4. On-off fault indication of contractors shall be fitted on the front of the starter compartment with a red light for "OFF", green light for "ON" and an amber light to indicate motor overload or fault conditions.
5. Suppliers shall provide a minimum 300mm space between the base of the switchgear and the underside of the lowest outgoing units.
6. All incoming and outgoing circuit breakers shall be provided with Adjustable short circuit and overload releases to trip the breaker, instantaneously if closed onto a fault.
7. All compartments shall occupy the full cubicle width; a semi module compartment or vertical division between compartments is not acceptable.
8. Supplier shall ensure that the number of outgoing feeders in any vertical section of switchboard shall be such that there is adequate space in the cable alley for all power and all control cables entering the panel. The number of feeders shall not exceed 8 numbers for each vertical panel.
9. MCC's shall have been type tested for internal arc withstand as per AS/ NZS 3439.1 and IEC TR 6164 and as the following:
 - a) Arc testing shall have been carried out:
 - 1) On the Supply side of incoming devices
 - 2) On the Load side of incoming devices
 - 3) Along the main bus-bars
 - 4) Along distribution and/or riser bus-bars
 - 5) On the Supply side of output units
 - 6) On the load side of output units
 - b) Personal protection is to be achieved by fulfilment of the following criteria during the arc testing:
 - 1) Correctly secured doors, covers, etc., do not open.
 - 2) Parts of the assembly, which may cause a hazard, do not fly off. (This includes large parts or those with sharp edges, for example inspection windows, pressure relief flaps, cover plates, etc.)
 - 3) Arcing does not cause holes to develop in the freely accessible external parts of the enclosure as a result of burning or other effects.

- 4) The indicators arranged vertically do not ignite (indicators ignited as a result of paint or stickers burning are excluded from this assessment)
 - 5) The protective circuit for accessible parts of the enclosure is still effective.
 - 6) The assembly is capable of confining the arc to the defined area where it ignited, and there is no propagation of the arc to other areas within the assembly.
 - 7) Hot gases are not discharged at or towards operators standing in front of the panel.
- a) In addition, the assembly is to be suitable for limited continued operation following the arc and after:
- 1) clearing of the fault or after isolation or disassembly of the affected functional units in the defined area, emergency operation of the remaining ASSEMBLY is to be possible. This is to have been verified by a dielectric test with a value of 1,5 times the rated operational voltage during 1 min.

2.10 EXTERNAL LIGHTING FEEDER PILLARS

A. General:

1. Provided where required by the particular specification, schedules and drawings for the provision of local supplies to external lighting and other low power equipment.
2. Compliant with BS EN 61439
3. Required to have a minimum life of 20 Years in the environment in which they are to be installed.
4. Submit manufacturer's warranty
5. Be ground mounted with a buried root upon which the feeder pillar cabinet sits.
6. Cable entry to be from below into the cabinet.
7. Cable glanding plate to be raised above ground level.
8. Cabinet to be IP65 with the door closed. The enclosure rating shall be C5 in compliance with ISO 12944.
9. Unless noted otherwise in the particular specification, schedules and drawings constructed to the form-2b type-2 requirements of BS EN 61439-2.
10. Functional units and protective devices to accord with the requirements noted elsewhere in this document.

B. Fabrication details:

1. Cabinet shall be in compliance with ISO 12944 and constructed from sheet steel with welded Joints and all hot dipped Galvanized to BS EN ISO 1461 after manufacture.
 - a) Cabinet to be plain galvanized or have an applied finish over the galvanizing as required by the particular specification schedules and drawings. Where no particular requirement is given in these documents for the finish, the Contractor shall include for providing a powder coated finish to a color to be agreed with the Engineers.
 - b) Root to be further protected against corrosion by the application of a minimum 3- coats of moisture resistant bitumastic paint.

- c) The Paints being specially selected to adhere to galvanized steel.
 - 1) submit manufacturers and paint suppliers' warranty for the paint and finish.
- 2. Full width and full height cabinet doors:
 - a) Finish to match the cabinet
 - b) Maximum width of each door leaf to be 800mm.
 - c) Each door leaf secured to the cabinet by a minimum of three long-life stainless-steel Hinges
 - d) Door Access control mechanisms shall be agreed with the Engineers or as required by the Particular specification, Schedules and Drawings but is expected to include one of the methods listed below:
 - 1) Try-headed wedge locks
 - 2) Cylinder locks
 - 3) Padlocks
 - e) A Minimum of locks or two padlock positions shall be provided for each door
 - f) Doors to be provided with fixed internal frame for circuit chart (and Circuit chart) to a standard to be agreed with the Engineers.
- C. Electrical requirements:
 - 1. To be suitable for the Electrical supply voltage, Frequency and phases being connected.
 - 2. To include:
 - a) Incoming isolating switch and main bus-bars: to be rated to match the larger of:
 - 1) the current rating noted in the particular specification drawings and schedules
 - 2) the current rating of supplying protective device
 - b) As required by the particular specification schedules and drawings:
 - 1) Outgoing ways
 - 2) Contactors and/or motorized circuit breakers for the control of incoming circuits and/or outgoing circuits.
 - 3) Time Clock(s) for the control of the lighting
 - 4) Photo-cell for the control of lighting
 - 5) Energy Metering.
 - c) Power supplies for the auxiliary control circuits.
- D. Accessories:
 - 1. Signage and labelling:
 - a) Cabinet doors to be fitted with 'Danger electricity' signage.
 - b) Labelling to be provided as noted earlier in this section.

2.11 DISTRIBUTION FEEDER PILLARS

A. General:

1. Provided where required by the particular specification, schedules and drawings for the provision of local supplies to low power equipment's.
2. Comply with latest revision of SEC-SDCS-02, SDMS-01, SDMS-02.
3. Required to have a minimum life of 20 years in the environment in which they are to be installed.
4. The pillar complete with all its fittings and shall be capable of withstanding the effect of solar radiation at their installed location.
5. Submit manufactures warranty.
6. Be ground mounted with a buried root upon which the feeder pillar cabinet sits.
7. Cable entry to be from below into the cabinet.
8. All Insulating materials shall be non-hygroscopic and resistant to tracking and cracking.
9. Proper earthing to be provided.

B. Construction details

1. Shall comply with latest revision of SDMS-02
2. The pillar shall be made of impact proof, heat resistant, self-extinguishing, hot moulded, non-flammable, fiberglass reinforced polyesters with a minimum thickness of 5mm and shall be covered by SASO approved epoxy coating.
3. The pillar shall be free standing type mounted on a fiberglass reinforced base. With a canopy type roof.
4. The access to the pillar shall be from front by means of hinged door fitted with locking mechanism and it shall be openable up to 180 degrees.
5. The finish of the pillar shall be as per landscape architect/Employer requirement.
6. The cabinet base shall comply with DIN-43629.

C. Electrical requirements

1. The bus bar shall be hard drawn high conductivity tinned copper of uniform cross section.
2. The bus bar shall carry a rated normal continuous current of 400 Amps.
3. The bus bar shall be made with minimum possible number of joints.
4. The distribution pillar shall be equipped for minimum of 5 outgoing with NH fuse ways and shall be of size DIN-1 with minimum rated current of 200 Amps.
5. The incoming circuit terminal shall be suitable for fixing Copper or Aluminum cable of size 300mm², 185mm², 70mm², 50mm². The outgoing circuit terminal shall be suitable for fixing Copper or Aluminum cable of size, 185mm², 70mm², 50mm², 25mm² or 16mm².
6. The pillar shall be made of impact proof, heat resistant, self-extinguishing, hot moulded, non-flammable, fiberglass reinforced polyesters with a minimum thickness of 5mm and shall be covered by SASO approved epoxy coating.
7. The strip fuse ways shall have a cable space barrier self-extinguishing and insulated materials.

8. The fuses shall be low loss type in conformity with latest IEC, DIN VDE and DIN recommendation as a minimum requirement.
9. The distribution pillar shall comply with latest revision of SDMS-02.
10. The pillar shall be type tested in an independent testing laboratory for all applicable tests as per SASO-774 and IEC-529.

D. Accessories

1. Signage and labelling.
2. Cabinet doors to be fitted with Danger electricity signage.
3. Labelling to be provided as noted earlier in this section.

2.12 CHANGE-OVER CIRCUIT BREAKERS

A. General:

1. Automatic (Auto C/O) and Non-Automatic (Non-Auto C/O) Change-over circuit breakers shall be provided where indicated in the particular specifications, drawings or schedules.
2. Change over circuit breaker systems up to 800A shall comprise mechanically and electrically interlocked breakers.
3. Change over circuit breakers systems of 800A and above shall comprise mechanically and electrically interlocked Air circuit breakers (ACB's).
4. Unless noted otherwise by the particular specification, drawings and schedules change over systems for non-paralleling operation shall not normally include overcurrent or earth fault protection to the principle circuit breakers.
5. Circuit breakers shall be 2-pole for Single-phase operation and 4-pole for three-phase operation.
6. Change over systems shall be arranged such that both supplies can be isolated and locked-off for maintenance of the current using equipment served and such that both incoming supplies can be independently isolated for separate maintenance of each of those incoming supplies.
7. Each change-over circuit breaker systems shall be complete with N/O and N/C volt free contacts (5A, 240V rated) for remote signaling of:-
 - a) Primary Supply Failed
 - b) Primary supply connected
 - c) Secondary supply failed
 - d) Secondary supply connected
 - e) Primary supply isolated locally
 - f) Secondary supply isolated locally
 - g) Output circuit breaker (where required by the particular specification and drawings) isolated
 - h) Others as required by the particular specification drawings and schedules.

B. Automatic Change-over devices shall:

1. Comprise mechanically and electrically interlocked circuit breakers with motor drives. The Motor drives shall be arranged such that the change-over process remains operational with:-

- a) Only the primary Supply available.
 - b) Only the secondary supply available.
 - c) Both of the primary and secondary supplies available.
 2. Automatically transfer the load to an alternative healthy supply on failure of a previously healthy supply.
 3. Have phase failures on each of the two supplies which shall:
 - a) Monitor each of the supply phase voltages.
 - b) Be able to have their actuation (change-over) levels manually adjusted between 90% and 60% of the nominal supply voltage. Once the voltage has dipped to the set level the phase failure relay shall automatically commence a transfer of the load to the alternative healthy (or healthier) supply.
 4. Where the Change-over devices are required to be Biased towards either one of their healthy supplies this will be as noted in the particular specification drawings and schedules.
 5. Requirements for automatic re-transfer back to a restored primary supply while the secondary supply remains healthy shall be as noted in the particular specification drawings and schedules. Where this requirement is not specifically noted the change-over device shall be provided with:
 - a) Panel mounted push button controls to affect a change-over back to a restored primary supply. The provision of this shall not obviate the requirement for the devices to automatically transfer the load to an alternative healthy supply on failure of a previously healthy supply.
 - b) Facilities to affect a remotely commenced change-over back to a restored primary supply. The provision of this shall not obviate the requirement for the devices to automatically transfer the load to an alternative healthy supply on failure of a previously healthy supply. The facilities to be provided include: -
 - 1) Terminals for wiring out to remote N/O and N/C relay contact pairs (230V 5A rated) such that either opening or closing of the remote contact pairs causes a change-over to the restored primary supply.
- C. Non-Automatic change-over devices shall:
1. Comprise mechanically interlocked Moulded case circuit breakers without over-current or earth fault protection.
 - a) Enable manual transfer of the load to an alternative healthy supply on failure of a previously healthy supply.
 - b) Be arranged such that both supplies can be isolated for maintenance of the current using equipment served.
 - c) Where required by the particular specification schedules and drawings be provided with castell key interlocking to prevent parallel operation of the supplies.
- D. Paralleling
1. Both Auto C/O and Non-Auto C/O devices shall normally be arranged and interlocked (mechanically and electrically) to prevent Parallel operation of the supplies to the current using equipment served by the Change-over device.
 2. Where short term parallel operation of both the primary and secondary supply is required by the particular specification, drawings and schedules then the parallel

operation and the controls, sensing and protection required shall be specifically agreed with the Electrical Supply Authority and any other local authorities having jurisdiction. The controls and protection that is expected to be required include;

- a) Check sync relays to prevent closing of both supply circuit breakers when the supplies are not synchronized.
- b) Protection relays for:
 - 1) Under and over frequency (UF, OF)
 - 2) Under and over voltage (UV, OV)
 - 3) Loss of mains (LOM)
 - 4) Rate of change of frequency (ROCOF)
 - 5) Reverse power (RP)
 - 6) Directional Overcurrent (DOC – for line and bus)
 - 7) Directional Earth Fault (DEF – for line and bus)
- c) Parallel operation timers to open the secondary power source circuit breakers after a pre-set parallel time and to disable the above protection (items 1 to 5 only) when both sources are not paralleled.

E. Construction:

1. Where change-over circuit breakers are incorporated within a main distribution board (MDB) or sub-main distribution (SDB) or power distribution unit (PDU) then the overall factory-built assembly (FBA) shall conform the requirements noted earlier for these
2. Where change-over circuit breakers are not incorporated within a main distribution board (MDB) or sub-main distribution (SDB) or power distribution unit (PDU) the change-over devices and their controls circuits shall be contained in factory-built assemblies of type tested switchgear complying with the general requirements for main distribution boards with:
 - a) a minimum degree of ingress protection to match the highest of:
 - 1) Being suitable for the environment in which it is to be installed.
 - 2) The requirements specified in the particular specification drawings and schedules.
 - b) The fault withstands rating of the Change-over devices and their enclosures shall match the upstream MDB's or SDB's supplying them.

2.13 FINAL DISTRIBUTION BOARDS (FDB)

A. General:

1. The specification hereunder shall be applied to all distribution boards referenced on the Design Drawings/ load schedules as FDBs. The final distribution board shall be:
 - a) Flush or surface mounted as required.
 - b) Have split bus bars as required
 - c) provided with standard extension boxes to allow cable glanding if required.
2. DBs inside electrical rooms shall be surface mounted type fixed onto a U channel support. Surface wall mounted DBs shall be fixed on U channel support and not

direct to the wall.

3. Total assemblies are to be type tested with type test certificate by ASTA or KEMA submitted to the Employer's Representative and Assistants for acceptance.
4. Distribution boards shall be provided with Disconnect switches (isolating switch) or circuit breaker incoming devices as required by the particular specification schedules and drawings.
5. Distribution boards shall be provided with common RCCB's for groups of circuits for as required by the particular specification schedules and drawings.
 - a) As a standard item, all MCB boards shall be provided with permanent circuit identification charts to the acceptance of the Employer's Representative and Assistants.
 - b) ELCBs in each FDB shall be provided as per requirements of the supply authority having jurisdiction without any variation.
 - c) The distribution boards and its breakers shall be from the same manufacturer as the Main Switchboard.

B. Enclosures:

1. The enclosure shall be of folded and bolted construction fabricated out of minimum 1.2mm electro galvanized steel sheet and epoxy powder coated to form a cubicle. Hinged doors shall be provided for access to the operational knobs of the circuit breakers. Closed knock out type openings shall be provided at top, bottom and at the sides for cable glands and conduits.

C. Bus bar

1. The MCBs shall be mounted on either 3 phase or single phase or split bus bars as appropriate. All spaces, which are not provided with breakers, shall be covered with blank plates.
2. A final sub-circuit neutral assembly and an earthing bar assembly shall be available to facilitate the connection of neutral conductors and protective conductors respectively.
3. Bus bars shall be of hard drawn tin-plated copper, fully shrouded by 2 No. layers of high impact polypropylene materials isolating the main bus bar from branch bus bars with IP20 minimum degree of protection and rated at 125A as required by the schedules or on the Design Drawings. The minimum withstand short circuit shall be not less than (9 or 10kA) for 1 sec. Rated insulation voltage shall be not less than 690V (AC).

D. Breakers Generally

1. MCB's, RCBO's and RCCB's shall be provided as indicated in the Particular specification, drawings and schedules.
2. All circuit breakers shall be factory calibrated to ambient temperature of 50°C.

2.14 DIGITAL MULTIFUNCTION METERING SYSTEMS

- A. Digital multifunction metering system complete with all CTs and VTs for customer's use shall be installed and factory wired in locations in each switchboard as indicated in the particular specification, drawings and schedules.
- B. All VT secondaries shall be for LV and all CT secondaries shall be 5A.
- C. The Metering system shall be an integrated micro-processor-based multifunction metering package, capable of displaying:

1. Line and phase volts (V).
 2. Line Current (A).
 3. Power factor (Cos F).
 4. Frequency (Hz).
 5. Kilovolt amperes (KVA).
 6. Kilovolt amperes reactive (KVAR).
 7. Kilowatt hours (KWH).
 8. Neutral current (A).
- D. A standard banana jack test block shall allow testing of the meters by injecting 230V and 5A while the phase display indicates T. 3
- E. Set point N/O and N/C Contacts shall be provided for the purpose of load shedding or alarm with each being field programmable to suit the Employer requirements.
- F. The meter shall be designed to include provisions for communication with external monitoring devices via an RS 232F port.
- G. The digital metering system and associated software shall be supplied by the switchboard manufacturer.
- H. The Contractor shall include for all hardware and software as required and recommended by the digital meter manufacturer for remote monitoring at the PMS terminals.

2.15 DISCONNECT SWITCHES (ISOLATING SWITCHES AND ISOLATORS)

- A. Disconnect switches (isolators or isolating switches) shall be manufactured to IEC and British standards.
- B. Disconnect switches shall be heavy duty (AC23 at the rated current indicated by the particular specification, drawings or schedules) with operating handle interlocked with the switch cover.
- C. Disconnect switches:
1. Used in internal conditioned spaces shall be Contained in general purpose rust proofed steel enclosures to IP44 finished in grey stove enamel.
 2. Switches mounted outside, in damp or dusty locations and unconditioned areas shall be supplied in weather resistant enclosures IP 65 made of aluminum with double wall construction.
- D. Switches shall be quick make, quick break action. Provision shall be made for padlocking in either the "On" or "Off" position.
- E. Switch blades shall be fully visible when in the "Off" position.
- F. Operating handles shall be interlocked to prevent doors from being opened when switch is closed. Provision shall be made to defeat this interlock with a screwdriver.
- G. Fuse clips shall be designed for HRC BS 88/ IEC 60269 -1 fuses without adapters and shall reject standard code fuses. Isolating switches shall have their fuse-ways linked out by suitable rated solid copper links.
- H. Sample and catalogues with installation details shall be submitted for acceptance by the Employer's Representative and Assistants, prior to ordering.
- I. Provide a disconnect switch ahead of all motors, starters and electrical equipment were indicated on the Design Drawings and where required to meet Code regulations and

Statutory Authorities, whether the equipment is supplied or installed under the Division 26 Electrical Work Sections or any other Division of the Performance Specification.

- J. All disconnect switches shall be provided with label to the Employer's Representative and Assistants acceptance to indicate equipment connected to the switch. The feeding circuit reference and the related distribution board number.

2.16 FUSED SWITCHES

- A. Fused switches shall be manufactured to IEC and British standards.
- B. Fused switches shall be heavy duty (AC23 at the rated current indicated by the particular specification, drawings or schedules) with operating handle interlocked with the switch cover.
- C. Fused switches:
 - 1. Used in internal conditioned spaces shall be Contained in general purpose rust proofed steel enclosures to IP44 finished in grey stove enamel.
 - 2. Switches mounted outside, in damp or dusty locations and unconditioned areas shall be supplied in weather resistant enclosures IP 65 made of aluminum with double wall construction.
- D. Switches shall be quick make, quick break action. Provision shall be made for padlocking in either the "On" or "Off" position.
- E. Switch blades shall be fully visible when in the "Off" position.
- F. Operating handles shall be interlocked to prevent doors from being opened when switch is closed. Provision shall be made to defeat this interlock with a screwdriver.
- G. Fuse clips shall be designed for HRC BS 88/ IEC 60269 - 1 fuses without adapters and shall reject non-standard fuses.
- H. Sample and catalogues with installation details shall be submitted for acceptance by the Employer's Representative and Assistants, prior to ordering.
- I. Provide a switch ahead of all motors, starters and electrical equipment were indicated on the Design Drawings and where required to meet Code regulations and Statutory Authorities, whether the equipment is supplied or installed under the Division 26 Electrical Work Sections or any other Division of the Performance Specification.
- J. All Fused switches shall be provided with label to the Employer's Representative and Assistants acceptance to indicate equipment connected to the switch. The feeding circuit reference and the related distribution board number

2.17 MOTOR STARTERS

- A. Description
 - 3. Starters shall be manufactured, and type tested in accordance with IEC 60947-4-1
 - 4. Motors not being provided with Inverter drive speed control shall be provided with heavy duty contactor type motor fuse-less starters selected for coordination type 2 in accordance with IEC 60947-4-1 generally complying with the following and protected through circuit breaker.
 - a) 3KW direct on line starting.
 - b) 3KW to 25KW Star Delta starting.
 - c) 25KW and above reduced voltage electronic soft starters.
 - 5. Each starter panel shall be provided with a main incoming MCCB capable of carrying the full load current.

6. Each starter shall comprise as a minimum:
 - a) On load triple pole MCCB with 2 No. normally open and 1 No. normally closed auxiliary switches. The MCCB to be mechanically interlocked with the starter component door and capable of breaking the motor starting current and of making onto a fault at the motor terminals.
 - 1) Provision to be made for padlocking the MCCB in the 'OFF' position.
 - b) 3 No. pole contactors to be fitted with 3 No. normally open and 3 No. normally closed auxiliary contacts.
 - 1) All the auxiliary contacts to be wired down to the starter terminal block.
 - c) 1 No. triple pole thermal over current relay incorporating over current, phase sequence and single-phase protection with adjustable trip settings.
 - 1) External mechanical hand reset to be provided.
 - 2) 1 No. control circuit MCB or fuse and 1 No. copper link.
 - d) Each starter shall be fitted with 1 No. set of local start/ stop push buttons and a local/ remote/ auto selector switch or hand/ off/ auto switch as required. Each starter control wiring terminal block shall include control terminals for connection of remote push buttons, auto circuits and local and remote emergency stop push buttons.
 - e) Where more than one motor with a duty/ standby or duty/ backup functions used, the starter control wiring shall be arranged to automatically change duty upon the fault tripping of the selected motor. A duty/ standby or sequence selector switch shall be provided.
 - f) Each starter shall be fitted with twin led indication lamps indicating:
 - 1) Motor running (green).
 - 2) Motor stopped (red).
 - 3) Overload tripped (amber).
 - g) Each starter shall be fitted with an ammeter and selector switch for motors 3 KW and above.
 - h) Each starter to be equipped with labels in English and Arabic giving drive designation, plant number and control operation.
 - i) Each starter control wiring shall include control terminal and control relays as necessary to achieve any interlocking indicated elsewhere or to achieve any control or monitoring through the PMS where indicated.
 - j) Adjustable time delay devices for Star Delta Starters.
 - k) Earth leakage relays as required by the supply Authority having jurisdiction.
7. Starter units for manual operation shall have push buttons for starting and stopping, together with auxiliary contacts for remote indicator lights where indicated. Starter units arranged for automatic operation shall have hand/ off/ auto controls and remote push buttons.
8. All Star Delta starters shall be provided with mechanical and electrical interlocks for star delta contactor assembled to prevent short circuiting.

B. Enclosure

1. Panels shall be constructed of a minimum 1.6mm thick electro galvanized steel coated with high solid enamel polyester electrostatic spray and oven baked and protected to IP54.
2. Front access shall be arranged for all panels with hinged lift off doors.
3. Dust and damp-proof gasket around the edge and fitted with lockable cam type chromium plated handle mechanically interlocked with the starting MCCB.
4. The enclosures for the motor starters are divided into 2 No. types as follows:
 - a) Single starter panel.
 - b) Motor control center.
5. Single starter panel
 - a) This specification shall be applied for starter panels used for starting a single equipment with a maximum of 2 No. motors.
 - b) All equipment shall be mounted on sheet steel mounting plate with screws into tapped holes and all live parts shall be shrouded to a minimum IP54.
 - c) The minimum short circuit rating for the different components shall be 25kA. However, the Contractor shall forward a short circuit calculation and upgrade the same if found necessary.
6. Compensated Equipment
 - a) Any motorized valve or damper controlled via a compensated system, shall be arranged such that a manual selector switch is provided to override compensated selection and enable manual opening/ closing or on/ off control, as appropriate. Any compensator unit mounted within the control cabinet shall remain in the manufacturer's purpose made enclosure and be installed strictly in accordance with the manufacturer's recommendations.

2.18 AIR CIRCUIT BREAKERS (ACB)

A. General

1. The circuit breakers shall be in accordance with IEC 60947-2, 3pole or 4pole as mentioned in the single line diagram. However, the incomer and bus coupler ACBs shall be of 4 poles.
2. The breaking capacity performance certificates shall be available for category B to the abovementioned standards. The test shall be carried out with a breaking performance during operation (Ics) equal to the ultimate breaking capacity (Icu).
3. All circuit breakers can be reverse fed without reduction in performance.
4. Breaker shall be equipped with a grounding device to solidly ground the framework before the main disconnecting contacts are engaged and to maintain the grounding until after the contacts have separated.
5. Circuit breakers shall be of the draw-out type with 3 positions for 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.
 - a) Mechanical indication on the front of the ACB shall be provided to indicate:
 - b) Main contacts closed 'on'.
 - c) Main contacts open 'off'.

- d) Springs charged.
 - e) Springs discharged.
 - f) Service position.
 - g) Test position.
 - h) Isolated position for draw-out mechanism.
6. The incoming air circuit breakers shall have manually and electrically operated spring charge mechanism while the outgoing air circuit breakers shall, unless required otherwise by the particular specification schedules and drawings, be manually operated.
 7. Any attempt to withdraw or insert the breaker when it is 'on' shall trip the breaker automatically. Interlocking shall be provided to prevent insertion of a circuit breaker having a rating higher than the current rating of the ACB cradle.
 8. It shall be possible to draw-out the circuit breaker with the switchboard door closed.
 9. Insulated safety shutters shall screen all live parts in the ACB cradle when the breaker is in the isolated or racked out position.
 10. 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.
 11. Breaker trips shall be completely self-powered with no external control power source required. If external control power is required, 110V D.C. batteries and charger shall be provided. Batteries to be Ni-cad type.
 12. Breakers shall be provided with adjustable releases for overload, short circuit and earth fault protection and have the following functions:
 - a) Adjustable long-time delay trip.
 - b) Adjustable short time delay trip.
 - c) Adjustable Instantaneous trip.
 - d) Selectable Ground fault trip.
 13. Breakers shall also be provided with other protection and control functions as required by the particular Performance Specification, schedules and drawings.
 14. Breakers shall be suitable for operating at 50°C ambient temperature and shall be tropicalized.

B. Construction

1. The air circuit breaker ratings shall be as indicated on the single line diagram.
2. All air circuit breakers main contact shall be encased in a reinforced polyester casing and offer double insulation from the operators on the breaker front face. The circuit breaker also shall offer total insulation between the control part and the power part.

C. Operating Mechanism

1. The operating mechanism shall be the O-C-O stored energy spring type motor/ manually operated as indicated on Design Drawings with a closing time of less than or equal 80msec.
2. Each breaker shall be provided with 3 nos. normally open and 3 nos. normally

closed potential free spare auxiliary contacts rated 10A at 240V AC.

D. Arc Chutes

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

E. Electrical Auxiliaries

1. All electrical auxiliaries including the motor spring charging mechanism shall be field adaptable without adjustment or the necessity for any tool (except a screwdriver).
2. Breaker Mounted Trip Unit
 - a) Each air circuit breaker shall be equipped with a solid-state tripping system consisting of 3 No. current sensors, microprocessor-based trip device and low energy trip actuator.
 - b) Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating a trip signal to the circuit breaker trip actuator when predetermined trip levels and time delay settings are reached. Interchangeable Current Sensors with its associated Rating Plug shall establish the continuous trip rating of each circuit breaker.
 - c) The Bus Coupler ACB shall Normally be equipped with dummy trip unit and shall not have any trip functions unless a de-rating of the bus bar has been specified on one side or the other.
 - d) The trip unit shall have an information system that provides LED's to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip.
 - e) A reset button shall be provided to turn off the flashing LED indication after an automatic trip.
 - f) The Trip Unit shall be provided with a display panel, including a representation of the Time/ Current curve of the trip unit that indicates the protection function settings. The unit shall be continuously self-checking and provide a visual indication that the internal circuit is being monitored and is fully operational.
 - g) Complete system selective coordination shall be provided by the addition of the following individually adjustable Time/ Current curve shaping solid state elements:
 - 1) All breakers shall have adjustments for long delay pickup and time.
 - 2) Main Incoming and Feeders ACBs shall have individual adjustments for short delay pick-up and time and include I²t settings.
 - 3) Main Incoming and Feeders ACBs shall have an adjustable instantaneous pick-up.
 - 4) When indicated on the drawing circuit breakers shall have individually adjustable earth fault current pick-up and time and include I²t settings and earth fault alarm only.
 - h) The Trip Unit shall be provided with a making-current release circuit. The circuit shall be armed for approximately 8 No. cycles after breaker closing and shall operate for all fault levels above 15 times the ampere value of the current sensor.

- i) Trip Units shall have selectable thermal memory for enhanced circuit protection.
- j) There shall be an optional display. This display shall show phase, neutral and earth sensors and high phase current. The accuracy of these readings shall be + 2% of full scale.
- k) A time delay shall be provided to avoid nuisance alarms.
- l) The microprocessor-based trip unit shall have both powered and un-powered thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession.
- m) The Trip Unit shall provide zone interlocking for the short time delay and earth fault delay trip functions for improved system coordination.
- n) The zone interlocking system shall restrain the tripping of the upstream breaker and allow the breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the pre-set time delay.
- o) Blocking facilities shall be provided as standard on ACB's to assist with protective device grading by the inhibiting of upstream protection where fault currents pass through the down-stream devices. The actual use of such blocking schemes shall however be expressly agreed with the Engineers prior to implementation.

F. Auxiliaries and Accessories

- 1. 1 No. ammeter and voltmeter with selector switch.
- 2. Operation counter.
- 3. ON/ OFF/ Fault/ Control Circuit fault indication light with lamp test facilities.

2.19 MOULDED CASE CIRCUIT BREAKERS (MCCB)

A. General

- 1. Moulded case circuit breakers shall conform to the latest editions of IEC 60947.
- 2. MCCB's shall be fixed pattern or plug-in as required by the switchboard descriptions noted herein and as required by the particular specification drawings and schedules.
- 3. MCCB's shall be complete with manual operating handles or with Motor driven operating units as required by the particular specification, drawings and schedules and as described hereinafter.
- 4. Rated service short-circuit breaking capacity (ICS) to be, as a minimum,
 - a) Equal to the short circuit rating of the switchboard in which they are installed.
 - b) Equal to the short circuit rating of the upstream switchboard from which they are supplied when not installed in a switchboard.
- 5. Rated Ultimate Short-Circuit breaking capacity (ICU) to be equal to or higher than ICS.
- 6. MCCB's shall be of the heavy-duty quick make quick break type. Each breaker shall have adjustable type thermal over current and magnetic release and also an instantaneous magnetic trip.

7. Two-pole, Three-pole and four-pole breakers shall have common trips with a single operating handle and be designed ensuring that any overload in one pole automatically causes all poles to open. Breakers shall be trip-free, and each shall have a trip indication independent of ON or OFF positions.
8. The MCCB's shall be provided with the necessary number of change-over auxiliary switch contacts and with a signaling unit which shall be connected to the PMS system in order to provide alarms and information on the breaker's conditions.
9. Plug-in type MCCB's shall be provided with safety shutters to cover the live parts when the breaker is withdrawn.
10. Wherever indicated on the Design Drawings or required by the supply Authority having jurisdiction, MCCBs shall be provided with earth leakage alarm relay or earth leakage relay of fixed/ adjustable sensitivity.
11. 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.

B. Construction

1. 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.
2. The operating mechanism of the moulded-case circuit breakers shall be of the quick make, quick-break type with fault tripping over riding manual or motor operation. All poles shall operate simultaneously for circuit breaker opening, closing and tripping.
3. The moulded-case circuit breakers shall be front operated by a toggle or handle that clearly indicates the 3 No. positions: ON, OFF and TRIPPED.
4. The moulded-case circuit breakers shall be equipped with a "push to trip" button in front to test operation and the opening of the poles.
5. Where required, motor operated mechanism, shunt trip, under voltage release, auxiliary switches up to 4 No. changes over contacts and a tripped signal contact shall be provided. Each of these units shall incorporate a pre-wired terminal strip, which is accessible from the front of the breaker without removing the cover.

C. Current Limiting

1. The moulded case circuit breakers shall be capable of limiting currents.
2. These characteristics shall enable cascading performance with other moulded-case or miniature circuit breakers.

D. Protection Function General Recommendations

1. Moulded case circuit breakers with ratings up to 250A shall be equipped with interchangeable Thermal-magnetic trip units when used in MDB's and non-interchangeable thermal-magnetic trip unit when used in SDB's and DB's.
2. Moulded case circuit breakers with ratings over 250A shall be equipped with electronic trip units.
3. The trip units shall not augment overall circuit breaker volume.
4. Electronic trip units shall be in accordance with appendix F of IEC 60947-2 standard (measurement of RMS current values, electromagnetic compatibility, etc.).

5. Electronic and interchangeable thermal-magnetic trip units shall be adjustable, and it shall be possible to fit lead seals to prevent unauthorized access to the settings.
 6. Protection settings shall apply to all circuit breaker poles.
- E. Auxiliaries and Accessories
1. The addition of motor mechanism or a rotary handle shall in no way affect circuit breaker characteristics.
 2. 48V dc motor mechanisms shall be used unless expressly required otherwise by the particular specification drawings and schedules. These shall derive their operating voltage from dedicated Battery backed power supply units located in the main switch rooms.
 3. Only 3 No. stable tripping mechanism positions (ON, OFF and TRIPPED) shall be possible with the motor mechanism.
 4. Suitability for isolation shall be provided by positive contact indication (ON and OFF) in front of the motor mechanism module.
 5. The moulded case circuit breakers shall be designed to enable safe on-Site installation of auxiliaries such as voltage releases (shunt and under voltage releases) and indication switches.
 6. The addition of a motor mechanism, module or a rotary handle, etc., shall not mask or block device setting.
 7. It shall be possible to equip the moulded case circuit breakers with devices indicating faults without tripping the circuit breaker.
 8. Provide 2 NO and 2 NC spare contacts.

2.20 MINIATURE CIRCUIT BREAKERS (MCB):

- A. General:
1. in accordance with BS EN 60947-2
 2. Rated service short-circuit breaking capacity (ICS) to be minimum of 10kA.
 3. Rated Ultimate Short-Circuit breaking capacity (ICU) to be at least 20kA.
 4. Of modular design (17.5mm-18mm module) and available in one, two, three or four pole versions.
 5. Symmetrical DIN-rail mounted type
 6. Be able to be reverse fed without reduction in performance or protection.
 7. Be in accordance with IEC 60898-1.
 8. Be factory calibrated to an ambient temperature of 50°C.
- B. Construction:
1. The operating mechanism shall be mechanically trip-free from the operating handle:
 - a) to prevent the contacts from being held closed against short circuit conditions.
 - b) of the "automatic resetting type" such that it can be manually re-closed after the operating handle has been moved into the tripped position.
 2. The individual operating mechanism of each pole of a multi-pole MCB shall be directly linked within the MCB casing and not by the operating handles.

3. The operating handle shall be of the toggle type.
4. Each pole shall be provided with bi-metallic thermal element for overload protection and magnetic element for short circuit protection.
5. Terminals shall be of the tunnel type (IP20) in order to minimize the risk of direct contact.

2.21 RESIDUAL CURRENT CIRCUIT BREAKERS WITH OVERLOAD PROTECTION (RCBO)

A. General:

1. Rated service short-circuit breaking capacity (ICS) to be minimum of 10kA.
2. RCBO's shall be in accordance with BS EN 61009 providing protection against earth leakage, overload and short circuit protection.
3. RCBO's shall be used wherever indicated on the load schedules and whenever requested by the supply Authority having jurisdiction.
4. RCBO's shall have 30mA sensitivity with type B tripping characteristic for power circuits and 100mA sensitivity with type C tripping characteristic for lighting and inductive load circuits.
5. For three phase circuits a three-pole circuit breaker with residual current device clipped to the side of the breaker can be used. The tripping characteristic shall be similar to what is described above.
6. Rated Ultimate Short-Circuit breaking capacity (ICU) to be at least 20kA.
7. Of modular design (17.5mm-18mm module) and available in one, two, three or four pole versions.
8. Symmetrical DIN-rail mounted type
9. Able to be reverse fed without reduction in performance or protection.
10. In accordance with IEC 60898-1.
11. Factory calibrated to an ambient temperature of 50°C.
12. Include a test button for testing the Residual current aspects of the circuit breaker

B. Construction:

13. The operating mechanism shall be mechanically trip-free from the operating handle:
 - a) to prevent the contacts from being held closed against trip conditions.
 - b) of the "automatic resetting type" such that it can be manually re-closed after the operating handle has been moved into the tripped position.
14. The individual operating mechanism of each pole of a multi-pole MCB shall be directly linked within the MCB casing and not by the operating handles.
15. The operating handle shall be of the toggle type.
16. Each pole shall be provided with bi-metallic thermal element for overload protection and magnetic element for short circuit protection.
17. Terminals shall be of the tunnel type (IP20) in order to minimize the risk of direct contact.

2.22 RESIDUAL CURRENT CIRCUIT BREAKERS (RCCB)

C. General:

1. RCCB's shall be in accordance with BS EN 61008 providing the functions of isolation, switching and earth leakage protection of electrical circuits.
2. The RCCB's shall have a residual current operated electro mechanical release.
3. The RCCB's shall incorporate a filtering device to eliminate unwanted tripping due to transient voltage.
4. A trip free mechanism is required to ensure that the unit cannot be held closed against an earth fault.
5. The tripping device is connected directly to the secondary of the current balance transformer.
6. No amplifiers or rectifiers are to be used.
7. Rated service short-circuits breaking capacity (ICS) to be minimum of 10kA.
8. Rated Ultimate Short-Circuit breaking capacity (ICU) to be at least 20kA
9. of modular design (17.5mm-18mm module) and available in one, two, three or four pole versions.
10. symmetrical DIN-rail mounted type
11. be factory calibrated to an ambient temperature of 50°C.
12. Be equipped with a test button to test the operation of the residual current circuit breaker.
13. The RCCB's shall have 30mA or 100mA sensitivity as indicated in the Design Drawings.
14. The breaker shall be double pole when used for single phase and 4 poles when used for three phase circuit protection.

2.23 CONTACTORS

A. All contactors shall be in accordance with IEC 60947-1, IEC 60947-4.

B. Utilization category for contactors shall be:

1. AC1 - non-inductive or slightly inductive loads, resistance furnaces
2. AC2 - Slip-ring motors: starting, switching off
3. AC3 - Squirrel-cage motors: starting, switching off motors during running
4. AC4 - Squirrel-cage motors: starting, plugging, inching
5. AC5a - Switching of electric discharge lamp controls
6. AC5b - Switching of incandescent lamps
7. AC6a - Switching of transformers
8. AC6b - Switching of capacitor banks
9. AC7a - Slightly inductive loads in household appliances and similar applications
10. AC7b - Motor-loads for household applications
11. AC8a - Hermetic refrigerant compressor motor 2) control with manual resetting of overload releases

- C. Where specific rating is given for Contactors, these shall be the ratings at the applicable utilization category
- D. Contactors shall:
 - 1. Be protected against direct finger contact,
 - 2. Have a mechanical life of 15 to 20 million operating cycles.
 - 3. Be suitable for 1200 operating cycles per hour.
- E. The contactors shall be of 1, 2, 3 or 4 pole construction capable of handling high rush currents and suitable for operating in the expected ambient temperature without any de-rating.
- F. Coils shall operate at between 85% to 100% of the nominal voltage.

2.24 METERS AND METERING

- A. Generally
 - 1. Meters (indicating instruments) shall be provided as indicated in the schematic diagram.
 - 2. KWh meters shall be to the acceptance of the Supply Authority having jurisdiction.
 - 3. All meters (indicating instruments) shall be of class 1.5.
 - 4. Instruments shall be temperature compensated to operate between -25°C and + 55°C and shall be tropical version.
 - 5. All meters shall be in accordance with IEC 62055-51.
- B. Digital Multifunction Metering Systems:
 - 1. A digital multifunction metering system complete with all CTs and VTs for customer's use shall be installed and factory wired in locations in each switchboard as indicated herein and as indicated in the particular specification, drawings and schedules.
 - 2. All VT secondary's shall be for LV and all CT secondary's shall be 5A.
 - 3. The Metering system shall be an integrated micro-processor-based multifunction metering package, capable of displaying:
 - a) Line and phase volts (V).
 - b) Line Current (A).
 - c) Power factor (Cos F).
 - d) Frequency (Hz).
 - e) Kilovolt amperes (KVA).
 - f) Kilovolt amperes reactive (KVAR).
 - g) Kilowatt hours (KWH).
 - h) Neutral current (A).
 - 4. A standard banana jack test block shall allow testing of the meters by injecting 230V and 5A while the phase display indicates T. 3
 - 5. Set point N/O and N/C Contacts shall be provided for the purpose of load shedding or alarm with each being field programmable to suit the Employer requirements.
 - 6. The meter shall be designed to include provisions for communication with external monitoring devices via an RS 232F port.

7. The digital metering system and associated software shall be supplied by the switchboard manufacturer.
8. The Contractor shall include for all hardware and software as required and recommended by the digital meter manufacturer for remote monitoring at the PMS terminals

2.25 CURRENT TRANSFORMERS (CT)

- A. Current transformers shall be in accordance with IEC 61869-2 and the current requirements of the supply Authority having Jurisdiction.
- B. The conditional ratings of current transformers shall correspond with the switchboard rating and shall be such as to maintain the overall metering accuracy and as is necessary to operate relays within the tolerances specified by the manufacturer.
- C. Current transformers secondary ratings shall be:
 1. For protection = 1A.
 2. For metering = 5A.
- D. Current transformers shall have the following accuracy as a minimum, for protection Class 5P (Except for REF Protection which will have PS class CT).
 1. For indication Class 1.
 2. For metering Class 1.
- E. The manufacturer shall ensure that the current transformers are such that the relays shall operate correctly when set at any point within their ranges.
- F. Current transformers secondary wiring shall be earthed on one side through a removable link. Where current transformers are connected in star, the star point shall be earthed through a removable link.
- G. Shorting links shall be provided for each current transformer.
- H. Current transformers shall be cast resin insulated.

2.26 VOLTAGE TRANSFORMERS (VT)

- A. Voltage transformers shall be in accordance with IEC 61869-5.
- B. Voltage transformers shall be suitable in rating and accuracy for their functions, loads and duties.
- C. As a minimum they shall have following accuracy.
 1. Protection applications Class 5P.
 2. Indication and metering applications Class 1.
- D. The primary and secondary circuits of the voltage transformers shall be protected by fuses and the secondary winding shall be earthed at one point through a removable link.
- E. Voltage transformers shall be cast resin insulated.
- F. The manufacturer shall provide MCBs with auxiliary contacts or alternatively 4-pole MCBs on the secondary side of the voltage transformers.

2.27 TIME SWITCH CONTROLLERS

- A. Each time switch shall be of the quartz movement type with minimum 24-hour battery

reserve or operated by a 230-volt synchronous motor and of the type incorporating separate motor supply and control switch terminals and be with a minimum of a 24-hour self-winding clockwork spring reserve.

- B. Unless more sophisticated operation is indicated elsewhere, then each time clock shall be capable of 2 No. 'on' and 2 No. 'off' operations every 24-hour period. Also, any control time switch incorporated within panels, shall be complete with an associated bypass selection facility to manually override 'on/ off'.

2.28 OVERLOAD RELAYS

- A. These are to be used in conjunction with motor starters to provide protection against overloads, phase sequence, phase failure (single phasing) and under voltage conditions.
- B. The relays shall be selected such that the full load current of the equipment protected falls at the center of the relays adjustment range.
- C. In case of Star Delta starter, the overload relays shall be placed on the main's contactor.
- D. Thermal overload relays shall be used for motors ratings, up to and including 11kW, giving protection against:
 - 1. Over -current unbalance.
 - 2. Single phase.
 - 3. Earth fault.
- E. For motors rated above 11KW, multi-functional relays shall be used. Multi-functional relays include protection, metering, control, monitoring and annunciating functions. It is envisaged that the following functions are available.
 - 1. Overload.
 - 2. Over-current.
 - 3. Single phase.
 - 4. Earth fault.
 - 5. Under voltage.
 - 6. Over voltage.
 - 7. Plus, digital indication of:
 - a) Relay settings % of FLC that the motor is taking.
 - b) Continuous monitoring of thermal capacity of motor.
 - c) Thermal capacity used during start of motor.
 - d) If tripped, how much time before restart to take place.
 - e) Stall or short circuit trip.
 - f) Earth fault trip.
 - g) Starting.
- F. All motor overhead relays shall include a manual resetting facility.

2.29 CONTROL RELAYS

- A. Shall be of the encapsulated plug-in type and incorporate visual indication that the operating coil is energized.
- B. Bases for relays shall be mounted horizontally, to ensure relay is vertical above the base when

the control cabinet is in its intended location, with screw type terminals, suitable for receipt of spade type crimped/ soldered lugs.

- C. Adjustable timer delay relays used for the star delta starter shall ensure precise reproducibility of the timing function. The relay shall have a linear setting scale over a 350° rotation by means of knurled knob with timing guide marks. The relay shall be equipped with 2 No. electrically separated time delayed contact 1 No. normally open and 1 No. normally close.

2.30 INDICATION LAMP

- A. These are generally used to indicate main's presence, run, trip and fault and to give fault alarm or indicate any other function.
- B. Indicator lamps shall be of the low voltage 24-volt transformer with twin LED lamp type and accord with the signaling colors laid down in BS 4099.
- C. Minimum lens diameter shall be 12.5mm and all lenses on a panel shall be of a matching size and appearance and removable from the front for lamp replacement.
- D. Terminations shall be screw grip to receive spade type crimped/ soldered lugs.

2.31 SELECTOR SWITCH

- A. They shall be of the complete rotary cam type rated to suit item controlled and fitted with pointer type switching knob. Terminations shall be screw grip to receive spade type crimped/ soldered lugs.
- B. Hand off auto selection switch shall have 3 No. positions with center position off and shall be key operated wherever necessary.
- C. Selector switch when used along with the voltmeter it shall have 8 positions, i.e. phase to phase, 3 phase and 2 off position.

2.32 ACCESSORIES

- A. Furnish the following accessories.
 1. Set of extension rails, if required.
 2. Hoisting device for removing breakers.
 3. Set of test plugs.
 4. Levering out device, if required.
 5. Manual maintenance closing lever, for electrically operated breakers.
 6. Set of special tools and hardware.

2.33 BATTERY BACKED POWER SUPPLIES

- A. Where battery backed power supply units are provided to give motorized circuit breakers the ability to be opened and closed under mains failure conditions they shall accord with the following:
 1. Be suitable for a low voltage electrical supply from the small power circuits in the vicinity of the switchboard.
 2. Be suitable for operating the circuit breaker motors
 3. separate units shall be provided for each switchboard and shall be sized to enable all of the controlled breakers to be opened and closed 8-times without recharging

the batteries.

4. Comprise an enameled sheet steel ventilated enclosure with indication lights:
 - a) Green supply healthy
 - b) Red supply failed.
5. Include monitoring of the following with alarm outputs to the PMS:
 - a) Incoming power supply
 - b) Outgoing power supply (to the motors)
 - c) Battery discharge state
6. Ammeters shall be provided to show the state of charge of the batteries
7. Details of the battery proposed battery packs shall be submitted to the Engineers for approval.

2.34 RISER DIAGRAMS

- A. Provide to the Employer 2 No. framed as-built single line diagrams of the electrical distribution systems.

2.35 RUBBER MATS

- A. Rubber mats complying with BS EN 61111 shall be provided to the requirements of the Electrical Authority Having Jurisdiction and as a minimum in front and where practicable behind all switchboards.
- B. The rubber mats shall extend the full length of the switchboard and shall be a minimum of 1.2m wide or where this is not practicable as wide as the space permits.
- C. The rubber mats shall be selected for the operating voltage of the switchboard and shall be visibly labelled in accordance with BS EN 61111.

2.36 WARNING NOTICES, LABELLING AND SHOCK NOTICES

- A. Electrical warning notices shall be provided to the requirements of the Electrical Authority Having Jurisdiction and as a minimum:
 1. Where parts of an electrical installation are accessible or visible to the general public:
 - a) Except those parts which are intended for the use of the general public
 2. Where multiple sources or supplies are provided into a single item of equipment, enclosure etc.
 3. Where three phase socket outlets are used
 4. Where multiple phases are installed in a single lighting switch.
 5. Where sensitive electrical and electronic equipment is supplied from the systems and where such equipment may be damaged by routine testing
 6. on each the access covers for live bus-bars and other un-insulated components for all items of switch gear
- B. Labelling shall be provided to the requirements of the Electrical Authority Having Jurisdiction and as a minimum:
 1. On both the AC and DC disconnecting switches for PV installations

2. On equipment and systems that are owned and operated by Third parties and/or the supply Authority having jurisdiction
 3. On all switch boards and distribution boards noting the recommended date for the next periodic inspection
- C. Electrical shock treatment notices shall be provided to the requirements of the Electrical Authority Having Jurisdiction and as a minimum:
1. In all electrical switch rooms
 2. Adjacent to plug-in bus bar systems at maximum 2.0m centers.

3. EXECUTION

3.01 INSPECTION

- A. Examine the rooms, areas and conditions under which the main or sub-main LV switchgear/distribution boards are to be installed and correct any unsatisfactory conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.
- B. Agree with the manufacturer of the LV switchgear/distribution boards, the suitability of the civil works for foundations which shall be compatible with equipment. All sizes and details shall be checked and confirmed before concrete is poured or revised with the approval of the Engineer where necessary. It is the contractor's sole responsibility to supply all materials, to construct the required concrete base in the correct location and to the specified dimensions, level and grade and to connect all incoming and outgoing cables.

3.02 VERIFICATION OF CONDITIONS:

1. Examine areas for compliance with requirements for installation and conditions affecting performance of the Work.
2. Identify conditions detrimental to a proper and timely completion and notify the Employer's Representative and Assistants of the unsatisfactory conditions.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION OF SWITCHBOARDS

- A. Generally:
 1. Install switchboards as noted on the Design Drawings. Ensure sufficient access for servicing and maintenance. Switchboard shall be provided at the base with 100mm reinforced plinth.
 2. Ensure switchboard floors are flat, even and within the tolerances recommended by the manufacturer of the switchboards.
- B. Over trenches
 1. Provide support steel work across trenches for the switchboards as recommended by the manufacturer of the switchboard.
- C. Bolting together on site
 1. In case of local re-assembly of switchboards, the authorized/approved assembler shall strictly follow the guidelines and standards laid down by the manufacturer and the Type Test Certificate which is issued by ASTA or KEMA for the authorized assembler for the supplied product.

3.04 INSTALLATION OF FINAL CIRCUIT DISTRIBUTION BOARDS

- A. Support cabinets and enclosures independent of connecting conduit and accurately install with reference to wall finishes.
- B. The Contractor shall include for all necessary brackets, angle iron frameworks, supports, etc., for fixing of panel boards. The Contractor's attention is specifically drawn in this respect to the need for frameworks where panel boards are mounted on dry lining stud partitions, where support frames shall fix to and span between, vertical steel supports to partition lining.
- C. Equip panel boards with suitable lugs or provisions to accommodate the main and branch conductors scheduled.
- D. Turn over to the Employer upon acceptance of the project, 2 keys for every lock complete with key rings, tags and key cabinets to the Engineer's acceptance.
- E. Where 2 or more panel boards are installed in 1 No. cabinet, equip the panel board with double lugs and increase gutter capacity to accommodate additional cabling. Busbars shall be rated for the combined current carrying capacity of the panel boards.
- F. On all flush mounted panel boards stub 2 - 50mm empty conduits into ceiling space above panel board.
- G. Complete all panel board circuit directories to the Engineer's acceptance.
- H. Fill in panel board directories using a typewriter, to identify circuits. Panel board directory shall be laminated and kept in a secure transparent pocket fixed to the interior of the board door.

3.05 ON SITE TESTING OF SWITCHBOARDS, PANEL BOARDS AND DISTRIBUTION BOARDS

- A. Inspection Testing
 - 1. Include in the tender price the cost of on-Site engineering inspection and testing of the following main distribution equipment.
 - a) Switchboards.
 - b) Distribution Equipment.
 - 2. This engineering inspection and testing shall be done prior to the system being energized and shall include the following items where applicable.
 - 3. Insulation resistance test
 - a) Locations: phase-phase and phase-ground each vertical section.
 - b) Test voltage: 1000 volts for 1 minute.
 - c) Resistance: 2 meg-ohms minimum.
 - d) Check buses for continuity and short circuits.
 - e) Operate each switch and circuit breaker at least 3 No. times.
 - f) Disconnect control wiring prior to testing.
 - g) All testing shall be in accordance with the manufacturer's testing requirements.
 - h) Testing, cleaning where necessary and calibrating all relays and circuit breaker trip devices. (Calibration of all protective devices shall conform to requirements of accepted coordination curves).
 - i) Function test of associated control devices.

- 1) Megger test interconnecting cables.
- 2) Carry out fault loop impedance test.
- 3) Continuity of protective conductors.
- 4) Earth resistance test.
4. Under a minimum of 80% rated load conditions perform an infra-red scan of the bus duct. Remove bus duct cover and torque all connections to manufacturer's standards.
5. An acceptance test in the presence of and satisfaction of the Employer and the Employer's Representative and Assistants.
6. The presence, for the length of the required, or qualified and competent equipment service representatives during start-up.
7. Forward for acceptance prior to energizing of the distribution system and equipment, form neat typewritten copies of the engineering and testing report.
8. The engineering and inspection testing shall be carried out by an independent engineering testing company specializing in this type of work.

3.06 COORDINATION STUDY

- A. The protective system devices have been selected such that protection is adequate and good coordination is possible, however, since differences do exist between manufactures, some changes in trip rating or relay settings may be necessary and shall be carried out.
- B. Carry out the following.
 1. Immediately upon award of the contract and prior to the manufacture of the switchboards, prepare a set of coordination curves on Keuffel and Essser (K.E.) NO. 336E time current characteristic graph paper and forward 2 copies to the Employer's Representative and Assistants for his acceptance. Make any changes as directed by the Employer's Representative and Assistants to no additional charge to the Employer.
 2. This shall be accompanied by supporting symmetrical as well as asymmetrical fault current calculation data with tabulations to verify protection of the various elements of the system under maximum and minimum fault conditions at the various points in the system.
 3. The time-current characteristic curves for the following shall be plotted:
 - a) The relays and breakers protecting the incoming service.
 - b) Main and feeder protective devices at all voltage levels used in the distribution system.
 - c) Protective devices associated with the largest motor in each MCC, the refrigeration compressor and largest device in each distribution panel.
- C. It shall be the responsibility of the Contractor to examine the plans and specifications to ensure that all the relays and protective devices installed in the distribution system shall provide satisfactory coordination.
- D. Breaker frame sizes, sensors and delay types shall be provided in accordance with the approved coordination study.
- E. Testing procedures shall be in accordance with the following Regulatory Authorities, British Standards Institution and International Electro-technical Commission IEC.

3.07 TRAINING

- A. The Contractor shall engage a factory-authorized service representative to provide start-up services and to demonstrate and train for up to 5 No. Client's representatives for 2 normal workdays at a job Site location determined by the Employer.
- B. Upon successful completion of a demonstration of the automated sequences of operation by the manufacturer and acceptance by the customer, the manufacturer shall provide an 8-hour "hands-on" training course for the customer's operating personnel which shall cover the following topics:
 - 1. Overall System Description and Theory of Operation.
 - 2. Modes of Operation as listed in the Sequence of Operations to include at a minimum:
 - a) Automatic Operation.
 - b) Manual Operation.
 - 3. Engine Safeties and Protective Relaying.
 - 4. Recommended System Check Lists and Log Sheets.
 - 5. Recommended Preventive Maintenance.
- C. The training session shall be conducted by a manufacturer's qualified representative. Training program shall include instructions on the assembly, circuit breaker, protective devices and other major components.

3.08 RISER DIAGRAM

- A. Install in Main LV room as directed by the Employer's Representative and Assistants.

END OF SECTION