TECHNICAL SPECIFICATIONS FOR ELECTRICAL WORKS

CONTENTS

I. SOLAR PHOTOVOLTAIC SYSTEMS....5
2 PART 1 GENERAL....6
3 PART 2 PRODUCTS....13
4 PART 3 EXECUTION....19
II. ELECTRICAL INSPECTION, TESTING AND COMMISSIONING....22
5 PART 1 - GENERAL....23
III. WIRING SYSTEMS – POWER CONDUCTORS AND CABLES....27
6 PART 1 - GENERAL....28
7 PART 2 - PRODUCTS....32
8 PART 3 - EXECUTION....43
IV. WIRING SYSTEMS - MICS CABLES....50
9 PART 1 - GENERAL....51
10 PART 2 - PRODUCTS....52
11 PART 3 - EXECUTION....54
V. WIRING SYSTEMS - LSF/LSF CABLES....55
12 PART 1 - GENERAL....56
13 PART 2 - PRODUCTS....57
14 PART 3 - EXECUTION....57
VI. EARTHING AND BONDING....59
15 PART 1 - GENERAL....60
16 PART 2 - PRODUCTS....60
17 PART 3 - EXECUTION....61
VII. CONDUIT SYSTEMS FOR ENCLOSING PVC AND LSF INSULATED CABLE....64
18 PART 1 - GENERAL....65
19 PART 2 - PRODUCTS....66
20 PART 3 - EXECUTION....69
VIII. RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS....72
21 PART 1 - GENERAL....73
22 PART 2 - PRODUCTS....76
23 PART 3 - EXECUTION....84
IX. TRUNKING SYSTEM....95
24 PART 1 - GENERAL....96
25 PART 2 - PRODUCTS....97
26 PART 3 - EXECUTION....101

X. VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS 102
27 PART 1 - GENERAL 103
28 PART 2 - PRODUCTS 103
29 PART 3 - EXECUTION 106
XI. LABELLING AND IDENTIFICATION 107
30 PART 1 - GENERAL 108
31 PART 2 - PRODUCTS 108
32 PART 3 - EXECUTION 110
XII. FIRE DETECTION AND ALARM SYSTEMS 115
33 PART 1 - GENERAL 116
34 PART 2 - PRODUCTS 119
35 PART 3 - EXECUTION 140
XIII. VOICE EVACUATION SYSTEM 144
36 PART 1 - GENERAL 145
37 PART 2 - PRODUCTS 147
XIV. WIND GENERATOR SYSTEMS 150
38 PART 1 GENERAL 151
39 PART 2 PRODUCTS 158
40 PART 3 EXECUTION 166
XV. LV SUPPLIES, DISTRIBUTION AND EQUIPMENT 174
41 PART 1 - GENERAL 175
42 PART 2 - PRODUCTS 177
43 PART 3 - EXECUTION 187
XVI. MOTOR CONTROL PANELS 190
44 PART 1 - GENERAL 191
45 PART 2 - PRODUCTS 192
46 PART 3 - EXECUTION 197
XVII. INSTRUMENTATION AND CONTROL FOR ELECTRICAL SYSTEMS 199
47 PART 1 - GENERAL 200
48 PART 2 - GENERAL 202
49 PART 3 - EXECUTION 209
XVIII. WIRING ACCESSORIES 211
50 PART 1 - GENERAL 212
51 PART 2 - PRODUCTS 213
52 PART 3 - EXECUTION 220

XIX. LOW-VOLTAGE CONTROLLERS....222
53 PART 1 - GENERAL....223
54 PART 2 - PRODUCTS....224
55 PART 3 - EXECUTION....228
XX. MECHANICAL WIRING SERVICES....229
56 PART 1 - GENERAL....230
57 PART 2 - PRODUCTS....231
58 PART 3 - EXECUTION....233
XXI. STANDBY DIESEL GENERATOR....234
59 PART 1 - GENERAL....235
60 PART 2 – PRODUCT....236
61 PART 3 Testing and Commissioning....245
XXII. CENTRAL BATTERY EQUIPMENT....251
62 PART 1 - GENERAL....253
63 PART 2 - PRODUCTS....254
64 PART 3 - EXECUTION....258
XXIII. POWER FILTERS AND CONDITIONERS....259
65 PART 1 - GENERAL....260
66 PART 2 - PRODUCTS....261
67 PART 3 - EXECUTION....267
XXIV. TRANSFER SWITCHES....271
68 PART 1 - GENERAL....272
69 PART 2 - PRODUCTS....273
APPENDIX – STORAGE BATTERY DATASHEET....277

I. SOLAR PHOTOVOLTAIC SYSTEMS

2 PART 1 GENERAL

2.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced.

IS 10236 (Part 16)	Procedure for basic climatic and durability tests for optical instruments part 16 solar radiation test
IS 11907: 1986	Recommendations for calculation of solar radiation on buildings
IS 12762 (Part 9): 2023 IEC 60904-9: 2020	Photovoltaic Devices Part 9: Classification of Solar Simulator Characteristics Part 9: Solar Simulator Performance Requirements (First Revision)
IS 16270: 2023	Secondary cells and batteries for solar photovoltaic application - General requirements and methods of test
IS 16663: 2018 IEC/TS 62727: 2012	Photovoltaic systems - Specifications for solar trackers
IS 16792 (Part 1/Sec 4): 2023 IEC 62788-1-4: 2020 (Ed 1.1)	Measurement Procedures for Materials Used in Photovoltaic Modules Part 1: Encapsulants Section 4 Measurement of Optical Transmittance and Calculation of the Solar-Weighted Photon Transmittance Yellowness Index and UV Cut-Off Wavelength (First Revision)
IS 16997: 2018 IEC 60364-7-712	Requirements for Low-Voltage Special Electrical Installations or Locations Solar Photovoltaic (PV) Power Supply Systems
IS/IEC 60269-6: 2010 IEC 60269-6: 2010	Low-Voltage Fuses Part 6 Supplementary Requirements for Fuse-Links for the Protection of Solar Photovoltaic Energy Systems
IS12834:2023 IEC/TS 61836: 2016	Solar Photovoltaic Energy Systems Terms Definitions and Symbols Second Revision
IS 12762 (Part 1): 2010 IEC 60904_1	Photovoltaic devices: Part 1 measurement of photovoltaic current - Voltage characteristics (First Revision)
IS 12762 (Part 1/Sec 1): 2020 IEC 60904-1-1: 2017	Photovoltaic Devices Part 1 Measurement of Current-Voltage Characteristics Section 1 Multi-junction PV devices
IS 12762 (Part 1/Sec 2): 2020 IEC TS 60904-1-2: 2019	Photovoltaic Devices Part 1 Measurement of Current-voltage Characteristics Section 2 Bi-facial photovoltaic (PV) devices
IS 12762 (Part 2): 2018 IEC 60904-2: 2015	Photovoltaic devices: Part 2 Requirements for photovoltaic reference devices (Second Revision)
IS 12762 (Part 3): 2020 IEC 60904-3: 2016	Photovoltaic Devices Part 3 Measurement Principles for Terrestrial Photovoltaic PV Solar

	Devices with Reference Spectral Irradiance Data (Third Revision)
IS 12762 (Part 4): 2014 IEC 60904-4: 2009	Photovoltaic devices: Part 4 reference solar devices - Procedures for establishing calibration traceability
IS 12762 (Part 5): 2014 IEC 60904-5: 2011	Photovoltaic devices: Part 5 determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open - Circuit voltage method (First Revision)
IS 12762 (Part 7): 2023 IEC 60904-7: 2019	Photovoltaic Devices Part 7: Computation of the Spectral Mismatch Correction for Measurements of Photovoltaic Devices (First Revision)
IS 12762 (Part 8): 2018 IEC 60904-8: 2014	Photovoltaic devices: Part 8 measurement of spectral responsivity of a photovoltaic (PV) device (First Revision)
IS 12762 (Part 8/Sec 1): 2020 IEC 60904-8-1: 2017	Photovoltaic Devices Part 8 Measurement of Spectral Responsivity of a Photovoltaic (PV) Device Section 1 Multi-junction (PV) devices
IS 12762 (Part 13): 2020 IEC TS 60904-13: 2018	Photovoltaic Devices Part 13 Electroluminescence of Photovoltaic Modules
IS 12762 (Part 14): 2023 IEC TR 60904-14: 2020	Photovoltaic devices Part 14: Guidelines for production line measurements of single-junction PV module maximum power output and reporting at standard test conditions
IS 14286 (Part 1/Sec 1): 2023 IEC 61215-1-1:2021	Terrestrial photovoltaic PV modules Design qualification and type approval Part 1-1: Special requirements for testing of crystalline silicon photovoltaic PV modules Third Revision
IS 14286 (Part 1/Sec 2): 2023 IEC 61215-1-2:2021	Terrestrial photovoltaic PV modules Design qualification and type approval Part 1-2: Special requirements for testing of thin-film Cadmium Telluride CdTe based photovoltaic PV modules Third Revision
IS 14286 (Part 1/Sec 3): 2023 IEC 61215-1-3:2021	Terrestrial photovoltaic PV modules Design qualification and type approval Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic PV modules Third Revision
IS 14286 (Part 1/Sec 4): 2023 IEC 61215-1-4:2021	Terrestrial photovoltaic PV modules Design qualification and type approval Part 1-4: Special requirements for testing of thin-film CuInGASSe2 based photovoltaic PV modules Third Revision
IS 14286 (Part 2): 2023 IEC 61215-2:2021	Terrestrial Photovoltaic PV Modules Design Qualification and Type Approval Part 2: Test Procedures Third Revision
IS 16077: 2013 IEC 61646: 2008	Thin - Film terrestrial photovoltaic (PV) modules - Design qualification and type approval
IS 16169: 2019 IEC 62116: 2014	Utility - Interconnected photovoltaic inverters - Test procedure of islanding prevention measures (First Revision)

IS 16170 (Part 1): 2014 IEC 61853-1: 2011	Photovoltaic (PV) module performance testing and energy rating: Part 1 irradiance and temperature performance measurements and power rating
IS 16170 (Part 3): 2022 IEC 61853-3: 2018	Photovoltaic PV Module Performance Testing and Energy Rating Part 3: Energy Rating of PV Modules
IS 16170 (Part 4): 2023 IEC 61853-4: 2018	Photovoltaic PV Module Performance Testing and Energy Rating Part 4: Standard Reference Climatic Profiles
IS 16221 (Part 1): 2016 IEC 62109-1: 2010	Safety of Power Converters for use in Photovoltaic Power Systems Part 1 General Requirements
IS 16221 (Part 2): 2015 IEC 62109: 2011	Safety of power converters for use in photovoltaic power systems: Part 2 particular requirements for inverters
IS 16221 (Part 3): 2023 IEC 62109-3: 2020	Safety of Power Converters for Use in Photovoltaic Power Systems Part 3: Particular Requirements for Electronic Devices in Combination with Photovoltaic Elements
IS 16781: 2018 IEC 62852: 2014	Connectors for d.c. Application in Photovoltaic Systems Safety Requirements and Tests
IS 16797: 2019 IEC 62509: 2010	Battery charge controllers for photovoltaic systems - Performance and functioning
IS 16798: 2018 IEC 62894: 2014	Photovoltaic inverters - Data sheet and name plate
IS 16911: 2023 IEC 62790: 2020	Junction Boxes for Photovoltaic Modules Safety Requirements and Tests (First Revision)
IS 16960 (Part 1): 2018 IEC 62446-1: 2016	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance: Part 1 grid connected systems - Documentation, commissioning tests and inspection
IS 16960 (Part 2): 2023 IEC 62446-2: 2020	Photovoltaic PV Systems Requirements for Testing Documentation and Maintenance Part 2: Grid Connected Systems Maintenance of PV Systems
IS 16960 (Part 3): 2020 IEC 62446-3: 2017	Photovoltaic (PV) Systems Requirements for Testing, Documentation and Maintenance Part 3 Photovoltaic Modules and Plants Outdoor Infrared Thermography
IS 17293: 2020	Electric Cables for Photovoltaic Systems for Rated Voltage 1 500 V d.c.
IS 17978: 2022 IEC TR 63227: 2020	Lightning and Surge Voltage Protection for Photovoltaic PV Power Supply Systems
IS 18124 (Part 1): 2023 IEC 63092-1: 2020	Photovoltaics in Buildings Part 1: Requirements for Building-Integrated Photovoltaic Modules
IS 18124 (Part 2): 2023 IEC 63092-2: 2020	Photovoltaics in Buildings Part 2: Requirements for Building-Integrated Photovoltaic Systems
IS 18127: 2023 IEC TS 63156: 2021	Photovoltaic Systems Power Conversion Equipment Performance Energy Evaluation Method

IS 18128: 2023 IEC TS 63157: 2019	Photovoltaic Systems Guidelines for Effective Quality Assurance of Power Conversion Equipment
IS 18129: 2023 IEC 61701: 2020	Photovoltaic PV Modules Salt Mist Corrosion Testing (First Revision)

2.2 SUBMITTALS

The following documents/drawings shall be issued for review prior to any installations and procurement.

2.2.1 Pre-Construction Submittals

a. Commissioning Plan
b. Commissioning Schedule

2.2.2 Shop Drawings

a. Site Plan Drawings
b. Riser Diagram and General Notes
c. Complete Solar PV System components and interconnection wiring diagrams
d. Installation and Assembly Details

2.2.3 Product Data

a. Photovoltaic Modules
b. Inverters
c. Disconnects
d. Combiner Boxes
e. Monitoring Equipment
f. System Wiring
g. Mounting Structures
h. Sample Warranty Certificate

2.2.4 Design Data

a. Design Calculations
b. Calculated / Projected Energy Annual Production
c. Shadow Analysis
d. Structural Analysis / Wind Loads

2.2.5 Tests / Commissioning / Close Out

a. Commissioning Procedures
b. Test Reports
c. Inverter Start-up Test
d. Functional Performance Testing Procedures
e. Certificates Materials
f. Seismic Certifications
g. Wind Certification
h. Manufacturer’s Instructions
i. Operation and Maintenance Data Package
j. Operating Instructions
k. Staff Training Documentation
l. Commissioning Reports
m. Warranty Certificates

n. As Built Drawings

2.3 QUALITY ASSURANCE

2.3.1 Regulatory Requirements

Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of the Authority Under Jurisdiction unless more stringent requirements are specified or indicated.

2.3.2 Drawings

Submit minimum of A1 size, three (3) hard copies of drawings for government approval prior to manufacturing and equipment construction or integration.

2.3.3 Product Drawings

Submit complete detailed product drawings for the solar PV system consisting of shop drawings and product data sheets. Include in the shop drawings wiring diagrams, utility interconnection diagrams, switchboard and switchgear drawings layout and arrangement of PV modules, support and mounting mechanism, inverters, combiner boxes, AC and DC disconnects, equipment enclosures, conduits, monitors, meters, and all other accessories associated with the installation of the PV system.

Provide equipment dimensions, weights and structural mounting details.

Provide design Calculations. Include nameplate data, size, and capacity of each PV module. Include all assumptions such as applicable wind speed, snow and seismic loads.

2.3.3.1 Installation and Assembly Drawings and Details

Submit site plan drawings, components and interconnection wiring and general notes, and installation and assembly Details drawings prior to start of construction. Include sufficient detail on drawings for all parts of the work to enable the Government to check conformity with the requirements of the contract documents. Include in the site plan drawings: topographic and utility survey; bore logs; soils report; site plan(s); site construction details; structural drawings; structural construction details; site electrical plan; and site electrical construction details. Include in the installation and assembly drawings and details: parts lists; assembly drawings; interconnection wiring diagrams; wire and cable schedules; wire and cable termination schedules; instrument plan; instrument and control wire, conduit and cable schedules; instrument wire and cable termination schedule; control diagrams; control sequence of operation; seismic restraint details; and wind restraint details.

2.3.3.2 "As-Built" and Record Drawings

After completion of construction, submit As-Built Drawings prepared and certified by the construction contractor, showing in red ink, on-site changes to the original construction details and all underground utilities measured from field benchmarks, accurate to within 20mm of centerline of the utility. Immediately record for inclusion into the as-built drawings all modifications to original drawings made during installation. Indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Prepare "as-built" on a minimum of A1 Size.

After submittal and approval of "As-built" Drawings, submit Record Drawings, prepared and by the project engineer(s) and architect(s), of the original design drawings reflecting all design changes and contractor noted changes in the "As-Built" drawings.

2.3.4 Standard Materials and Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products with satisfactory commercial or industrial use for 2 years prior to bid opening, and past performance documentation with consistent design and bill of materials. Include applications of equipment and materials under similar circumstances and of similar size. Where two or more items of the same class of equipment are required, products will be from a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

Proof of compliance with requirements of UL, where material or equipment is specified to comply. The label of or listing in UL Electrical Construction Directory will be acceptable evidence. In lieu of the label or listing, a written certificate from an approved nationally recognized testing laboratory equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of Underwriters Laboratories may be submitted.

2.3.5 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

2.3.6 Operations and Maintenance Data

Submit operation and maintenance for review and approval in accordance with related specifications.

2.3.7 Commissioning Agents

Commissioning Agents Qualifications: Engage commissioning service personnel, that specialize in the types of inspections and tests to be performed.

2.3.8 Installers

Demonstrate that installers have successfully installed at least Four projects that, in aggregate, equal or exceed the size of the proposed project. Provide references for each of these referenced projects.

2.3.9 Qualified Testing Organization

Engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the solar PV system and equipment listed herein. The organization must be independent of the supplier, manufacturer, and installer of the equipment.

The organization must have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization must have a calibration program, and test instruments used to be calibrated in accordance with NABL (national Accreditation Board for testing and Calibration Laboratories.

2.3.10 Permitting

The Contractor is responsible for obtaining all necessary development permits and regulatory and utility service provider approvals prior to construction.

The Contractor is responsible for obtaining all necessary electrical and building permits and inspections.

2.3.11 Training

Provide training by a factory trained instructor to provide full instructions to designated Government personnel in the operation, maintenance and programming of the specified systems and equipment. Include safety training for first responders including fire department and its representatives.

Submit Training documentation along with the proposed training date/s, at least 14 days prior to date[s] of proposed training course.

Provide training session for six personnel specifically oriented to installed equipment, system layout, and user operations.

2.4 DELIVERY, STORAGE, AND HANDLING

Store solar PV panel modules in the original packaging according to the manufacturer's guidance, and remain in packaging until day of installation. If a solar PV module is removed from its packaging, store according to the manufacturer's guidance. Do not store solar PV panel modules on-site for more than 12 months.

2.5 WARRANTY

Warrant the overall system for both parts and labor for a minimum period of 5 years. Provide the following component specific warranties:

a. Photovoltaic Modules: Minimum warranty period of 25-year for linear minimum output and 10-years for workmanship, material, visual, and manufacturing defects from the date of manufacture followed by an additional fifteen (15) years at not more than 20 percent power loss.
b. Mounting Structure: Mounting structure system hardware to be free from defects in the material and workmanship for a minimum period of 10 years.
c. Combiner Boxes: Combiner boxes to be free from defects in material and workmanship for a period of 5 years.
d. Inverters: Inverters to be from defects in material and workmanship for a minimum period of 20 years.

Provide a list of all applicable warranties for all equipment and components. Include warranty information, names, addresses, telephone numbers, and procedures for filing a claim and obtaining warranty services.

2.6 Inverter Software Upgrades

Provide and install, at no cost or charge, any inverter software upgrades that become available during the warranty period.

2.7 Warranty Exclusions

The warranty must cover all system malfunctions and failures except those resulting from misuse, abuse, neglect, fire, vandalism, acts of nature, or other causes beyond the control of the Contractor or manufacturer.

2.8 CERTIFICATIONS

Provide Seismic Certification and Wind Certification, prepared by a licensed professional engineer for all components and assembled systems in accordance with state and local building codes. Seismic and wind certifications must demonstrate system will withstand wind and seismic requirements as installed and remain online and functional after a seismic or wind event.

3 PART 2PRODUCTS

3.1 SYSTEM DESCRIPTION

Provide utility scale solar PV system feeding AC power to utility grid in accordance with IS Standards stipulated on Part 1 of this specification and applicable local utility regulations. The PV system must comply with these specifications, all applicable codes and standards, all construction documents, and all local authorities having jurisdiction.

Installation must consist of either a fixed-axis, single- or dual-axis utility scale-façade/roof mount system. Tracking requirements must comply with local siting requirements regarding reflectivity restrictions and airspace safety requirements. Support structures must either be individual modules or where applicable, groups of panels configured for shade structures.

Provide all necessary accessories for a complete, secure, and operational solar PV system.

3.1.1.1 System Requirements

3.1.1.2 System Characteristics

The system characteristics include minimum rated 352kWp DC output, with a minimum 507,000.00 kWh/year, 415V system voltage, and fixed axis façade/roof-mounted at full load rated power 1 percent mean ambient summer operating temperature. Rate all electrical equipment for the current and voltage ratings appropriate for the application.

Note, the Solar Capacity is only indicative and may increase to satisfy the NZEB (Net Zero Energy Building) requirements.

The system must be rated for outdoor installation. Provide system equipment capable of operating under the location's maximum and minimum documented temperatures during summer and winter times. The entire system must be rated and warranted to withstand and operate under these conditions.

3.1.1.3 Capacity Ratings

Specify rated PV system capacity in direct current (DC) kWp under both Standard Test Conditions (STC) and Photovoltaics for Utility Scale Applications Test Conditions (PTC) ratings.

a. The STC rating assumes direct current referred as "kWpdc-STC". It is also referred as kilowatts peak, or "kWp". Specific PV module manufacturer maximum and minimum power data must be specified for this rating. The STC rating is based on 1,000 watts/m^2 solar irradiance, 25 degrees C cell temperature, air mass equal to 1.5, and standard spectrum as per IS 12762 (Part 3): 2020, IEC 60904-3: 2016
b. The PTC rating is based on 1,000 watts/m^2 solar irradiance, 20 degrees C ambient temperature and 1 meter/second wind speed at 10 meters above ground level.

3.1.1.4 System Wiring

System wiring must conform to Volume II “Specifications for Common and Building Construction Works 2018, published by Municipal Corporation of Greater Mumbai. The conductors used must have a temperature rating of 90 degrees C or higher and be sized according to the appropriate DC or AC voltage application. Cabling exposed to sunlight must be UV resistant.

Use galvanized rigid steel conduit above grade and mount on UV resistant high-density polyethylene (HDPE) supports. Conduit below grade must be Schedule 40 PVC, minimum.

3.1.1.5 Site Design

Provide adequate space for personnel, vehicles and equipment throughout the PV array to facilitate installation, inspection and maintenance access to all modules.

3.2 PHOTOVOLTAIC MODULES

Photovoltaics Modules to be supplied shall be sourced from eligible models and manufacturers complying with BIS Standards and published under "Approved List of Models and Manufacturers' (ALMM), 2019.

Utilize PV modules with crystalline silicon. Include bypass diodes with each PV module installed in the module junction box.

3.2.1 Compliance

The PV modules must comply with the Buy Indian Act and must be listed on the MNRE ALMM. The system must comply with IEC 61215 or IEC 61646.

3.2.2 Electrical Characteristics

Provide high-power type PV module(s), with typical peak power of not less than 570 watts, +/- 3 percent power tolerance, under Standard Test Conditions (STC). The AC output must not be less than 80 percent of the DC kWp rating.

The operating voltage corresponding to the power output mentioned above should be at least 42 volts. The open circuit voltage of the PV modules under STC should be at least 50 volts. Operate PV module at an ambient temperature range of -40 deg C to + 85 deg C with 100 percent relative humidity.

3.2.2.1 Terminal Box

Include a terminal box on the module having a provision for opening for replacing the cable, if required.

3.2.3 Nameplate

Include the following on the module nameplate so as to be clearly visible:

a. Name of the Manufacturer or distinctive logo;
b. Model or Type Number;
c. Serial Number;
d. Year of make;
e. Peak wattage rating;
f. Peak voltage; and
g. Peak current.

3.3 INVERTERS

Provide solid state type inverter unit capable of accepting the output of the photovoltaic panels and providing rated output as indicated. Provide the inverter with monopole, negative grounded, and positive grounded array configuration capabilities.

Inverters shall be grid tied and stand by generator synchronized.

3.3.1 Listings

The inverter must be IEC 62109, IEC 61727, IEC 62116, IEC 60068, IEC 61683, VDE-AR-N 4110:2018, VDE-AR-N 4120:2018, IEC 61000-6-3, EN 50549, AS/NZS 4777.2:2015, CEI 0-21, VDE 0126-1-1/A1 VFR 2014, UTE C15-712-1:2013, and all relevant IS Standards.

3.3.2 Ratings

Rate the inverter's output as 125kVA, 1500Vdc Vdc, 3 phase, 860-1450V maximum power point tracking (MPPT) voltage range. The peak inverter power conversion efficiency must be 98.5 percent or greater.

Operate inverter at an ambient temperature range of minus 30 deg C to 60 deg C, 0-100% humidity (non-condensing).

3.3.3 Safeties and Protection

Equip each inverter with the following safeties and Protection:

a. DC input disconnect;
b. Surge protection;
c. Ground fault interrupter;
d. Isolation transformer;
e. AC output disconnect; and
f. Data Monitoring Equipment/System.

The inverter must be able to sustain an overload across its output terminals up the 150 percent load, while supplying any load within its rating and without reducing its output voltage. Fuse power semiconductors in the inverter with fast acting fuses to prevent cascading failures. Provide each fuse with a blown fuse and alarm indicating diodes on the control panel.

3.3.4 Features

Include each inverter with the following:

a. Automatic operation including start-up, shutdown, self-diagnosis, and fault detection;
b. Digital Signal Processor (DSP) based controls with self-diagnostics and [remote][local] display of operating status;
c. Over- and under-voltage and frequency protection, shutting down the inverter in compliance with UL 1741 or equivalent; and
d. Anti-islanding protection to prevent back-feeding inverter generated power to the grid in the event of a utility outage.

Provide inverter in floor-mount / wall-mount / support structure mount, steel / aluminum / stainless steel / polymeric enclosure in accordance with NEMA 250 or equivalent.

3.4 COMBINER BOXES

Provide combiner box/es in wall-mount, steel / aluminum / stainless steel enclosure in accordance with NEMA 250 or equivalent. Include in the combiner box[es] fuses and a bus to combine the outputs of the strings. Each combiner box must be UL 1741 listed and operate at an ambient temperature range of minus 25 degrees C to plus 57 degrees C. Provide combiner box capable of at least 12 inputs and an input fuse rating of 15 amps. Include output circuit disconnecting means listed for intended use and purpose.

Provide combiner box output terminals for paralleling two conductors for the PV positive and negative, as well as the equipment ground conductors. Run set of wires from the combiner box to the inverter. Combiner output must be compatible with inverter input.

3.5 GROUND MOUNTING STRUCTURES

Provide array façade / roof mounting structure for PV modules that provides the designed panel tilt. The mounting system must ne UL 2703 and UL Subject 3703 listed or equivalent.

Design all structural components in a manner commensurate with attaining a minimum 30-year design life. Array mounting hardware must be compatible with the site considerations and environment. Aluminum and stainless-steel components and hardware are preferred.

3.5.1 Wind and Seismic Ratings

The mounting system and overall installation must be capable to withstand winds of Category 5 as defined by the Saffir-Simpson Hurricane Wind Scale for all attachment points and consistent with the manufacturer's installation instructions. Provide wind certifications for all components and assemblies.

All structures and structural elements must be suitable for Seismic Design Category C2 in accordance with UFC 3-301-01, ICC IBC, ASCE 7-10, and all other applicable building codes and standards pertaining to the erection of such structures.

3.6 CAST-IN-PLACE CONCRETE

Provide façade fixings and roof mounted foundations for mounting structural members in accordance with manufacturer's recommendations.

Provide mounting assembly and connections where system is to be installed on a concrete structure.

3.7 METERING AND POWER MONITORING

Provide and install a revenue grade alternating current (AC) Interval Data Recording (IDR) meter, located on the output side of the inverter, complete with industry standard telemetry for communications with Ethernet, cellular or other common output capabilities. Meter must conform to the MNRE and Electrical Utility metering requirements.

3.7.1 Meter Characteristics

The meter must be UL listed and have an operating temperature range of minus 20 degrees C to plus 70 degrees C with a humidity range of 95 percent relative humidity (RH) non-condensing. Provide the meter conforming to ANSI C12.1 or equivalent.

Provide meter capable of measuring kWh, Demand, Instantaneous power, volts, amps, watts, VAR and VA per ♠ phase.

3.7.2 Power Monitoring System

Provide and connect meter to a power monitoring/data collection system recording solar production through Time of Use (TOU) increments applicable to the installation and utility standards, with a minimum 15-minute intervals and 30-day memory.

3.8 POSTED OPERATING INSTRUCTIONS

Provide posted operating instructions for solar PV system equipment laminated between thermoplastic sheets. After operating instructions are approved, install where directed.

3.8.1 MANUFACTURER'S NAMEPLATE

Provide on each equipment item, including PV panels, a nameplate bearing all manufacturer's information securely affixed in a conspicuous place. Nameplates exposed to weather are to be ASTM A240/A240M Type 316 stainless steel with stamped engraving.

3.8.2 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with ASTM D709 as specified or as indicated on the drawings. Minimum size of nameplates is 25 by 65 mm. Lettering is a minimum of 6.35 mm normal block style.

3.8.3 WARNING SIGNS

Provide clearly visible warning signs for arc flash protection in accordance with IS Standards for all electrical equipment and components that are required to examine, adjust, service, or maintain while energized.

3.8.4 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide machine printed polyethylene cable tags for each cable entering or leaving manholes, handholes, and vaults. Do not provide handwritten tags.

3.9 GROUNDING AND BONDING

IEEE 80, IEEE 142, IEEE 242, and IEEE C2 Or equivalent, except that grounds and grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.9.1 Ground Rods

Provide ground rods made of copper-clad steel conforming to conform to UL 467 Or equivalent with minimum diameter of 19mm and length of 3m.

3.9.2 Ground Plates

Provide grounding plates made of copper-clad steel conforming to UL 96 or equivalent.

3.9.3 Ground and Bonding Conductors

Equipment grounding conductors must be insulated stranded copper, except that sizes No. 10 AWG and smaller must be solid copper. Insulation color must be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger must be identified per IS Standards.

Bonding conductors must be bare stranded copper, except that sizes No. 10 AWG and smaller must be bare solid copper. Bonding conductors must be stranded for final connection to motors, transformers, and vibrating equipment.

3.9.4 Ground Connections

Below Grade and Inaccessible Locations: Exothermic-welded type connectors. Above Grade:

a. Bonding Jumpers: Listed for use with aluminum and copper conductors. For wire sizes No. 8 AWG and larger, use compression-type connectors. For wire sizes smaller than No. 8 AWG, use mechanical type lugs. Connectors or lugs must use zinc-plated / steel bolts, nuts, and washers. Bolts must be torqued to the values recommended by the manufacturer.
b. Connection to Building Steel: Exothermic-welded type connectors.
c. Connection to Grounding Bus Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated/ steel bolts, nuts, and washers. Bolts must be torqued to the values recommended by the manufacturer.
d. Connection to Equipment Rack and Cabinet Ground Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated / steel bolts, nuts, and washers. Bolts must be torqued to the values recommended by the manufacturer.

3.10 Lightning Protection System

Provide Lightning Protection System and components in accordance with IS 17978: 2022, IEC TR 63227: 2020.

4 PART 3EXECUTION

4.1 INSTALLATION

4.1.1 Site Preparation

Prepare all approved / certified drawings and installation details. Ensure adequate health and safety measures are in place prior to installation. All works shall be in accordance with the approved method statements.

Provide access / space throughout the PV array to facilitate installation, inspection, and maintenance access to all modules.

4.1.2 Equipment Installation

Install all equipment and all required wiring for a complete and operational system. Follow manufacturer's guidelines for the installation of the array components, including mounting hardware and PV modules.

Provide required conductor terminations to devices for a complete system to function as specified and indicated. Complete installation must comply with all local building codes, manufacturer's instructions, and applicable industry standards.

4.1.3 Conductor Installation

Furnish and install conductors required to connect incoming and outgoing circuits. Install conductors with conduits, boxes, and terminal cabinets in a totally enclosed installation. Color-code all conductors per as recommended by the equipment manufacturer and in accordance to relevant IS Standards.

4.2 GROUNDING

Ensure PV system grounding installation is in accordance with IS 17978: 2022, IEC TR 63227: 2020

4.2.1 Grounding Electrodes

Provide ground rods as specified in IS 3043:2018. Connect grounding conductors to ground rods by exothermic weld.

4.3 FOUNDATIONS OF EQUIPMENT AND ASSEMBLIES

Design structural mounting in accordance with structural design recommendations. Construct equipment foundations.

4.4 FIELD APPLIED PAINTING

Apply field painting as specified in IS 1477 (Part 1 & Part 2): 1971

4.5 FIELD FABRICATED NAMEPLATE MOUNTING

Provide equipment nameplates as indicated.

4.6 WARNING SIGN MOUNTING

Provide the number of warning signs required to be readable from each accessible side. Locate and space signs in accordance with IS 16449 (Part 1 to Part 4): 2018

4.7 CABLE TAG INSTALLATION

Install cable tags in manholes, handholes, and vaults as specified, including each splice. Locate tags over any fireproofing, if any, and clearly visible on cabling without disturbance in manholes, handholes, and vaults.

Identify and label all cables per IS 1255 (1983).

4.8 FACTORY SYSTEM TESTING

Provide testing of the complete system in accordance with IS 16960 (Part 1 to 3): 2018 allows for type testing to be performed on complete systems, multifunction relays, discrete devices, or any combination. If type testing is performed on anything other than a fully integrated system, some of the component times may not be available.

4.9 FIELD QUALITY CONTROL

4.9.1 Manufacturer's Field Service

Provide the services of factory trained and approved field service engineer during system installation, testing and commissioning.

4.10 COMMISSIONING

Conduct Commissioning, after the system is installed and is ready for operation, in accordance with IS 16960 (Part 1): 2018, IEC 62446-1: 2016; IS 16960 (Part 2): 2023, IEC 62446-2: 2020 and IS 16960 (Part 3): 2020, IEC 62446-3: 2017.

4.10.1 Commissioning Agent Qualification

Individual qualified in testing protective equipment (e.g., professional engineer, factory-certified technician, licensed electrician with experience in testing protective equipment) must perform or directly supervise commissioning tests.

4.10.2 Commissioning Plan and Schedule

Develop and implement a commissioning plan and commissioning schedule.

4.10.3 Start-up Pre-functional Checklists

Carry out a checklist of startup requirements and conduct a series of safety tests to ensure proper installation, safe operation, and performance conforming to specification.

4.10.4 Functional Performance Testing

Prepare test procedures and conduct functional performance testing of the installed system. Include the following test requirements:

a. All inverter startup tests as specified by the inverter manufacturer in the inverter operation manual;
b. Actual power;
c. Loss of grid;
d. Grid resume;
e. Data monitoring check out;

f. V_{oc} measurement of every source circuit and log it;
g. Verify tightness of all wiring terminations;
h. Verify proper markings and labeling of all wire terminations and enclosures;
i. Verify startup/shut down procedures;

j. Verify system 5 minutes delay upon restart;
k. Verify PV array quick connectors are fully mated and wires are neatly secured;
l. Verify no debris on the modules, no damaged or broken modules;
m. Verification and inspections
n. Field-conducted type and production tests
o. Unintentional islanding functionality test
p. Cease-to-energize functionality test
q. Unintentional islanding functionality test
r. Cease-to-energize functionality test
s. Revised settings

4.10.5 Functional Performance Testing Results

Coordinate, observe and record the results of the functional performance testing. Coordinate retesting as necessary until satisfactory performance is verified. Verify the intended operation of individual components and system interactions under various conditions and modes of operation.

Document items of non-compliance in materials, installation or operation. Immediately address observed non-conformance and deficiencies in terms of notification to responsible parties, and provide recommended actions to correct deficiencies.

4.10.6 Final Commissioning Report

Prepare and submit final commissioning report. Summarize all of the tasks, findings, conclusions, and recommendations of the commissioning process in accordance with IS 16960 (Part 1): 2018, IEC 62446-1: 2016; IS 16960 (Part 2): 2023, IEC 62446-2: 2020 and IS 16960 (Part 3): 2020, IEC 62446-3: 2017. Include the results of all tests and a listing of the final settings.

4.11 FINAL ACCEPTANCE

The acceptance of the solar PV system occurs only after all deficiencies identified by the functional acceptance tests and commissioning report are corrected, and the system operates successfully during a 30-day initial testing period.

The Contracting Officer must sign appropriate certificates, if equipment and systems are operating satisfactorily in accordance with the specifications, stating the system's operation has been tested and accepted at the end of the final start-up and testing.

4.12 CLOSEOUT ACTIVITIES

4.12.1 Demonstration

Demonstrate, upon completion of functional acceptance tests, that all circuits and devices are in proper operating condition and performing as intended.

4.12.2 Training

Furnish training service by a factory-trained representative for a period of 5 calendar days. Document that each qualified employee has received the required training. Maintain all training documentation in a central location for the entire employee's employment duration. Minimum documentation data includes employee's name, training name, and date(s) of training.

-- End of Section –

II. ELECTRICAL INSPECTION, TESTING AND COMMISSIONING

5 PART 1 - GENERAL

5.1 GENERAL

A. The electrical installation shall be inspected and tested as required by BS 7671 and shall then be fully commissioned and left working.

B. Include in the Tender for all labour, special instruments, materials, fuel, lubricants, coolants, tools, plant and equipment required to undertake the pre-commissioning, commissioning and the performance testing of all elements.

C. The Engineer may request tests, at the Contractors or suppliers premises, for all or any of the materials and equipment to be installed to ensure conformity with the specification. The results of such tests shall in no way relieve the Contractor of his responsibilities to ensure that all materials and equipment installed in the works are entirely suitable for the applications and conditions of operations.

D. The testing of elements under the various sections of the specification may be required to be carried out in parts, or as a whole.

E. All tests shall be carried out to the complete satisfaction of the Engineer.

F. All instruments shall be calibrated immediately prior to commencement of the testing and shall be recalibrated in accordance with the manufacturer's recommendation during the course of testing, as necessary. Copies of the calibration certificates shall be provided with the test results.

G. The Contractor shall demonstrate the installation or any portion thereof, which has been set to work, complies with the requirements of the specification.

H. Any defects of workmanship, materials, performance, maladjustment, non-compliance with the specification, or other irregularities which become apparent during the tests shall be rectified by the Contractor, at no additional cost to the Contract and the tests repeated at the Contractor's expense until the whole is proved free from defects and in complete working order. All systems shall be left sound and correct.

I. Publish a program of the proposed inspections and testing works and detail requirements for the Engineer to witness such inspections and tests at least fourteen days prior to the beginning of such works.

J. The Contractor shall provide to the Engineer, full settings, data and works of all equipment and systems at least fourteen days before beginning such works. The Engineer shall have the right to comment on such proposals.

K. All costs and charges associated with or arising from the inspections and tests detailed within this Specification, including costs incurred by the Contractor in carrying out the prescribed tests and in attending upon the Engineer whilst tests and inspections are in progress shall be deemed to have been included in the Contract price and shall be borne in full by the Contractor.

5.2 APPROVAL AND ACCEPTANCE

A. After receipt of the results of satisfactory tests, the Engineer shall authorize the Contractor to proceed with the commissioning and system performance tests.

B. The Contractor shall give the Engineer a minimum of fourteen days written notice to his intention to demonstrate and seek 'approval' for any item or system.

C. The Contractor shall allow for giving such notice and making adjustments, setting up and other preparations for testing and for witnessing such tests.

5.3 PERSONNEL

A. Carry out testing work using trained, experienced electrical operatives.

B. Testing and commissioning of major items of proprietary plant shall be carried out by manufacturer's personnel. The Contractor shall be responsible for arranging their programme of works to allow the Engineer to witness tests as required.

C. The Engineer shall ensure that all testing work carried out by such specialist manufacturers is carried out to his, and the Engineer's satisfaction and in such a way that it does not prevent him proceeding with the overall commissioning of the installation.

5.4 INSPECTION, TEST AND ELECTRICAL INSTALLATION CERTIFICATES

A. Inspection and test certificates shall be dated, numbered and clearly referenced to the item tested by means of serial, chassis or other manufacturer's reference number permanently marked in a conspicuous position on the item concerned.

B. The Contractor shall issue and electrical installation certificate as required in BS 7671 at the practical completion of the works.

5.5 WORKS TESTS

A. The Engineer shall have the power to inspect at the makers' works, during manufacture and after completion, all or any manufactured material, apparatus or equipment ordered by the Contractor for incorporation in the Works and to require tests to be carried out in the presence of his representative in order to prove that the said material, apparatus or equipment meets the requirements of this Specification.

B. The Contractor shall be responsible for ensuring that the Engineer is advised in writing whenever material, apparatus or equipment is ready for inspection and/or test at his own or his suppliers' premises. At least five days' notice shall be given and due allowance shall be made for this period of notice in drawing up the programme of works.

C. The Engineer shall have the right to reject any material, apparatus or equipment which, as the result of inspections and/or tests may be found to be defective or unsatisfactory in any respect, or not in accordance with the requirements of the specification, and to require the Contractor to repair, adjustment, modification or replacement of the defective items before dispatch to site. If the defective item be adjudged by the Engineer to be unsuitable for repair, adjustment or modification, then it shall be replaced by a completely new item at the expense of the Contractor.

D. No inspection or testing by the Engineer nor the witnessing of satisfactory tests nor the authorizing of dispatch to site shall in any way relieve the Contractor of any of his obligations under the Contract, nor shall it in any way limit the right of the Engineer to reject such items after delivery to site if they subsequently prove to be defective or unsatisfactory or unsuitable for their intended purpose.

E. The Contractor shall be responsible for ensuring that all materials, apparatus and equipment required for the execution of the works are ordered sufficiently early to ensure delivery to site at the time as required by the construction programme. It shall be the responsibility of the Contractor to ensure that adequate time is available for inspection and/or testing by the Engineer, including the giving of required due notice. No materials, apparatus or equipment subject to inspection and/or test shall be recognised as complete and ready for dispatch until after such inspections and tests have been satisfactorily carried out and no claim for delay shall be allowed unless the Engineer has failed to carry out inspection or to waive inspection after being given the specified period of notice.

5.6 SITE TESTS

A. The Engineer shall have power to inspect all work in progress and upon completion or substantial completion and to require the Contractor to carry out tests in his presence or in the presence of his authorized representative in order to prove that all work carried out and all material, apparatus and equipment installed are wholly satisfactory and fully meet the requirements of this Specification.

B. Upon completion of the electrical installation, or any substantial section thereof, the installation or that section and all of the associated electrical equipment shall be subjected to the tests specified in the relevant British Standards together with such other tests as may be required by the Engineer in order to prove compliance with this Specification. When no relevant British Standard exists, or the appropriate British Standard fails to specify tests, tests shall be carried out to the requirements of the Engineer.

C. The Contractor shall record all the details, measurements and data as required in the relevant standards. All test results shall be written at the time of test in blue ink and signed by the tester and any witness. Alterations or corrections shall be made by crossing out not by over-writing the previous data. No test results shall be corrected with correction fluids or similar correction media. Where the Contractor is unable to provide the original test certificates as described above, the tests shall be repeated at the Contractors cost.

D. The Contractor shall provide the original and a copy of the inspection and test sheets, together with any supportive documentation required by the relevant standards, to the Engineer within two days of the tests being carried out.

E. The inspection and test documentation shall indicate all of the test instrument details including the manufacturer, type, date of calibration, scale used and the recorded results/tolerances.

F. The result of each and every inspection and test carried out in accordance with the provisions of this Specification, whether or not witnessed by the Engineer shall be accurately recorded on an approved form of test certificate signed by the person in charge of the testing procedure. Test results shall be written at the time of test in blue ink and signed by the tester and any witness. Alterations or corrections shall be made by crossing out not by overwriting the previous data. No test results shall be corrected with correction fluids or similar correction media. Where the Contractor is unable to produce test results as described above the test shall be repeated at the Contractors cost.

G. An additional copy of every test certificate relating to site tests of the completed installation or parts thereof shall be included in the operation and maintenance manual specified elsewhere.

H. The Contractor shall give at least fourteen days' notice to the Engineer when the works or substantial sections thereof, shall be completed and ready for inspection and test and before covering such works.

I. The Engineer shall have the right to reject any material, apparatus or equipment which, as the result of inspections and/or tests may be found to be defective or unsatisfactory in any respect, or not in accordance with the requirements of the Specification, and to require the Contractor to repair, adjust, modify, or replace the defective item. If the defective item be adjudged by the Engineer to be unsuitable for repair, adjustment or modification, then it shall be replaced by a completely new item at the expense of the Contractor.

J. No material, apparatus, equipment or installation shall be covered or otherwise permanently concealed from view until the Engineer has had the opportunity to inspect it and either has formally waived his right to inspect it or has given written authorization for covering to proceed following satisfactory tests and/or inspection.

5.7 COMMISSIONING

A. Following the satisfactory conclusion of final inspections and tests on completed sections of the works, the Contractor shall duly commission each section of the electrical installation and leave it in full working order. For the purpose of this specification, the term 'commissioning' shall be deemed to include:

B. The energising of electrical distribution circuits and equipment that have previously been inspected, tested, and found satisfactory and capable of being energised with complete safety.

C. The setting of electrical protective devices and systems, where relevant, in accordance with the directions of the Engineer or, failing such directions, in accordance with sound Engineering practice.

D. The starting up of all electrically powered plant and equipment, including that supplied and installed under other Contracts, as detailed in the annexed Schedules.

E. The verification of the performance of all such plant and equipment by the carrying out, where required, of further tests and the making of all necessary adjustments so as to obtain optimum performance.

F. Mere compliance with the requirements of this section of the Specification shall not by itself in any way relieve the Contractor of any of his obligations under the Contract.

G. No approval given by the Engineer in connection with the commissioning process, whether by way of approval of procedures carried out or proposed, or approval of results obtained shall in any way relieve the Contractor of the Contractual and statutory obligation to ensure that all connections and adjustments are made correctly and

that the installations and equipment are handed over in a complete safe and satisfactory condition. Where required commissioning shall be carried out by the equipment manufacturer's commissioning Engineers.

H. No connections or adjustments shall be made to plant or equipment that has already been commissioned and set to work, except with the prior consent of the Engineer.

I. All commissioning procedures shall be carried out in a safe and satisfactory manner and in accordance with the provisions of the Electricity at Work Regulations, and the Electricity Supply Regulations and to the complete satisfaction of the Engineer.

J. The Engineer shall have power to require that the whole of the plant, equipment and installations, or selected parts thereof, be re-inspected and, if necessary, re-test immediately before the end of the Contractual maintenance period, and the Contractor shall be responsible for making all necessary arrangements with the Employer.

K. All commissioning documentation and certificates shall be included in the operation and maintenance documentation.

5.8 SITE POWER SUPPLIES

A. The Contractor shall ensure that all electrical site power supplies under his control on the site shall be responsibly installed in accordance with the requirements of local supply authority regulations and the specific requirements of the IEE Wiring Regulations and associated guidance notes for site supplies.

B. Generally all site supplies shall operate at 230V AC from safety isolating transformers including lighting and power and the Contractor shall satisfy himself as to the safety of all personnel on site from direct and indirect contact with site electricity supplies.

C. All equipment forming the site services distribution shall be properly installed in accordance with the manufacturer's recommendations and more specifically for the site environment in which they are installed.

D. Before works commence on site, the site power supplies system shall be fully tested to demonstrate compliance with the relevant standards in the presence of the Engineer and ample time shall be allowed for such inspections prior to works commencing.

E. The Electrical Contractor is wholly responsible for the safety of site electricity supplies and the management thereof.

-- End of Section –

III. WIRING SYSTEMS – POWER CONDUCTORS AND CABLES

6 PART 1 - GENERAL

6.1 SUMMARY

A. Section Includes:-

1. All Power System Conductors and Cables
2. Connectors
3. Related accessories

B. Definitions

1. LSZH: Low Smoke Zero Halogen.
2. PVC: Polyvinyl Chloride.
3. XLPE: Cross-Linked Polyethylene.
4. SWA: Steel Wire Armoured.
5. AWA: Aluminium Wire Armoured

6.2 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company regularly engaged in the manufacturer of all materials specified in this section of types and sizes required, whose products have been in satisfactory use under similar service conditions for not less than 10 years.

B. Installers Qualifications: Use competent persons to install the equipment and provide them with documentary evidence of their competence, which the Engineer or Employer, or their nominees, shall be entitled to see at any time.

C. Standards and other Codes of Practice: In addition to the requirements indicated on the Design Drawings or specified in the Specification, the Work shall be in accordance with provisions of the following standards and codes. The current editions of the publications listed below form a part of this Section.

1. BSI Group, (BS) British Standards:

a. BS 5308 Instrumentation cables.

b. BS 5467 Electric cables Thermosetting insulated, armoured cables for voltages of 600/ 1000V and 1900/3300V.

c. BS 6004 Electric cables PVC insulated, non-armoured cables for voltages up to and including 450/750V, for electric power, lighting and internal wiring.

d. BS 6007 Electric Cables Single Core Unsheathed Heat Resisting Cables for Voltages up to and Including 450/750V, for Internal Wiring.

e. BS 6121 Mechanical cable glands.

f. BS 6207 Part 1 Mineral insulated cables.

g. BS 6234 Polyethylene insulation and sheath for cables.

h. BS 6346 Electric cables PVC insulated, armoured cables for voltages of 600/ 1000V and 1900/ 3300.

i. BS 6500 Electric cables. Flexible cords rated up to 300/500V, for use with appliances and equipment intended for domestic, office and similar environments.

j. BS 6724 Electric cables. XLPE insulated armoured single core PVC insulated copper sheathed cables

k. BS 7211 Electric cables. single core insulated copper insulated non-armoured cables / wires

l. BS 6360 Copper conductors for cables.

m. BS 6746 PVC insulation and sheaths.

n. BS 7671 Requirements for electrical installations, IEE UK.

o. BS IEC 60287 All parts Electric cables. Calculation of the current rating.

p. BS 6724 Electric cables. XLPE insulated armoured single core PVC insulated copper sheathed.

q. BS EN 50288-7 Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for instrumentation and control cables.

r. BS EN 50307 Composition of lead and lead alloy sheaths of electric cables.

s. BS EN 50525 Insulated cables and flexible cords for use in high temperature zones

t. BS EN 60228 Conductors of insulated cables.

u. BS EN 60332 Test on electric cables under fire conditions.

v. BS EN 60702-1 Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Cables.

4. Cable terminations shall comply to:

a. BS 1858 Bitumen based compounds for electrical purposes.

b. BS EN 61238-1 Performance of mechanical compression joints in electric cable and wire connectors.

c. BS 6121 Mechanical cable glands for elastomer and plastic insulated cables.

d. BS 6910 Cold pour resin compound and heat -shrink cable joints in the voltage range up to 1000 V.A.C. and 1500 V.

5. International Electrotechnical Commission, IEC Standards.

a. IEC 60227 Power and lighting PVC insulated cable.

b. IEC 60228 Conductors of insulated cable.

c. IEC 60287 Calculation of the continuous rating of cable.

d. IEC 60331 Fire resisting characteristics of electrical cables.

e. IEC 60332 Tests on electric cables under fire conditions.

f. IEC 60502/ BS 7835 Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.

g. IEC 60811 Common test methods for insulating sheeting materials of electrical cables.

6. Engineering Equipment and Materials Users' Association (EEMUA) 133 Underground cable protected against solvent penetration and corrosive attack.

7. Institution of Electrical Engineers (UK), IEE Standards.

8. Telecommunications Industry Association, TIA Standards.

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

10. 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. D. Quality Control: Comply with Contract Conditions.

E. Provide testing and inspections in accordance with full specification requirements.

F. Preconstruction Testing/ Reports

1. Submit reports of independent tests demonstrating that the products and systems comply with the specified performance requirements.

2. Where test results for a material or product are not available, undertake testing to show compliance with the Specification at an independent testing laboratory acceptable to the Engineer.

3. The provision of testing data or the carrying-out of tests shall not relieve the Contractor of his responsibilities regarding the performance requirements, durability or service life requirements.

6.3 INSTALLATION CONDITIONS

A. The cables shall be suitable for continuous operation in desert locations under high ambient temperatures and humidity. The atmosphere is to be considered saliferous, sulphureous, dusty, and with high concentrations of windburn sand as commonly encountered in the UAE. The possibility of condensation, as experienced during large temperature fluctuations in humid atmosphere, shall be taken into account

1. Cables shall be installed as stated below:

   a. Buried LV cable depth shall be minimum of 700mm under footpath and minimum of 850mm under road.

   b. Directly buried in the ground or in formed concrete trenches with backfill.

   c. Fastened to cable ladder rack or tray in the open air exposed to direct sunlight or within buildings.

   d. In underground ducts.

2. Unless specified otherwise the following site conditions shall apply:

   a. Design temperature (Outdoor) + 50° C

   b. Surface temperature due to solar radiation + 85° C

   c. Maximum ambient air temperature - shaded + 55° C

   d. Minimum ambient air temperature + 5° C

   e. Altitude not exceeding 1000m AMSL

   f. Maximum relative humidity at 46° C 100%

   g. Ground temperature + 35° C

h. Soil thermal resistively 2.5 K m/ w.

7 PART 2 - PRODUCTS

7.1 GENERAL

A. Ensure that each cable is of sufficient rating for its normal and fault conditions. To assess the rating and cross section required for each cable the following factors shall be considered.

1. Fault level.

2. Conditions of ambient temperature relevant to method of laying.

3. Voltage drop.

4. Voltage drops in motor circuits due to starting.

5. Over-current settings of circuit breakers.

6. Disposition of cabling whether in air ducts or grounds.

B. Submit details of the cable sizes for the Engineer's acceptance before ordering.

C. Assume responsibility for measuring the length of cable required.

D. Each cable shall be supplied in a suitable length and be continuous through its run. Through joints shall not be permitted without written permission from the Engineer.

E. The earthing conductor shall be of adequate cross sectional area and shall either be one core of a multicore cable or a separately run single core cable. The use of conduit water or other service pipes in any part of the earth continuity conductor shall not be permitted.

F. Supply and install all necessary cable glands and sealing boxes required to complete the installation.

G. All materials used in the manufacture of the glands and similar items shall have no deleterious effect on the cable core or armouring and shall not be susceptible to corrosion.

H. The cores of each cable shall be taken direct to the terminals of the equipment to be connected.

I. Cable ends shall be sealed in suitable chambers bolted to terminal boxes. Compression glands with armour clamps, where required, shall be supplied as an integral part of switchboards, distribution boards, switches, motor starters and similar equipment, unless otherwise stated.

J. The general routing of cables may be indicated on the Design Drawings but the final routes and duct locations shall be agreed with the Engineer before any work in connection with the cable installation is commenced. All cables shall be installed in strict accordance with the requirements of this Section.

K. All cables used shall bear the manufacturer's original guarantee and all cables shall be delivered to Site in their original wrappings. Obtain the permission of the Engineer before any wrappings removed or cables are installed.

L. A minimum length of 250mm tails shall be left on all cables at outlet positions for connection of the lighting fittings or other apparatus fed by the outlet.

M. The installation of multi-core and single core cables or bunching of cables in conduit shall be carried out on the assumption that such cables shall carry alternating current.

N. The excessive bunching of small cables in large conduits shall not be permitted. Do not exceed the requirements of the stated Regulations within this Section. O. Conduits shall not be more than 60% full.

P. Include for terminating each cable in a pressure operated mechanically crimped leg terminal or terminal socket.

7.2 PRODUCT SELECTION

A. Manufacturers: Provide systems and products from one of the listed manufacturers within the approved manufacturer list.

7.3 DESIGN CRITERIA

A. General

1. Buried LV cable depth shall be minimum of 700mm under footpath and minimum of 850mm under road.

2. Cables shall be drummed in maximum continuous lengths on nonreturnable cable drums.

3. Cables ends shall be sealed and fixed to the drum. Cable drums shall be fitted with battens, fixed around the entire periphery of the drum.

4. All cable drums shall have their identification reference clearly stenciled on the outside of both flanges.

5. Drum identification labels shall be attached on the outside and inside of the drum flange. Labels shall be robust and non-fading and give the following information:

   a. Drum identification number

   b. Voltage grade

   c. Cable construction (i.e. XLPE, SWA, and PVC)

   d. Number of cores and cross sectional area.

   e. Cable quality

   f. Purchase order number and item number

   g. Manufacturer's name

6. In addition to the information required by the specified standards, the following information shall be embossed every one meter along the entire cable length on the external surface of the outer sheath.

   a. Number of Cores

   b. Size of Conductor

   c. Voltage rating

   d. Manufacturer's name

   e. Remaining cable length

      - Example: 4 Core 25 Sq. mm 1.1 kV grade. (XYZ Company).

B. The following data shall be furnished by the manufacturers:

1. Insulation thickness

2. Diameter under armour

3. Diameter over armour

4. Overall diameter

5. Current rating in air and ground for the ambient conditions specified

6. Resistance, reactance per km.

7. Maximum continuous drum length for each size of cable

8. Maximum pulling tension

9. Minimum recommended Bending Radius

C. Application

1. Wire and cable installed in conduits shall be of the single core PVC insulated copper type single core to BS 7211.

2. All power cables shall be XLPE insulated, armoured type, PVC sheathed, or single core PVC insulated copper as specified copper conductor cables of 600/ 1000V grade (for size of cable 4 mm² and above sizes) as per BS 5467 unless otherwise stated .

3. All lighting distribution wiring shall be single core PVC insulated copper insulated wiring cables non-armoured to BS 7211 installed in conduit unless otherwise stated.

4. All control cables shall be PVC insulated sheathed, 2.5 mm² copper conductor cables of 600/ 1000V grade as per BS 5467.

5. Fire resistant polymer cables shall be used for power feeders serving life safety equipment.

6. No cables smaller than 2.5 mm² shall be used and cables of 2.5 mm² and above shall be multistrand.

7. All earth cables shall be in accordance with the requirements specified in Section 260526 Grounding and Bonding for Electrical Systems.

8. Cables shall be sized in accordance with the requirements specified in Section 260100 Operation and maintenance of electrical Systems.

9. All conductors shall have the colour impregnated into the insulation at the time of manufacture.

10. Painting of conductor insulation shall not be accepted.

11. Type and size of Cables shall, as a minimum, be as indicated in the electrical diagrams, electrical load schedules and other related Design Drawings. Final subject to shop drawing development based on installation routes and loads.

12. Unless otherwise indicated, the following final sub-circuit connection and wiring details shall apply throughout the works as a minimum:

    a. Lighting Circuits up to 1000 Watts: 10 amp breaker protection wired with 3 x 2.5mm² single core PVC insulated copper wires.

    b. Lighting Circuits 1000 to 1800 watts: 15 amp breaker protection wired with 3 x 2.5mm² single core PVC insulated copper wires.

    c. High integrity earthed 13 amp socket outlets: 32 amp breaker protection on ring main basis wired with 4 x 4mm² and 2 x 4.0mm² single core PVC insulated copper wires.

    d. Clean earth 13amp socket outlets: 32 amp breaker protection on ring main basis wired with 4x4mm² and 2 x 4.0mm² single core PVC insulated copper wire

    e. Unit water heaters up to 3 KW rating: 20 amp breaker protection Wired with 2 x 4mm² and 1 x 4mm² single core PVC insulated copper wires.

    f. Domestic cooker control unit: 40 amp breaker protection wired with 3 x 10mm² single core PVC insulated copper wires.

g. Fan coil units each: 15 amp breaker protection wired with 2 x 4mm² and 1 x 4mm² single core PVC insulated copper wires.

h. Electric hand dryers: 20 amp breaker with 30 mA earth leakage sensitivity protection Wired with 2 x 4mm² + 1 x 4.0mm² (2Kw rating) single core PVC insulated copper wires.

i. The above details for connections shall apply throughout the Works, except where the IEE Regulations would be contravened. In such cases the Contractor shall utilize a larger conductor size as appropriate.

13. Cable specification and manufacture shall be consistent throughout each wired system. All cable utilized shall be continuously run from source to termination, without any through jointing included.

14. Cable shall be adequately stored and protected from damage pending installation and also during installation until permanent protection is affected.

15. Cable reels shall be supported on purpose formed support frames and under no circumstance shall cable be drawn from reels laid on the ground. This shall be strictly enforced, as the Engineer's condemnation of any cable that is considered to have been abused shall involve total replacement at cost to the Contractor.

16. The cross sectional area of every cable shall be suitable for carrying the maximum sustained load current under normal conditions and shall be selected in accordance with IEE Regulations.

17. The cross sectional area of the neutral conductor for 3-phase circuits shall be equal to the cross sectional area of the phase conductors.

18. The cables shall be selected such that the drop in voltage from the origin of the installation to any point in the installation does not exceed 4% of the nominal voltage when the conductors are carrying the full load current, but disregarding starting conditions. Voltage drop calculation shall be submitted for approval and the cross sectional area of the cable shall be increased accordingly if required to meet the above mentioned requirement without any extra cost.

19. The cables connected in parallel shall be of the same type, cross sectional area, length and disposition and be arranged so as to carry substantially equal load currents.

20. Where cables are to be connected to the busbars, breakers etc. the insulation and/ or sheath shall be removed for a distance of 150mm from the connection and replaced by suitable heat -resisting insulation.

21. The wire armour of single core cables in the same circuit shall be bonded together at both ends.

7.4 MATERIALS

A. General

1. PVC insulated, non-armored single core stranded copper conductors not less than 2.5mm² and not less than 750 volt grade for all types of branch circuit wiring in conduit to BS 7655. Size of cables shall be as detailed on Design Drawings.

2. Heat resisting three core circular flexible cable, copper strands and rated not less than 15 amp, to BS 5467. Compression glands shall be used for making final termination to conduit systems.

3. Mineral insulated cables from single core through to four core.

4. Copper conductors and copper sheath with PVC outer covering over sheath. Not less than 750 volt grade.

5. Factory made glands, pots, seals and neoprene sleeving for making termination of the cable.

6. Saddles and clips as specified elsewhere in these documents.

7. Bending and straightening tools for the installation of the cable.

8. General: Cable marking tabs for identification of circuits.

B. Conductor Sizes for Lighting, Power and Controls

1. Conductors for all cables and flexible cords provided on this Contract shall be to standard metric cross-sectional areas and stranding. The terms 'hard wiring' conductors shall mean those conductors installed within raceways and multi-core armoured or metal sheathed cables, excluding mineral insulated copper sheathed cables which by nature of their manufacture, shall be solid hard drawn conductors with the cross sectional area as indicated on the Design Drawings and Load Schedules.

2. Hard wiring conductor sizes smaller than 2.5 mm^2 for lighting circuits and 4mm^2 for small power circuits shall not be used. The sizes of current carrying conductors for all sub-circuit and distribution wiring shall be as indicated on the Design Drawings, Load Schedules and in these specifications, and shall comply with the regulations of authorities having jurisdiction.

C. Cable Cores

1. The metal core of the conductor shall be annealed high conductivity copper. Rubber insulated cables shall have high conductivity tinned copper conductors.

D. Cable Insulation

1. The core of each conductor shall be surrounded by insulation. The insulation shall have a constant thickness which shall not be less than those given in the relevant BS Specifications. The insulation characteristics and testing shall correspond with the requirements of these standards. The characteristics of cross-linked polyethylene shall conform to the requirements of BS 6724 Standard. The mix composition shall satisfy the stringent requirements regarding water absorption and the addition of the appropriate stabilizing agent to prevent aging.

2. The insulation shall be applied by extrusion, hard against the core, without however, adhering to it, in a single layer.

3. No natural rubber or synthetic Butadiene-styrene insulated cables shall be used.

4. The synthetic rubber used in the manufacture of flexible cable shall have excellent resistance to thermal aging, good flexibility and low water absorption properties.

5. Flexible cables which are synthetic rubber insulated shall not be used wherever cables are subjected to mechanical stress.

6. High temperature PVC or silicone rubber insulated cables shall be used where high ambient temperatures are expected. They shall be designed to function continuously in an ambient temperature range between 80°C and 150°C.

E. Cable Outer Covering/ Sheaths

1. Unless specified otherwise, multi-core cables shall have one or more outer coverings and armouring. The outer covering shall ensure the following characteristics:

   a. Resistance to vermin.

   b. Resistance to oil.

   c. Satisfactory thermal aging.

   d. Resistance to mechanical stresses and to abrasion.

   e. Waterproof.

   f. Non-flame propagating property.

2. The outer covers shall be PVC or LSF types and single wire armour.

3. The PVC / LSF outside sheaths shall be of homogenous manufacture, consist of a single layer and be flexible.

4. Single conductor armoured cables shall have non-magnetic armouring of aluminum wire or strip. The armouring of all single core cables in the same circuit shall be solidly bonded together at both ends of their run.

F. Cables covered in this specification shall be used on 400 V 3 phase, 4 wire 50 Hz neutral solidly earthed systems. Cable Construction shall be as follows:

1. 600/ 1000V Low Voltage XLPE insulated, LSZH inner sheath, SWA, LSZH outer sheathed power and control cables.

   a. Conductors: Stranded annealed high conductivity copper. Circular or shaped section.

   b. Cable shall comprise of plain copper, stranded circular conductors insulated with an adequate thickness of extruded cross linked polyethylene (XLPE).

   c. Conductors shall be laid up together and warmed circular with suitable performed fillers and warnings, bound with LSZH tape and covered with an the outer sheath of cable which shall be an extruded layer of low smoke zero halogen colored black, intrinsically flame retardant and anti-termite protected and emitting very low levels of smoke and non - toxic levels of poisonous halogen gases (typically less than 0.5% HCI emission).

   d. Armoured multicore cable shall have steel wire armouring and extruded sheath of black LSZH.

   e. Armoured single core cable shall have aluminium wire armouring and extruded sheath of black LSZH.

   f. Outer sheath of single core cables shall be at least 2.5 mm thick.

   g. Conductor screen: non-metallic comprising either semi-conducting tape or a layer of extruded semi-conducting material.

   h. Prevent void formation in insulation by careful control of its passage through temperature graded water baths.

   i. Cable shall be terminated with compression glands as specified below, giving adequate mechanical support by locking on the armour and ensuring high earth continuity.

   j. Armoured single core cable from transformer to LV Panels shall have copper wire armouring as per DEWA.

   k. Up to four cores colored (Red, Yellow, Blue, Black). All control cables shall be colored white with black numbers along the length of cores at 150mm intervals. Core numbering shall be of the non-fading type. 3 core cables used for lighting shall have (red, black, green, yellow colours for the core).

   l. Power cables installed within the building shall be of BS 6725 XLPE/ SWA multi or single core PVC insulated copper with low smoke zero halogen outer and inner sheath.

2. PVC/ SWA/ PVC Cable

   a. Cables shall be 600/ 1000V grade complying with BS 6346, copper core, PVC insulated, extruded PVC bedded, steel wire armoured and PVC sheathed.

   b. Conductors shall be high conductivity stranded copper conductors complying with BS 6360, each conductor core shall be of the same cross-sectional area.

   c. The insulation of cores shall be PVC type TI1 complying with BS 6746.

   d. The bedding shall be an extruded layer of type TM1 compound complying with the requirements of BS 6746.

e. Each core of the cable shall be identified by the appropriate colour as specified in BS 6346 throughout the whole of the insulation.

f. Wire armour shall consist of a single layer of galvanized steel wire of sizes as shown in the appropriate table in BS 6346 and comply with BS 1442.

g. The over sheath of the cables shall be an extruded layer of black PVC complying with the requirements of BS 6746 type TM1 compound and shall comply with the requirements of IEC 60332 for flame retardance. The PVC material shall contain approved anti-termite additives.

3. 450/ 750V PVC insulated single core cable (wire) for use in conduit

a. Cable shall be to BS 7211, rated 450/ 750 V, with high conductivity copper conductors and extruded polyvinyl chloride (colour red, yellow, blue, black etc, as required) insulation.

b. Colour coding shall be in accordance with table 51 A of BS 7671.

c. Wires shall be continuous from outlet to outlet and no splice shall be made except within outlet and junction boxes. A separate neutral wire shall be provided for each circuit. Wires shall be left sufficiently long enough (minimum 150 mm) to permit making final connections.

4. 600/ 1000V PVC Insulated PVC Sheathed (PVC/ PVC) Cable:

a. To BS 6346, 600/ 1000V Grade, or to BS 6004, 300/ 500 V Grade

b. Flat twin and three core cable shall be to BS 6004 and incorporate an earth conductor placed between the red and black cores for two core cable and between the yellow and blue cores for three core cable

c. Conductor: annealed high conductivity copper, stranded, shaped and laid in an approved manner.

d. PVC for sheath and insulation: to BS 6724

5. Mineral Insulated Cables:

a. To BS 6207: Part 1, rated 600/ 1000 V and IEC 60331 Fire Resistance test.

b. Cable shall comprise of a pressure packed magnesium oxide insulation contained within a continuous soft ductile copper sheath and copper conductors embedded in the dielectric in standard formation.

c. Cable termination kit shall comprise of conductor insulation of neoprene sleeving retained by cone shaped beads beneath a fiber sealing disc. Each conductor shall be identified with regard to phase etc, by means of sleeving placed over the neoprene insulation.

d. Cable seals shall comprise of screw-in-pot type seals, with brass ring glands designed to accommodate the pot seal.

6. Heat Resistant and High Temperature cable:

a. To BS 6500, or BS 6004 300/ 500 V grade, designated EPR (ethylene polypropylene rubber) insulated HOFR sheathed, 85 °C or EPR insulated OFR sheathed, 60 °C.

b. Conductor(s) shall be flexible class 5 tinned copper to BS EN 60228.

c. Insulation shall be type GP.1 to BS 7655-2-2. Outer sheath shall be HOFR (heat, oil, fume resistant) or OFR (oil and fume resistant) sheath type RS3 to BS 7655-2-2 and flame retardant to IEC 60332-1-2, temperature rating 60 ° or 85 °C.

d. High temperature cable shall be to BS 6500 or BS 6007, designated 300/ 500 V grade silicone insulated glass braided, 180 °C.

e. Conductors shall be flexible class tinned copper to BS EN 60228. Insulation shall be silicone rubber type EI 2 to BS 7655-2-2. Outer sheath shall be treated glass fiber braid, temperature rating 180 °C.

7. Fire Resistant Cable - General

a. Power supply cables feeding power to equipment such as lifts and other lift safety equipment shall be fire rated cables.

b. Fire resistant cables shall be used for all equipment related to life safety, including, but not limited to the following:
   1). Emergency lighting circuits (Central Battery System).
   2). Elevators.
   3). Fire Pumps
   4). Fire Alarm Control Panel.
   5). Complete Fire Alarm Cabling.

8. Fire Resistant Cables: (Single core up to 25mm²)

a. Shall be LSOH rated for 450/ 750V to BS7629.

b. The cable shall meet categories CWZ of BS6387 and shall pass the test requirements of IEC 60331. The cable shall comply with BS EN 50268-2 on smoke emissions and has acid gas emissions < 0.5% when tested to BS6425-1.

c. Cable shall be flame retardant to IEC 60332-1-2 and reduced flame propagation to IEC 60332-3-24 category C.

d. The cables shall have the approvals of British Approvals Service for Cables (BASEC) approved to BS7629 and Loss Prevention Certification Board (LPCB) approved to BS6387, category CWZ and BS7629.

e. Shall have annealed copper conductors complying BS EN 60228

f. Cable shall be suitable for wiring in conduit or in trunking. All cables shall be installed in accordance with the appropriate regulations, including IEE or any other national legislation.

g. The cables shall not be used in hazardous areas, zones, 0, 1 and 2 as defined in BS EN 60079-1

h. Shall be suitable for continuous operation at temperatures up to 90ºC.

9. Fire Resistant Cables (Multi-Core Up to 400mm²)

a. Fire resistant cable shall maintain circuit integrity during a fire.

b. Shall be available in multi-core designs from 1.0mm2 to 400mm2 in 2, 3, and 4 Core. Shall be Fire resistant to IEC 60331 and comply with BS6387 categories CWZ. Shall be approved by Loss Prevention Certification to BS 6387, categories CWZ.

c. Shall be suitable for use to satisfy the requirements of the BS 9999 for the operation of equipment in the event of fire. Shall be a low smoke zero halogen (LSOH®) cable, which produces very low quantities of smoke, and virtually no acidic gas, satisfying BS6724.

d. Shall be to IEC 60332-1-2 with reduced flame propagation to IEC 60332-3-22/ 23/ 24.

e. Armoured cable that is highly resistant to third party damage. Easy handling and installation so similar in design to familiar armoured cable, no special installation skills are required. Shall be rated for 600/ 1000V and shall be surge resistant.

f. The cable shall meet the requirements of IEC 60331 and BS6387 categories CWZ. When the complete cable is tested in accordance with BS6724 or with BS EN 50268-2. It shall meet the minimum light transmittance

requirements as stated in BS6724 or BS EN 50268-2. When tested in accordance with BS EN 50267-1, all non-metallic components shall give a level of HCI not greater than 0.5%.

g. Shall meet the requirements of IEC 60332-3-24 category C.

h. Shall meet the approval of British Approval Service for Cables (BASEC) approved to BS7846.

1). LPCB approved to BS6387, categories CWZ for cables up to 20 mm overall diameter.

2). Additional tests passed and witnessed by recognized third parties e.g., Lloyd's Register.

i. Shall be plain copper stranded circular conductor complying with BS EN 60228.

j. Insulation - Mica/ Glass Fire Resistant tape covered by an extruded cross-linked insulation complying with BS7655 type GP8 or type GP6, operating temperature 90ºC.

k. Cores identified as follows:

1). 2 Core black, red.

2). 3 Core red, yellow, blue.

3). 4 Core red, yellow, blue, black.

l. Cores are laid up with fillers and binder tape as appropriate.

m. Bedding - Extruded layer of LSOH® bedding compound.

n. Armour - Single layer of galvanized steel wires.

o. Outer Sheath - extruded LSOH® sheath complying with BS7655 type LTS 1.

p. All cables shall be installed in accordance with the appropriate regulations including IEE Wiring Regulations or any other national regulations.

10. Flexible Cord

a. Flexible cord shall comply with BS6007, PVC insulated with flame retardant white circular PVC over sheath to BS 6500 at 450/ 750V grade.

b. Flexible cord shall be multi-strand copper conductor insulated by vulcanised rubber, PVC, butyl rubber, ethylene propylene rubber (epv), silicon rubber or glass fiber. Cord shall be twin or three core with colour code brown for line, blue for neutral and green/ yellow for earth complete with PVC or CSP (chlorosulphorated polythene) sheath.

c. Cord shall have cross-section area of not less than 0.75 sq. mm and shall be held firmly by cord grips provided in plugs.

d. Cords shall be used for pendant fixtures, portable lamps, portable appliances and stationary equipment. Cord shall not be permanently fastened to building surfaces and shall not pass through holes in wall, ceiling, floor, door-way and window.

11. Cable Glands

a. Cable glands shall be used for terminating cables to switch gear, switch boards, Motor Control Panels, motors and other equipment

b. They shall be brass compression glands and comply with the relevant part of BS 6121, except for MICC cables, which shall comply with BS EN 60702-2.

c. Glands for armoured or screened cables shall have suitable clamps.

d. External compression glands shall have close fitting PVC shrouds, earthing for armouring and metallic sheaths: suitable brass or copper clamps and copper strip conductor in accordance with local power authority requirements, and not less than 2.5 sq. mm.

12. Cable Sealing Compounds

a. Shall: be tropical grade to BS 1858 or BS 6910 and approved by cable manufacturer, of an oil resisting compound where the difference in level between cable ends exceeds 6 m.

13. Cleats:

a. Shall be approved claw type cast aluminium, gunmetal, plastic or brass of approved type, two bolts fixing for cables greater than 50 mm diameter

14. Cable Markers:

a. Shall be precast concrete, minimum size 300 x 300 mm x 100 mm deep.

b. The markers shall be engraved "HV CABLE", "ELECTRIC CABLE", "ELV CABLE", "EARTH PIT" or "CABLE JOINT", as applicable cable marker construction.

7.5 CABLE CORE IDENTIFICATION

A. The colour identification for single core insulated cables shall be as follows:

1. Phase conductor: Red, Yellow or Blue.

2. Neutral conductor: Black.

3. Protective conductor: Green or Green/ Yellow

B. The colour identification for multi-core insulated cables shall be as follows:

1. Two core

a. Red (Phase conductor).

b. Black (Neutral conductor).

2. Three core: Red, Yellow and Blue (Phase conductor).

a. Four core

b. Red, Yellow and Blue (Phase conductor).

c. Black (Neutral conductor).

3. Control wiring: White with black numbers along the length of cores at 150mm interval with cable marker to match the diagrams at each point of connection and termination.

4. Neutrals: Shall be color coded black.

5. Earth wires: Shall be color-coded green/ yellow striped.

C. All cables which do not form part of the mains voltage power and lighting distribution system shall be wired in white cables which shall be fitted with numbers tight-fitting rubber or plastic marker sleeves, at each end, as listed below. Combinations of markers each bearing a single digit may be used to make up each number.

1. The sleeves for fire alarm system cables shall be numbered:

    a. 100 for positive or live feed conductors.

    b. 110 for negative or neutral conductors.

    c. 121 up to and including 399 used in sequence as necessary to identify individual alarm detection circuits.

    d. 401 up to and including 599 used in sequence as necessary to identify individual plant/ equipment activation relay circuits.

2. The sleeves for fire alarm sounding system cables shall be numbered:

    a. 600 for positive or live feed conductors.

    b. 610 for negative or neutral conductors.

    c. 620 up to 749 for individual alarm sounding circuits switch lines in sequence.

D. The core identification for mineral insulated cables shall be as previously specified for multicore cables with tight fitting sleeves being used on cable tails.

7.6 TEMPORARY WIRING

A. No part of the new installations shall be connected temporarily to the Supply Authority's mains without the approval of the Engineer and the Authority.

B. All temporary lighting and electric wiring which the Contractor may require shall be provided by the Contractor who shall be responsible for all charges for electricity consumed as stated in the Contract conditions.

C. Temporary wiring and connections executed by the Contractor to the instructions of the Engineer shall be arranged in accordance with the IEE Regulations. Where the ambient air temperature is in excess of 50°C. heat resisting silicon rubber cables shall be used for temporary connection. Where such cables may be subject to mechanical damage they shall be protected by conduit.

8 PART 3 - EXECUTION

8.1 EXAMINATION

A. Verification of Conditions: Examine areas for compliance with requirements for installation and conditions affecting performance of the Work. Identify conditions detrimental to a proper and timely completion and notify the Engineer of the unsatisfactory conditions. Proceed with installation only after unsatisfactory conditions have been corrected.

B. All wire and cable shall be examined prior to installation. Do not use wire and cable with bruised, cut or abraded insulation, or wire that does not pass a continuity test.

8.2 CABLE SIZES

A. The sizes of all main and sub-main cables shall be as, as a minimum, be as indicated on the Design Drawings.

B. Sizes have been determined by reference to various factors including the relevant IEC, BSI standards for cable rating, and ambient temperature of 50°C for cables installed inside the complex and 85°c for cables installed exposed outside the complex and the run lengths have been taken as the most direct route consistent with the main cable routes indicated on the drawing. The Contractor shall re-evaluate the cable sizes and provide full details for the Engineer's review based on the final shop drawing installation arrangements.

C. Multi-core cables with reduced neutral conductor shall not be permitted.

8.3 INSTALLATION

A. Installation of Multi-Core Armoured and Metal Sheathed Cables

1. No cable installation work shall be carried out in temperatures at which the cable being installed is likely to suffer damage.

2. The arrangement of cables and all methods of installation shall be reviewed by the Engineer.

3. Cables shall be installed from terminal point to terminal point and straight through joints shall not be made unless approved. Where a run of MICC cable is of a length which exceeds the maximum which can be manufactured, a through joint of a pattern agreed with the Engineer shall be permitted.

4. The radius of each bend or change in direction of the route of any cable shall not be less than that laid down in the relevant table or current issues of the IEE Regulations and the relevant British Standards Specification and shall not be less than the manufacturer's recommended minimum.

5. The spacing of cable supports shall be those laid down from the relevant size and type of cable in the current issue for the IEE Regulations, but the horizontal longitudinal distance between wire armored cable support centers shall not exceed 1 meter, the horizontal distance between support centers of unarmored cables shall not exceed 800mm and the distance between support centers for either type of cable on vertical runs is not to exceed 1 meter. Cable of and less than 50mm external diameter shall be supported at not less than 800mm centers.

6. The cables may be installed in a number of different ways:

   a. Installed in floor trenches with concrete walls and base.

   b. Installed to concrete encased duct banks.

   c. Installed on racks.

   d. Installed on cable tray or ladder systems.

   e. Fixed to concrete, brickwork and block work. (For MICC cables only).

f. Fixed to steelwork.

7. Single core cables forming a three phase group shall be fixed in trefoil cleats of the alloy pattern. Flat formation may be used where specified.

a. Pull cable into position by hand, where possible using an adequate number of operative roller guides suitably positioned along cable length.

b. Obtain approval of pulling cables by winch or similar appliance when pulling by winch or the like, fit a suitable tension gauge into the haulage line between winch and cable. Pulling tension shall not exceed the limit recommended by the cable manufacturer.

c. Do not allow cable to twist or rotate about its longitudinal axis.

d. Damaged cables shall be removed, unless agrees to a repair.

e. All wiring of multi-point circuits shall be carried out in a 'looping-in' system and joints and connections other than those required for the connection of switches, fuses, socket outlets, motors, etc, shall not be allowed.

f. PVC cables shall not be in direct contact with any form of polystyrene used in the building.

g. PVC cables shall not enter any luminaire or heat-producing equipment. In the case of tungsten luminaries, heat-resisting cables shall be installed from the luminaries to the lighting switches or equivalent. In the case of fluorescent luminaries high temperature PVC cables shall be installed from the lighting switch or equivalent. In the case of recessed tungsten and fluorescent luminaries and heat producing/ emitting equipment having final connections effected using flexible cables, final connections shall be made using heat-resistant flexible cables.

Where cables are permitted to traverse channel-ways or similar on continuously mounted fluorescent luminaries, heat-resistant cables shall be used throughout.

h. Soldered connections or lugs shall not be permitted. All conductors requiring bolted connection shall be terminated with compression lugs using an automatic compression crimp tool which will only release after the correct crimp depth has been obtained.

All bolted connections shall have spring washers. Pinch screw terminals may not be used for conductors greater than 6.0 MM2.

i. All single strand cables shall be doubled back on themselves when terminations are made.

j. PVC cables shall not be used for final connections to any appliances containing a heating element or any appliance emitting heat. Where flexible conduit is used a final connection wiring medium, heat-resistant cables shall be used and these shall commence at the solid conduit end of the flexible conduit provided it is not in a heated area. If this is not possible, heat-resistant cables shall be run back to the first switch not in a hot area.

k. PVC cables shall not exceed the capacity of the conduit or trunking. The installations shall comply strictly with the IEE Wiring Regulations regarding capacity of conduits and trunking for 450/ 750 V cables, but a space factor of 40% shall not be exceeded for trunking.

l. Circuit protective conductors shall be used throughout the installation and these cables shall be the same grade and temperature rating of the live conductors of the circuit.

The conduit and/ or the trunking system shall not be used exclusively as a circuit protective medium. Circuit protective conductors shall be colored green and yellow.

The cross-sectional area of protective conductors shall be in strict accordance with the requirements of the IEE Wiring Regulations.

m. Cables shall be drawn-in a careful and workmanlike manner.

Cables shall be 'combed' as drawing-in proceeds and the neutral and circuit protective conductor of each circuit shall be run with the phase cable(s) of that circuit.

Cables of one circuit shall run in the same conduit.

Cables of a circuit when run in trunking shall be 'grouped' together with approved plastic binding clips. Tape shall not be used.

n. Clip cables neatly to tray with cable separation and support spacing as recommended by the manufacturer.

o. Where more than two power cables are run together, provide a cable tray. Secure cables with cleats, saddles or ties as appropriate for location and use spacers where more than one layer is required.

p. Install cables in accordance with the manufacturer's instructions and using the manufacturer's approved terminating devices and considering the manufacturer bending radius.

q. Terminate all single conductor cables entering steel cabinets in a non-ferrous plate.

r. Where cables pass through a floor or fire barrier provide a cable transit or equivalent fire stop with openings sized for the cables.

s. Run surface cables similar to exposed conduit installations. Run cables concealed above ceilings in finished areas. Where exposed, run parallel to building lines. Avoid proximity to water.

t. The phase of each conductor termination or joint shall be indicated by applying red, yellow and blue identification tape to the phase conductors. The neutral identification of black will be associated with the neoprene sleeving, without the addition of identification tape. The installation of MICC cables shall be carried out in accordance with approved manufacturer's printed recommendations by electricians experienced in such work.

u. Cable joints in circuits shall not be permitted. Where a cable is terminated at a motor terminal box the cable shall be looped to absorb vibration. The loop shall be so formed and positioned to be free from mechanical damage.

v. Where single-core cables are used the cable gland entry holes shall be slotted to prevent circulating currents.

w. Runs of two or more cables shall be fixed to galvanized cable tray by means of multi-way 2 hole saddles at intervals not exceeding:
   1). 450 mm for cables up to 2.5mm²
   2). 600 mm for cables up to 6 mm² core
   3). 750 mm for cables 10mm² core upwards

   Under no circumstances shall the copper sheath be in contact with the galvanized tray.

x. Where cables terminate at a surface or flush box with a drilled entry, the gland shall terminate with a coupling, proprietary compression washer and male bush. This does not apply to spout boxes.

y. Where surface mounted equipment is to be installed on a concealed MICC installation the cables shall terminate in a flush mounted box (adaptable or circular) and the back of the equipment shall be drilled and bushed for back entry. The equipment shall be installed over to conceal the box.

z. All conductors requiring bolted connections shall be terminated with compression lugs using an automatic tool which will only release after correct crimp depth is obtained. Soldered connections or lugs are not permissible.

aa. In surface installations, the cables shall run in a manner which shall be as inconspicuous as possible. The runs shall be truly vertical and truly horizontal and parallel with the features of the building.

bb. After 'marking off' all cables shall be tested with a 1000 V 'Megger' before erection. All cables shall be tested not less than 24 hours after completion. Nothing less than an infinity reading will be acceptable between conductors or between any conductor and the cable sheath, and conductors being disconnected from the apparatus. The Contractor shall provide evidence of these tests to THE Consultant.

cc. In all cases where cables pass through floors or walls, steel pipes shall be Inserted in the floors or walls to protect the cables as they pass through these structures. These pipes shall extend to a height of 250 mm above finished floor level or 76 mm either side of any wall. In all cases these pipes shall be so fitted as to blend into the building surfaces.

dd. All cables shall be run either vertically or horizontally and where installed on the building surface. The cable is to be concealed wherever possible, being run in false ceiling spaces and as approved by The Engineer.

B. Cables Laid in Ducts

1. Where cables are indicated as being in ducts on the Design Drawings, the cables shall be drawn into ducts. The removal of temporary plugs, rodding and cleaning of the ducts shall be the responsibility of the Contractor who shall seal the ends of these ducts immediately after installation of the cables by firstly caulking with hemp and spun yarn, then a 150mm fill of plastics compound and a final wood infill block.

2. Particular attention shall be given to the sealing of ducts where any of such ducts enter cable trenches within the confines of the complex.

C. Cables in Covered Concrete Trenches

1. All cables shall be so arranged and fixed that any one cable may be removed without disturbance of the remainder.

2. XLPE/ SWA/ PVC multi-core cables shall be installed on cable racks or tray work fixed to backstraps which in turn are fixed to the side of the trench.

3. All single core phase cables shall be AWA and installed in die-cast, non-ferrous, trefoil cleats and neutral cables in similar single way cleats of the same manufacture. Flat formation may be used in specified cases when approved cleats shall be used.

4. MICC cables shall be installed on cable trays and secured to backstraps fixed to the side of the trench. Such cables shall be saddled to this cable tray at intervals of not more than 500mm.

5. The crossing over of cables in the same trench shall be avoided as far as possible. All unnecessary bends shall be straightened after laying.

6. In very exceptional circumstances, and then only by agreement with the Engineer, cables installed under this method shall be laid in the bottom of trenches and then in a neat and orderly manner, complete with steel support underneath.

7. The laying of cables shall require the removal of trench covers from time to time, and the Contractor shall include in his price for the removal and immediate replacement of covers after laying each cable. The trenches shall not at any time therefore be left to be fouled and trench covers damaged. Whilst trenches are open the Contractor shall be responsible to ensure that covers are undamaged and trenches are clean before recovering; any damage to covers shall be made good by the Contractor at his own expense.

D. Cables on Racks

1. Where agreed with the Engineer, a cable racking system may be run. The rack shall be of adequate width for disposing the cables with a width allowance of 25% for additional cables. Care shall be taken to ensure that the rack does not foul overhead cranes, doors or other features. The rack shall be of such strength that, when loaded with all the cables for which it is designed, plus an additional 15kg/ m, it shall not deflect from the horizontal by more than 3°.

2. The Contractor shall supply where necessary all steel racks, fixing bolts, etc., for supporting the cable, including marking out and checking.

3. Cables shall be supported on steel racks using approved cleats. All single core phase cables are to be installed in die-cast, non-ferrous, trefoil cleats and neutral cable in similar way cleats of the same manufacture unless flat formation is used when single cleats may be used.

4. For cables of core area of and less than 25mm² multicore cleats on a common bolt or spindle shall be acceptable. Multiple cable shall be secured with PVC cleats at a spacing consistent with the size of cable used.

5. Special care shall be taken in cable handling during erection to avoid the slightest damage to cables. When cables are clamped in the racks, the Contractor shall ensure that undue stress is not placed on any sheathing or armoring.

6. All supports and racks shall be arranged as far as practicable for the easy removal of any single cable in a multi-cable run, without disturbing other cables and without threading through supports or racks.

7. Cutting away, fixing and grouting of raw bolts and making good shall be done by the Contractor. Cables shall be run in a near and orderly manner. The Contractor shall be responsible for the design and detailing of the steelwork for cable racks and shall submit such design for review before putting the work in hand. The Contractor shall include the cost of this design work in his price for this method of installation.

E. Cables on Trays

1. Trays shall be adequately supported to prevent sagging by more than 3° between fixed points; all supporting steelwork shall be fixed at no more than 1m centers unless otherwise specified.

2. All cables shall be saddled to tray work. MICC cabling shall be saddled at not more than 500mm centers and all other cabling at no more than 1m centers.

3. All cables, other than pilot or control, when installed on trays shall not be in more than one layer.

4. The saddling of MICC cable to tray work shall be by 12mm copper strip unless otherwise specified.

5. Clear spacing between power cables shall be equal to minimum twice the diameter of the cable throughout the entire length of cables.

F. Cables Fixed to Concrete, Brickwork and Blockwork

1. Cables run individually shall be saddled with spacer bars at intervals of not more than 500mm. Where five or more cables are required to be supported, the fixing saddles and spacer bars shall be fabricated from 12mm copper strip.

2. Where multiple runs of cables are to be installed along walls, or in ducts, the hangers shall be of the 'claw' type sized to suit cables and mounted on slotted channel the full height of the ducts.

3. All cleats, clamps and hangers shall have rounded edges and a single lapping of bitumastic felt inserted between the cable and the metalwork of any hanger or bracket. Spacing of fixings shall be in accordance with the relevant IEE regulations and where a number of cables are run together, the spacing of the fixings shall be that required by the smallest cable in the run.

4. Bends in cables shall not exceed the limits as laid out in the IEE regulations or relevant manufacturers recommendations whichever gives the largest radius.

5. Cables installed in open positions shall be cased to the full height of the cable. Wherever possible sheet steel of not less than 2mm shall be used for this purpose.

G. Cables Fixed to Steelwork

1. Structural steelwork shall not be drilled for cable fixing. Individual cables other than MICC cable run on steelwork shall be supported in cleats fixed to backstraps clamped or welded to the structural steelwork. These cleats shall be spaced so as to avoid sagging of cables and in no case at more than 1m between centers.

H. Cable Routes

1. The Contractor shall be responsible for ascertaining the lengths of all cables covered by the Specification and to be supplied under this Contract.

2. Final cable routing details are to be issued to the Engineer for review.

I. Special Tools

1. one month prior to issue of Practical Completion Certificate, turn over to the Employer all tools required for MICC cables installation:

2. Stripping tool for each size used - 1 No.

3. Potting tool including cable wrench - 1 No.

4. Crimping tool for each size used - 1 No.

5. Bending machine - 1 No.

6. Tool for aligning cable - 1 No.

J. Fire Barriers

1. Where conduit, ducting and/ or trunking pass through fire-resistant structural elements such as walls and floors designated as fire barriers, the openings made shall be sealed according to the appropriate degree of fire resistance. In addition to this external fire barrier, an internal fire-resistant barrier shall also be provided to prevent the spread of fires.

K. Terminations

1. All cable conductors shall be fitted with a correctly sized cable socket or thimble and a means of identification. The cable sockets may be of the sweated or crimped compression types. If for the former the solder should have a melting point of not less than 185°C. And if for the latter they shall be the appropriate tools as specified by the manufacturers of the joint connectors. The cable terminations shall be made following the positive identification of the conductors in accordance with the specified phase rotation sequence.

2. Cable lugs shall be tinned copper compression type.

3. Cable glands shall be brass double sealed compression type with earth clamping features to IP 55.

4. Cable insulation/ sheath shall be removed for a distance of 150mm from the connection and replaced by suitable heat resisting insulation.

5. Joints in XLPE cable shall not be carried out.

6. All cable terminations shall be strictly in accordance with cable manufacturer recommendations.

7. Termination kits shall be compatible to the cables used with the same shall be confirmed by cable manufacturer.

8. Insulation tape use is not permitted.

8.4 CABLE PROTECTION

A. Sleeves consisting of plastic conduit shall be installed for all cables passing through brick, concrete and similar structures to permit future withdrawal without disturbing the structure. All sleeves shall be tightly packed with fire-resisting material of approved type.

B. All exposed or concealed cables rising from the ground or floor as well as horizontally run cables 2 meters or lower from finished floor level shall be protected. The protection shall be by means of galvanized steel tube or metal channel of minimum thickness 2mm.

C. All data communication and telephone cables installed in trays shall be protected throughout the entire run. Means of protection shall be by manufacturer supplied perforated galvanized steel covers.

8.5 SITE QUALITY CONTROL

A. Wire and cable shall be delivered to the job in standard coils or reels with approved tag noting length, wire size, insulation type, and manufacturer's name, suitably protected from weather and damage during storage and handling.

B. Inspect wire and cable for physical damage.

C. Cable Testing: Inform the Engineer prior to the testing of the cables and be responsible for liaising with any other Subcontractor to whose equipment the cables may be terminated to ensure that all parties concerned are aware of the impending tests, to guarantee the safety of personnel and that the isolation of any equipment has been completed. Any special isolation or preparation required to be carried out before cable testing can be completed, shall be carried out by the Specialist Subcontractor responsible for that equipment. All tests shall be carried out by the Specialist Subcontractor but shall be supervised by the Engineer.

1. Provide DC test equipment and apply, after isolation, in the presence of the Engineer, the following DC test voltages on all cables between cores, cores and sheath and cores and armor:

   a. PVC SWA PVC and XLPE SWA PVC 1000V grade cable.

      1). Between cores: 3500V.

      2). Between core and armor: 7000V.

2. Demonstrate correct phasing of cores in all cables throughout the works and test the insulation of all cables, both between the cores and between the cores and earth, during installation with a 500V insulation tester.

D. All cable type shall have been subjected to Type Tests in accordance with the relevant IEC or British Standards. Type test certificates shall be furnished.

E. All cables shall be subjected to routine tests at the cable manufacturer's works in accordance with the relevant IEC or British, tests shall be subject to the Engineer witness if required.

IV. WIRING SYSTEMS - MICS CABLES

9 PART 1 - GENERAL

9.1 CODES AND STANDARDS

A. Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

International Codes:

BS 6207	Mineral insulated cables with a rated voltage not exceeding 750V. Guide to use
BS 7671	Requirements for electrical installations IEE Wiring Regulations
BS EN 60702-1	Mineral insulated cables and their terminations with a rated voltage not exceeding 750V. Cables
BS EN 60702-2	Minerals insulated cable and their terminations with a rated voltage not exceeding 750V. Terminations

10 PART 2 - PRODUCTS

10.1 WIRING SYSTEMS - MICS CABLES

A. MICS cables shall comply with BS EN 60702-1, BS EN 60702-2 and BS 6207 and be 600V grade light duty, or 750V grade heavy duty, LSF sheathed overall as indicated. Unsheathed cable shall not be used without the specific approval of the Engineer.

B. Where the cross-sectional area of the number of cores required is outside the range of 600V grade, then 1000V grade, heavy duty shall be used.

C. Where conductor sizes are not indicated in the specification and/or the associated drawing(s) they shall be selected in accordance Appendix A7(e) A7(g) of The Electricity Wiring Regulations Issued by the Regulation and Supervision Bureau for the Emirate of DEWA for the current rating required by the circuit loading and ambient temperature correction factors.

10.2 TERMINATIONS

A. Terminations for MICS cable shall comply with BS EN 60702-2 and BS 6207 and all termination components shall be of the same manufacture as the cable. The ends of all MICS cables shall be sealed by means of 1050C cold screw-on pot type seals with integral earth tail and compression ring type glands.

B. MICS cables shall be kept sufficiently sealed during erection and prior to making off and the cut end shall remain on the coil shall be efficiently capped to prevent ingress of moisture.

C. Where connections are to be made on to busbars, etc., cone grip connecting lugs shall be used.

D. Cables terminating at switchboards, distribution boards, adaptable boxes, etc. shall be connected thereto be means of smooth bore male brass bushes, compression washers and sockets.

E. All MICS cable tails shall be clearly marked indicating the phase colour to which they are connected.

F. All persons employed to make terminations on MICS cables shall have attended a course of instruction and they shall demonstrate, if so requested, to the Engineer their ability to make a satisfactory seal prior to commencing work on the site.

G. Where terminations are made to flush accessory boxes within a plaster finish cable clamps fixed to the accessory box and firmly gripping the cable seal may be used in lieu of the brass gland.

H. Where glands are terminated in equipment without screwed entries, a lock washer and back nut shall be used.

I. Where cables are exposed, shrouds shall be fitted over the glands. These shrouds shall be of similar colour to the sheath.

J. All circuits with inductive loads supplied by MICS/LSF cabling shall be fitted with voltage surge suppressors in accordance with the manufacturer's recommendations.

10.3 JOINTING

A. If a run of MICS cable is of a length that exceeds the maximum to which the cable can be manufactured, a through joint will be permitted. Such a joint shall be made with an adaptable box into which shall be fitted a fixed base mechanical clamp type connector of approved design.

11 PART 3 - EXECUTION

11.1 GENERAL

A. All MICS cables not on cable tray shall be fixed by LSF coated copper clips of an approved design at a maximum of 375mm centres on vertical runs and a maximum of 200mm centres on horizontal runs.

B. Where MICS cables pass through floor slabs or other structural work, they shall be protected by short pieces of heavy gauge galvanised steel conduit. The conduit shall be plugged with non-setting cold mastic compound after the MICS cables have been installed.

C. Where MICS cables without LSF outer sheath run across or pass in close proximity to steel or other conducting building material, water pipes etc. the cable shall be bonded to the said materials at intervals to ensure that no difference in potential can exist. Spacing saddles shall be installed to prevent the cables from contact with dissimilar metals.

D. All cables shall be installed in a neat and workmanlike manner, being dressed into shape and free from corrugations and damage to the sheaths. All cables shall run vertically on walls and at right angles or parallel to floors of the room or areas served. on no account shall diagonal or arbitrary routes be permitted.

E. Minor runs of not more than two MICS cables may be fixed direct to non-fireproofed structures, masonry and concrete. In all other situations, they shall be run on cable tray.

F. Multiple runs of MICS shall be laid neatly on perforated cable tray of an approved type, spaced from the tray by multiple fixing cleats recommended by the manufacturer.

G. All cable routes shall be agreed by the Engineer before work is started. Cables shall be run at least 150mm clear of all plumbing and mechanical services. The use of conduit and/or cable trunking to enclose conductors shall be kept to the minimum.

H. Where an MICS cable is connected to a motor or other appliance liable to vibration, the cable shall be taken direct to the terminal box. A coil of one turn to a radius of not less than 100mm shall be formed in the cable to take up their relative movement between the machine and the solid base.

I. After installation and connection, cables and terminations shall be inspected and all conductors shall be tested for continuity and insulation resistance in accordance with the requirements of BS 7671. The tests shall be repeated a minimum of 24 hours after termination. All results shall be recorded by the installer and approved by the Engineer.

V. WIRING SYSTEMS - LSF/LSF CABLES

12 PART 1 - GENERAL

12.1 CODES AND STANDARDS

A. Materials, equipment and associated works shall be carried out in strict accordance with the following standards and regulations as applicable:-

International Codes:

BS 6004 Electric cables. PVC insulated non-armoured cables for voltages up to and including 450/750V for electric power, lighting and internal wiring.

BS 7671 Requirements for electrical installations IEE Wiring Regulations

13 PART 2 - PRODUCTS

13.1 WIRING SYSTEMS USING LSF/LSF CABLES

A. Cables shall comply with BS 6004, 300/500 volt grade. All cables shall have an integral protective conductor. Cables shall be handled and installed in accordance with the manufacturers recommendations.

B. Circuit protective conductors within insulated and sheathed cables shall be sized to suit the circuit requirements and in any case shall be 1.5 mm^2 minimum for 2.5 mm^2 phase conductors. C. All cables shall be LSF/LSF type.

13.2 JOINT BOXES

A. Joint boxes shall be made from insulating material resistant to heat. They may be provided with or without brass terminals. If terminals are not provided, porcelain or non-hygroscopic connectors shall be used to join the conductors.

14 PART 3 - EXECUTION

14.1 GENERAL

A. Cabling shall be concealed within the carcass of the building or clipped neatly on the surface walls and ceilings using plastic type cleats.

B. All joints shall be fully accessible.

C. Cables are to be installed clear of thermal insulation unless properly derated.

D. The circuit protective conductor shall be continuous and terminated at every point or outlet.

14.2 SEGREGATION OF SERVICES

A. Cables shall be run at least 150mm clear of non-electrical services.

14.3 PROTECTION OF CABLES

A. Cables concealed in floor screeds or masonry walls shall be protected throughout their entire length by one of the following means:

1. Rigid halogen free conduit

2. Non-circular conduit or halogen free trunking.

B. Cables run on the surface shall be clipped neatly; multiple runs of cable shall be enclosed in small section halogen free trunking.

C. Cables run in voids shall comply with the specific requirements of BS 7671.

D. Cables run in wood joist floors shall be run over joists where furring pieces are provided, through holes in the joists drilled not less than 100 mm down or suspended from the sides

of the joist by free running cable loops spaced not more than 250 mm apart. Cables in accessible roof or floor voids shall be fixed at similar spacings with plastic cable clips to the sides of the joists.

E. Notching tops of joists shall not be permitted and drilling holes shall be agreed with the Engineer prior to commencement.

F. Cables shall not be installed in the cavity of cavity walls.

G. Cables shall be installed at least 150mm clear of expanded polystyrene or bitumastic products, which can cause migration of plasticiser in the sheath.

14.4 TERMINATIONS

A. The circuit protective conductor shall be identified with green/yellow LSF sleeving.

B. Where the termination is made in a metal box, the wiring entry holes shall each be bushed with a LSF grommet.

VI. EARTHING AND BONDING

15 PART 1 - GENERAL

15.1 CODES AND STANDARDS

A. Materials, equipment, and associated works shall be carried out in strict accordance with the following standards and regulations as applicable:

Local Authorities:

BS 951	Clamps for earthing and bonding purposes.
BS 2754	Construction of electrical equipment for protection against electric shock.
BS 6651	Code of Practice for protection of structures against lightning.
BS 7430	Code of Practice for earthing.
BS 7671	Requirements for electrical installations IEE Wiring Regulations

16 PART 2 - PRODUCTS

16.1 GENERAL

A. Earthing and bonding of the electrical services installation shall comply with the British Standards and Codes of Practice detailed at the end of this section and the particular requirements of the local supply authority i.e. ADEWA & DEWA.

B. The function of Earthing System for an electrical installation shall be:

1. To maintain potential of any part of the installation of a definite value with respect to the ground.

2. To allow current to flow in the event of a fault to ground, so that the protective equipment will operate and the faulty circuit thus become isolated.

3. To ensure that in the event of the fault, equipment normally “dead” (un-energised) does not attain a dangerous potential above or below ground.

17 PART 3 - EXECUTION

17.1 GENERAL

A. Where pipes etc. are to be bonded, the cable shall be connected to an adjustable metal clamp complying with BS 951 for use with variable sizes of water and/or gas pipe.

B. Approved warning labels shall be fixed to each earth termination or bonding connection to structural steel, water or gas pipes etc., durably marked with the words 'Safety Electrical Connections – Do Not Remove'.

C. Where metal conduit, trunking, cable sheaths and/or armouring is employed as part of the earthing system all joints, terminations and connections shall be constructed to afford a low impedance path for fault currents. All joints and connections shall be suitably protected to prevent deterioration caused by bi-metallic or other corrosion. The cross sectional area of the material shall comply with the requirements of BS 7671.

D. Mechanical joints between aluminium and copper shall have the joint faces lightly coated with a suitable compound to prevent corrosion, before the connection is made.

E. The armouring of plastic sheathed cables shall terminate in a suitable compression gland fitted with a purpose made earth tag. A suitable protective conductor shall connect the earth tag to the apparatus earthing terminal. The earth tag shall be manufactured from a high conductivity material compatible with the cable gland.

F. The armouring of metal sheathed cables shall be securely clamped to the gland at the cable termination with a purpose made bolted clamp. A suitably sized protective conductor shall be installed to connect the armour clamp or gland to the apparatus earthing terminal.

G. For an outdoor termination, the armouring shall be suitably protected to prevent corrosion.

H. Where metal sheathed and/or armoured single core cables are employed, bonding conductors shall be installed at each end of the cable run and connected to the apparatus earthing terminal. These bonds shall effectively connect the sheaths and/or armouring of the single core cables where they leave trefoil formation. Cable glands in such circumstances shall be lightly insulated to prevent circulating sheath currents. Where the cable run does not exceed 10m, only one bond shall be installed, to earth the cable sheath and/or armouring.

I. Metal sheaths and/or armouring of multicore cables connected to a cubicle-type switchboard shall be effectively connected to the switchboard earth bar as described elsewhere in this specification.

J. Where armoured multicore cables are terminated on a unit motor starter panel or local disconnector a separate protective conductor shall connect the incoming and outgoing armouring to the starter panel or disconnector earthing terminal. Similarly, the motor frame shall be connected to the cable armouring or the starter panel or local disconnector whichever is more convenient.

K. Where flexible conduits are installed a suitable green/yellow LSF insulated protective conductor shall be installed and connected to the equipment at each end of the flexible connection.

L. The earth terminal of all socket-outlets shall be connected to the protective conductor of the final circuit. Where the protective conductor is formed by conduit, trunking or the metal sheath and/or armouring of cables the earth terminal of the socket-outlet shall be connected to an earth terminal in the box or enclosure associated with the conduit, trunking, or cable. M. Joints in cable runs will not be permitted.

17.2 CLEAN EARTH

A. Where a 'clean' earth system is specified it shall be derived directly from the main earth bar and only connected to earth at that point and at no other point throughout its entirety. The connection shall be made through a disconnecting test link. A white engraved label with the legend clean earth in 25mm orange lettering shall be provided in a prominent position above the test link.

B. The 'clean' earth earthing connections shall be made using cream coloured LSF insulated single core cables of the sizes detailed in BS 7671.

C. Protective earth functions must take priority however and any combined 'clean'/protective conductor shall be coloured green/yellow.

17.3 EARTHING FOR HV/LV TRANSFORMERS

A. The earthing system shall comprise low resistance earth electrodes for earthing the transformer neutral and metalwork associated with the low voltage distribution, a main earth busbar, and connections to the transformers and switchgear.

B. The earth electrode system shall consist of driven copper clad steel rods or copper strips lay in formed trenches. The earth resistance shall not exceed 1 ohm before interconnection with the building metal work, cable armour, etc.

C. Insulated stranded cables shall be run to the transformer neutrals via dedicated earth electrodes.

D. The size of all cables and tapes shall be as detailed on the drawings and / or as required by the local authority.

E. Earthing of HV/LV Transformers shall be to the requirements and approval of the local supply authority i.e. ADEWA & DEWA.

17.4 MAIN EARTH TERMINAL

A. Main earthing bars, mounted on insulators, shall be located in a convenient position in the LV room and shall be drilled to accept copper tape and insulated standard conductors. Each earth bar shall be rated in accordance with BS 7430 with a minimum size of 60mm x 6mm. It shall be at least 500 mm long and shall comply with the particular requirements of the local supply authority i.e. ADEWA & DEWA

B. Main earth bars shall be provided with two 100% rated main earthing lead connections. Disconnecting test links shall be provided to allow periodic testing of a live installation. The requirements of the main earth bar shall be as detailed elsewhere.

C. Copper tape shall be run to connect the frames, HV switchgear frames, any fences, gates, etc., and the LV switchgear frames.

17.5 EARTHING ELECTRODES AND PITS

A. Earth electrodes shall be copper clad steel, complete with all drive type heads and connectors, and cable clamps. The number, locations, and depth of installation shall be as specified elsewhere.

B. Each earth rod shall be protected by a purpose made enclosure that is accessible for testing and maintenance purposes.

C. Where the earth rod is internal to the building, the enclosure can be formed in the floor structure, with a load bearing cover. It shall be of a proprietary manufactured sealed type, to prevent water ingress. The rod shall pass through a 75mm diameter tube that has been cast into the floor structure. The top of the 75mm diameter tube shall be sealed with a non-hardening mastic compound and a sealing gland assembly to prevent the ingress of water into the earth pit.

17.6 PROTECTIVE MULTIPLE EARTHING (PME)

A. Metalwork forming part of a telegraphic, telephone or signalling circuit need not be bonded.

B. The minimum size of the consumer PME bonding is related to the size of the service cable and shall be as required by the PME regulations where applicable.

C. The earthing connections shall be made using single core cables with LSF insulation coloured green/yellow or equal and approved.

D. Approved warning labels shall be fixed to each connection suitably marked with the words ‘Safety Electrical connection - Do Not Remove’.

E. The final termination of the PME terminal shall be carried out by the local supply authority.

VII. CONDUIT SYSTEMS FOR ENCLOSING PVC AND LSF INSULATED CABLE

18 PART 1 - GENERAL

18.1 CODES AND STANDARDS

A. Materials, equipment, and associated works shall be carried out in strict accordance with the following standards and regulations as applicable:

International Code:

BS 4568	Part 1- Steel conduit, bends and couplers.
BS 4607	Non-metallic conduits and fittings for electrical installations.
BS 7671	Requirements for electrical installations IEE Wiring Regulations
BS EN 50086	Specification for conduit systems for cable management.
BS EN 61386 - 21	Conduit systems for cable management. Particular requirements. Rigid conduit systems
BS EN 61386 - 22	Conduit systems for cable management. Particular requirements. Pliable conduit systems
BS EN 61386 - 23	Conduit systems for cable management. Particular requirements. Flexible conduit systems
BS EN 60529	Specification for degrees of protection provided by enclosures (IP code)

19 PART 2 - PRODUCTS

19.1 CONDUIT SYSTEMS FOR ENCLOSING PVC AND LSF INSULATED CABLES

A. Adaptable Boxes

1. All draw boxes and junction boxes shall be of ample size to permit the cables to be drawn in and out. They shall be of sheet steel and shall be of square or rectangular pattern. Circular draw-in or junction boxes shall not be used. At all lighting points and switch points, the conduit shall terminate in suitable boxes provided with internal lugs to permit the back plates of the fittings or switches to be attached to them by metal threaded screws.

2. In damp situations, box lids must be fitted with rubber gaskets and external boxes must be filled with non-setting cold plastic compound.

3. All spare ways in junction boxes, etc., left for future extensions shall be fitted with brass stopping plugs.

4. Adaptable box minimum size shall be 100mm x 100mm x 50mm unless otherwise indicated.

B. PVC Conduits and Accessories

1. All PVC conduits shall be high impact PVC complying with BS 4607, BS EN 50086 and BS EN 61386. The minimum size of conduit shall be 20mm external diameter (25mm for ELV/LC systems).

2. Light gauge conduit may be used for protected pre-cast and in-situ concrete work where builders' traffic is minimal.

3. Heavy gauge conduit shall be used for surface installation and where it is laid in floor screeds.

4. Conduits shall be jointed and terminated utilising the appropriate rigid PVC components detailed below or standard conduit entry electrical equipment. Jointing will conform to one of the following techniques:

a. Permanent Adhesive

The solvent cement supplied by the conduit manufacturer shall be used to produce a rigid sealed connection.

b. Flexible Adhesive

A non-hardening adhesive supplied by the conduit manufacturer shall be used to produce a flexible sealed joint where allowance is necessary for longitudinal movement (e.g. expansion couplers).

5. Bends and sets in conduit will be made in accordance with the manufacturers' instructions. The radius of the bend shall not be less than 2.5 times the outside diameter of the conduit or such greater radius that will facilitate easy drawing-in of cables.

6. PVC conduits shall not be used in situations where ambient temperatures are likely to exceed 70ºC or where the normal working temperature of conduits and fittings will exceed 60°C.

Conduits shall not be installed adjacent to steam or hot water pipes. Adequate allowance shall be made for longitudinal expansion and contraction of the conduits under normal working temperature variations as follows:

7. Expansion couplers should be used on straight runs exceeding 6.0m with a loose or flexible type joint (b above) at the long spout end of the coupler.

8. Saddles as supplied by the manufacturers shall include a sliding support tolerance for longitudinal expansion.

9. Special consideration shall be given to the fixing of accessories where this may prevent natural conduit movements. Oversize or slotted fixing holes may be necessary or the introduction of expansion couplers.

10. Conduits shall be saddled at not more than one metre intervals.

C. PVC Conduit Boxes

1. PVC adaptable boxes shall be of moulded or fabricated PVC of square or oblong shape complete with PVC lids secured by two M4 round or pan headed screws. All adaptable boxes and lids of the same size shall be interchangeable. No adaptable box smaller than 75 x 50mm or larger than 300 x 300mm shall be employed. Boxes shall be of adequate depth in relation to the size of conduit entering them.

2. Conduit shall be terminated at adaptable boxes, fuse boards, switches, socket-outlet, or other equipment not possessing push-in or threaded spouts by means of the appropriate size adaptors. All cemented joints are to be made to a depth not less than the diameter of the conduit being used.

19.2 PROTECTIVE CONDUCTORS

A. A separate circuit protective conductor shall be provided within non-metallic conduits and trunking. The conductor shall have green/yellow LSF insulation and shall be sized in accordance with the requirements of BS 7671. A protective conductor may be common to more than one final circuit providing it is sized for the worst circuit conditions.

B. An earthing terminal shall be provided at every switch and outlet position for connection of a circuit protective conductor as required.

19.3 CONDENSATION PREVENTION

A. Install conduit systems to ensure internal condensation does not affect the operation of associated circuits. Provide drainage points in accordance with BS 7671.

B. Where conduit passes through external wall between two areas of different ambient temperatures or in other locations likely to cause condensation, install a conduit or adaptable box. After wiring fill box with inert, permanently plastic compound with high insulation value.

19.4 CONDUIT IDENTIFICATION DABS

A. The Contractor shall use coloured paint dabs on the inside of outlet boxes and paint interior side of the panel covers as they are installed. In ceiling spaces, provide colour to outside of the boxes.

B. The paint colour shall match the system colours as defined in finishes. Paint colour code shall be as follows:-

Red - Life Safety System

Pink - Intercom & Public Address System

Black - Annunciator & Buzzer System

Green - 230V IPH Circuits

Purple - Telephone/data communication system

Blue - 230/400V Circuits

Orange - Security Alarm System

Yellow - Fuel Control System

20 PART 3 - EXECUTION

20.1 STEEL CONDUIT INSTALLATION

A. Unless otherwise specified the whole of the various installations specified herein shall be carried out in heavy gauge galvanised screwed conduit complying the BS 4568 Parts 1, BS EN 50086, and BS EN 61386.

B. Resistance to ingress of water and against ingress of solid foreign bodies shall be to the stated rating to BS EN 60529.

C. The conduit installation shall be suitable for the environment and be protected against corrosive or polluting substances and excessive solar radiation.

D. Ensure fittings are the same class and finish as associated conduit system

E. No conduit less than 20mm diameter or larger that 32mm diameter will be permitted (25mm for ELV/LC systems).

F. No conduit bearing traces of rust or damage shall be used. The conduits shall be cleaned and free from oil before erection.

G. The end of conduits shall be cut square and the length of screw threads shall be sufficient only to allow the ends of the conduit to butt solidly in all couplings and against the shoulders provided in conduit boxes.

H. The ends of all conduits shall be carefully reamed to remove all burrs or sharp edges after the screw threads have been cut. All dirt, paint, or oil on the screwed threads of the conduit and accessories shall be carefully removed immediately prior to erection.

I. The number of running joints in conduit shall be kept to a minimum and where installed locknuts shall be used to secure the sockets.

J. Where conduits terminate in switch-fuses, fuse-boards, adaptable boxes, etc., they shall be connected thereto by means of smooth bore male brass bushes, compression washers, and sockets. Where a conduit terminates on a sheet steel enclosure a flanged coupler shall be used.

K. All bends are to be made on site to suit conditions and not more than two right angle bends or runs exceeding 15 metres will be permitted without the interposition of a draw box. No tees, elbows, sleeves, either of solid or inspection type will be permitted.

L. Immediately conduits are fixed in position all exposed threads, scratches and bends shall be painted with one coat of aluminium spirit paint.

M. All conduits shall be swabbed through before wiring is commenced and cables shall not be drawn into any section of the system until all conduits and draw boxes for that particular section are fixed in position.

N. All conduits shall be concealed unless specifically indicated otherwise, i.e. in roof spaces, above suspended ceilings, under floors, in flooring screeds, cast insitu, and in chases cut or cast into walls and/or concrete ceilings.

O. Where a concealed installation is called for, all conduits shall be chased into walls and concealed in the ceilings and floor screeds as far as the structure of the building will permit. Conduits installed in chases shall be fixed by means of crampets and painted 2 coats bitumastic paint prior to the chases being filled in.

P. Deep boxes or extension rings on standard circular conduit boxes shall be used where necessary in order to bring the front face of each box flush with the surface of the ceilings and walls.

Q. Conduit runs shall be determined by the installer and approved before any work is started. Conduit shall be run at least 150mm clear of plumbing and mechanical services.

R. Conduit runs shall be planned to obviate the need for draw-in-boxes, but where the use of them is unavoidable they shall be accessible at all times and be fitted with covers.

S. Conduit run on the surface shall be run vertical, horizontal, or parallel with the features of the building.

T. Conduit buried in concrete shall have at least 35mm depth of cover over its entire length. Conduit buried in plaster shall have at least 5mm depth of cover over its entire length.

U. Where conduit is buried in the carcass of a building or in the ground, all open ends shall be temporarily plugged or wrapped in 'Denso' tape to prevent ingress of foreign matter, moisture, or water.

V. Where conduit buried in concrete crosses an expansion joint in the concrete, it shall be wrapped with 'Denso' tape for a distance of 300mm on each side of the joint. The coupling method for protecting the conduit against stresses due to expansion shall be approved by the Engineer.

W. Conduit shall be supported at regular intervals not exceeding 1.2m on horizontal runs and 1.5m on vertical runs.

X. At each distribution board and multi-gang switchbox the conduit provided must be of the capacity to accept all cables, which could be connected to outgoing ways, whether they are installed at this stage or in the future.

Y. Conduit systems shall be sized in accordance with ADEWA requirements and the details given in Appendix A of Guidance Note No. 1 published by the IEE. The cable capacities given in these document shall not be exceeded (note that protective conductors can be ignored in capacity calculations, so long as cables can be easily installed and removed).

Z. Wire pulling lubricant shall not be used. The Engineer reserves the right to require all cables pulled in with any lubricant to be removed and replaced and conduits cleaned out.

AA. Where surface conduit is specified, it shall be fixed by means of spacer saddles and shall terminate in deep pattern conduit boxes. Surface conduits shall not be bent or cut to enter accessories. If a suitable accessory is not obtainable, the accessory shall be mounted on an approved backing piece of sufficient thickness to align the conduit entry with the surface conduit.

BB. No more than one system shall be combined in the same conduit.

CC. For heavily corrosive areas and exposed emergency circuits, exposed installations shown on the drawings, rigid steel conduits shall be used.

DD. Keep conduits at a minimum distance of 150mm from parallel runs of flues, hot water pipes or other source of heat.

20.2 CONNECTIONS TO MOTORS AND APPLIANCES

A. Conduit shall not be connected direct to a motor, or other appliance liable to vibration, but shall terminate in a through type conduit box or adaptable box at a convenient position adjacent to the motor.

B. The cable shall be continued in a short length of flexible metallic conduit (PVC coated) or composite PVC/metal foil conduit that shall be fixed to the motor terminal box.

C. An independent stranded copper cable protective conductor shall be run through all such flexible conduit and shall be connected to the motor earth terminal at one end and to an M 3.5 screw tapped into the side of the connected box at the other. The cable is to be sized in accordance with the requirements of BS 7671.

VIII. RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

21 PART 1 - GENERAL

21.1 CODES AND STANDARDS

A. Standards and other Codes of Practice: In addition to the requirements indicated on the Design Drawings or specified in the Specification, the Work shall be in accordance with provisions of the following standards and codes. The current editions of the publications listed below form a part of this Section.

1. BSI Group, (BS) British Standards.

   a. BS EN 50085 Cable trunking systems and cable ducting systems for electrical installations.

   b. BS EN 61386-21 Conduit systems for cable management. Particular requirements Rigid conduit systems.

   c. BS EN 60670 Boxes and enclosures for electrical accessories for household and similar fixed electrical installations.

   d. BS EN 61386 Conduit systems for cable management.

   e. BS EN 61537 Cable management. Cable tray systems and cable ladder systems.

   f. BS 4678 Cable trunking.

   g. BS 5733 General requirements for electrical accessories. Specification.

   h. BS 1004 Zinc alloy for die casting.

   i. BS EN 10143 Continuously hot-dip zinc coated low carbon sheet steel.

   j. BS EN 10152 Electrolytically zinc coated cold rolled steel flat products for cold forming.

   k. BS 1474 Aluminium alloys for extruded sections.

   l. BS 6099 Part 1 and Part 2 uPVC conduits and accessories.

   m. BS 6399: Part 1 Loading for building. Code of practice for dead and imposed loads.

   n. BS 4678 Part 2 Cable trunking. Steel underfloor (duct) trunking.

   o. BS 1706 Method of specifying electroplated coatings of zinc and cadmium on iron and steel.

   p. BS EN 10143 Continuously hot-dip coated steel sheet and strip. Tolerances on dimensions and shape.

   q. BS 4607 Non-metallic conduits and fittings for electrical installation.

   r. BS 6099 Conduits for electrical installations.

s. BS 4662 Boxes for flush mounting of electrical accessories. Requirements, test methods and dimensions.

t. BS 476 Fire tests on building materials and structures.

u. BS 4678 Part 4 Cable trunking. Specification for cable trunking made of insulating material.

v. BS 4678 Part 1 Cable trunking. Steel surface trunking.

w. BS 3505 Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water.

x. BS 497 Specification for manhole covers, road gully gratings and frames for drainage purposes.

y. BS EN 124 Gully tops and manhole tops for vehicular and pedestrian areas.

z. BS EN 1452 uPVC Ducts.

2. European Committee for Electrotechnical Standardizations, CENELEC Standards.

3. I.E.E. Wiring Regulations

a. All related Test reports for loading on Ducting, Service, Junction outlet boxes from a recognized testing institution should be made available for final approval of materials.

4. Preconstruction Testing/ Reports

a. Submit reports of independent tests demonstrating that the products and systems comply with the specified performance requirements.

b. Where test results for a material or product are not available, undertake testing to show compliance with the Specification at an independent testing laboratory acceptable to the Engineer.

c. The provision of testing data or the carrying-out of tests does not relieve the Contractor of his responsibilities regarding the performance requirements, durability or service life requirements.

21.2 1.2 PROJECT CONDITIONS

A. Civil Work Coordination

1. Take into account all of the Civil/ Mechanical Work performed by other Subcontractors associated with installation of electrical, mechanical, plumbing and other facilities.

21.3 1.3 SEISMIC RESTRAINT

A. Seismic Restraint Requirements: Provide seismic restraints for rigidly and resiliently supported raceways to prevent permanent displacement in any direction caused by lateral

motion, overturning or uplift, in accordance with requirements of the latest Uniform Building Code.

B. Product Data: Submit for Engineer's action. Furnish a material list with technical data documenting the primary functions, quality, and performance of each system to be used in the Work, e.g., the load ratings, or other such primary characteristics as required by the Design Drawings or the Specification. Furnish a listing for each of the following.

1. Safety Disconnects

2. Seismic Restraining Devices

C. Calculations: Submit for Engineer's information.

1. Furnish engineering calculations prepared and sealed by a Professional Engineer experienced in seismic applications and who is licensed in the country where the project is located, showing that equipment mountings, foundations and their seismic restraints can accept external forces of "1.0g" load for rigidly and resiliently supported equipment without failure and permanent displacement.

2. Furnish calculations and revised equipment schedule data if changes are made to system routing, location, size, or components or any other changes to a system are made, and the changes impact the design parameters scheduled or indicated in the Contract Documents.

3. Furnish movement calculations for risers based on the following criteria.

   a. Minimum creepage and shrinkage factor of 0.94 mm per 1.0 meter, (approximately 3mm per 3.2m floor-to-floor height).

   b. Verify this data with the Creep and Shrinkage Report.

22 PART 2 - PRODUCTS

22.1 2.1 PRODUCT SELECTION

A. Manufacturers: Provide systems and products from one of the listed manufacturers within approved manufacturer list.

22.2 2.2 MATERIALS

A. Underground Duct Banks

1. Supply, Installation, Testing and Commissioning of UPVC duct banks as indicated on the Design Drawings and as specified hereunder for the following systems:

   a. Electrical Power System (for LV and HV Cables).

   b. Electrical Lighting System

   c. Low Current Systems

   d. Spare Ducts at Road Crossings

2. Concrete encased uPVC ducts shall be installed at locations wherever indicated on the Design Drawings including cable entry ducts to each building and at road crossing.

3. Size and type of ducts shall be as indicated in the related electrical system Design Drawings.

4. Ducts shall be Type heavy duty uPVC complete with associated couplings, spacers and all required accessories including pulling ropes. Duct shall be suitable to withstand a minimum pressure of 6 bars.

5. Concrete, reinforced concrete, materials methods of construction and methods of test shall comply with the requirements of this Division, as well as relevant Civil Specification Division 03 Concrete.

B. Skirting, Dado, In-Screed, Raised Floor and General Purpose Trunking

1. Skirting Trunking

   a. The trunking shall have 3 No. compartments within its profile with provision for an interlocking extension trunking compartment. The central compartment shall carry power cables and shall be in a position to accommodate boxes to mount wiring accessories. The dimensions of the system shall be as indicated on Design Drawings.

   b. The system shall be modular to the extent that covers and bases are supplied separately. Covers for the central section shall be straight, while the covers for the bottom and top sections shall be curved, chamfered or square.

   c. The trunking shall be such that all electrical energy requirements can be satisfactorily contained and visually coordinated with the system, it should also allow heavy concentration and mixture of outlets possibly requiring changes to their location at a later

date. The system shall have all accessories either mains or ELV positioned adjacent to one another.

d. The end caps and couplers of the system shall be manufactured in one piece to facilitate a neat and easy installation. The main carrier shall be pre-drilled at 100mm centres for ease of fixing. All internal and external corners shall be a one piece construction with a clip on cover and a moulded corner carrier.

e. Boxes shall be available in two depths 25mm and 35mm. The appropriate box shall be used for installation of Power and Data/ Telecom Accessories.

f. Carriers, extensions, covers and cable dividers shall be manufactured from extrusion process, while the corners, couplers, corner covers, accessory boxes and other components shall be manufactured by injection moulding.

g. The extruded components shall have a semi-gloss finish and the moulded components shall have a compatible finish.

2. Dado Trunking

a. The dado trunking shall be manufactured in accordance with the requirements of BS 4678 Part 4 and BS 4662.

b. The uPVC material used shall be tested by the Engineer (at the Contractor's expense) approved laboratory in accordance with the requirements of the British Standards (BS) – BS 4607 Part 1, BS 6099-2-2 and BS 476: Part 7.

c. Dado trunking shall comprise of 3 No. compartments, the side compartments are one for power and one for voice and data and central compartment is for fixing of all sockets.

d. All the trunking shall be installed at the dado/ skirting level surface mounted or semi recessed in walls and according to the Engineer's approval.

e. Trunking size shall be as indicated on Design Drawings.

f. Suitable accessories shall be used wherever required, like couplers, internal, external corners, cable dividers, cable retainers, flat tees, flat angles, stop ends, etc. to give a neat and strong system.

g. Suitable back boxes shall be used as 1 Gang, 2 Gang, etc. according to the requirements to fix the wiring accessories flush with the trunking system.

h. The trunking color shall be to the Engineer's selection and the finish of the wiring accessories shall be with color to the Engineer's selection.

i. The socket outlets for power, outlets shall be fixed on the middle compartment, through PVC back boxes of 1 Gang or 2 Gang according to the requirement.

j. Samples of accessories shall be provided for approval by the Engineer prior to ordering.

3. In-screed Trunking

a. Ducts: Metal

1). The ducts and associated accessories shall be manufactured from galvanized sheet steel.

2). The ducts shall be of three-compartment construction and of size 225x38mm and made to BS 4678 Part 2 and all necessary accessories to provide complete installation.

3). The ducts shall have dimensions as indicated on the Design Drawings for power cables and/ or telephone wirings and/ or ELV cables.

4). Couplers shall be used to connect two lengths of trunkings. The complete trunking system shall be set in truly horizontal position prior to casting of concrete or screeding.

b. Service Outlet Box and Junction Box

1). Service outlet boxes and junction boxes shall be of the size 250x250x75/ 90mm (if 90x35 ducts or metal ducts of 275mm are used the size would be 300x300x75-90mm).

2). The support pillars shall be constructed from high pressure zinc alloy die casting. These pillars shall be fixed on to heavy gauge galvanized steel base plate for support.

3). The boxes shall be totally corrosion proof.

4). The boxes shall be equipped with a throwaway lid that is to be used during screeding to prevent concrete leakage into the box.

5). The boxes shall be constructed with provisions for ducts or conduit access on all four sides.

6). Unwanted entries shall be blanked off with detachable side blanks.

7). Covers for services boxes shall be manufactured from corrosion proof UL94V-0 flame retardant ABS material. The polyamide trap and frame incorporate a carpet trim necessary to cover carpet edges. The traps shall incorporate a 2.5mm sheet steel infill that can accommodate a carpet recess of 7mm.

8). A retractable handle shall provide access to the interior of the floor box.

9). The lid and frame of the floor box shall have an easy-to-clean texture as well.

10). Cables shall be guided through detachable cable retainers through nylon cable grommets fixed to the lid.

11). The grommets shall lock in position when cables are present, hence preventing snapping of cables.

12). The trap shall be fully reversible to allow for change of direction of the cable exit without the need to remove the trap frame.

13). The services boxes shall be adjusted using ratchet arrangement.

14). The services outlet boxes shall have a fully flexible plate configuration within them to ensure that difficult configurations are achieved with ease.

15). The frame, trap and flyover of the junction box shall be manufactured from pre-galvanized sheet steel and shall be polyester epoxy coated to provide protection against chemical and saline corrosion.

16). The screws of the trap cover shall be manufactured from stainless steel.

17). The junction boxes shall be a 7mm recess to take carpet.

18). The pre-galvanized sheet steel used in the manufacture of the junction boxes shall comply with the requirements of BS EN 10143.

19). As an option, the boxes shall be supplied in different colors and in stainless steel versions to the satisfaction of the Engineer.

20). All exposed portions of the boxes shall be epoxy coated in grey color.

21). The junction boxes shall be adjusted using levelling studs.

22). Adequate segregation shall be provided between service runs within junction boxes by using crossover bridges and rigid compartments.

23). The Junction boxes on the header trunking shall be of size 250x250x75/ 90mm (or 300x300x75-90 if uPVC ducts are used or 275mm wide are used).

24). Adaptor junction boxes shall be used of interconnection between large header ducts to lower size branch ducts.

25). The adaptor junction boxes shall be of size 300x250x75-90mm for re-ducting from 300mm wide header, to 255mm branch ducts.

26). Junction boxes shall serve as outlet device boxes with a hinged retractable flush cover, reinforced to bear any normal floor loading in the service area.

27). Type and number of socket outlets provided shall meet with the requirements indicated on the layout.

28). Openings for ducts or conduits shall be made as per site requirement on the removable side blanks of the floor box.

4. Raised Floor Trunking

a. Raised Floor Trunking: Metal

1). The raised floor trunking shall comprise of triple compartment rectangular sheet trunking and should serve as main feeder for distribution of telecommunication, power and data cables separately in accordance with layouts and sizes as indicated on the Design Drawings.

2). Raised floor trunking system shall be complete with segregators, end caps, etc., and shall be manufactured from electro-galvanized sheet steel confirming to BS EN 10152 and finished in epoxy coating to a minimum of 50 microns complying to BS 6496. The trunking system shall also comply with BS 4678 Part 1 class (2).

3). The thickness of the trunking body, compartment segregators shall not be less than 1.2mm with depth of 38mm.

4). The trunking and covers shall be so designed to be easy for replacement of cables at a later date.

5). Proper earthing studs shall be provided as each end of the trunking lengths for earth
continuity.

b. Service Outlet Boxes

1). Service boxes shall be constructed from a GI sheet steel base.

2). The trap frame shall be manufactured from polyamide with appropriate carpet trims on the frame to cover carpet edges.

3). The trap shall incorporate a 25mm sheet steel infill, with a recess thereafter to accommodate a carpet backing of 7mm.

4). The grommets shall have an automatic lock function that prevents the cables from getting cut should traffic pass over the box.

5). The trap shall be fully reversible to allow for change of direction of cable exit without the need to remove the trap frame.

6). The service outlet boxes shall have a fully flexible plate configuration within them to ensure that difficult configurations are achieved with ease.

c. Junction Boxes

1). Junction boxes shall be universal and adaptable to cross, tee and elbow configurations. Directional changes in trunking shall be achieved using junction boxes.

2). To maintain cable capacity in the junction box as that seen in the trunking, double height junction boxes shall be used.

3). Junction boxes shall be constructed either from pre hot dipped galvanized sheet steel to BS EN 10143 or mild steel plate with epoxy coating. The thickness of the junction box shall not be less than 1.2mm with a depth of 38mm.

4). Proper earthing stud shall be provided at each end of the trunking lengths for earth continuity.

5. General Purpose Trunking

a. Metal cable trunking is to comply with BS 4678 Part 1 and finished in hot dipped galvanising.

b. only purpose made fittings, connectors, covers and accessories are to be used and finished in hot dipped galvanised steel to BS EN 10143.

c. Copper earth straps shall be provided at every joint.

d. Covers are to be of the overlapping type and secured to the trunking by either an approved clip or screws.

e. Trunking shall be provided/ designed by the Contractor to comply with regulations. The sizes indicated on the Design Drawings are indicative and the Contractor shall be required to provide trunking/ conduits to form a complete system at no extra cost to the Contract.

f. Fire sealing is to be provided for all containment systems that pass through fire zone barriers.

C. Conduits and Fittings

1. Materials

a. Surface conduits shall be heavy gauge hot dipped galvanized after fabrication rigid steel seamless Class 4 manufactured in accordance with BS 4568 Part 1.

b. All conduits embedded in concrete, plaster and screed unless otherwise specified shall be very heavy gauge high impact PVC type, minimum 1.7mm wall thickness manufactured in accordance with BS 4607 and BS EN 500 86-2-1.

c. Use liquid tight (LFMC) galvanized flexible steel conduit with ground conductor for final connections to motors. Lengths shall not exceed 500mm.

d. All metal cable trunking shall be manufactured from sheet steel in accordance with BS EN 50085, galvanized to Class 3. Body and cover thickness shall be as per BS EN 50085.

e. Protection against corrosion shall be hot-dip zinc coating after fabrication.

f. All conduit and trunking in unconditioned and unfinished areas e.g. plant rooms, electrical rooms etc. shall be painted with one coat of metal primer after installation.

g. Each steel conduit shall be coated with aluminium paint upon conduit installation completion.

D. Outlet Boxes

1. Materials

a. Outlet boxes shall be manufactured of galvanized sheet steel, unless otherwise specified.

b. Use metal clad weatherproof boxes outdoors or in damp locations.

c. Use metal clad boxes where surface mounted in unfinished areas.

d. Ceiling boxes shall be 75mm circular or square, and min. 40mm deep complete with fittings where required to support fixtures.

e. Outlet boxes in walls; ceilings or floors shall be of an approved type suitable for the construction.

f. Provide gang boxes at locations where more than one device is to be mounted.

g. Provide combination boxes with barriers for wiring of more than one system.

h. Provide panel mounted fixing frames where outlet boxes are installed in panelling.

i. Brass earth lead shall be provided for the outlet box to allow connection of earth wire.

j. Outlet box shall be of adjustable grid type.

k. All circular PVC boxes where used to support light fittings shall be provided with steel insert clips.

E. Pull Boxes

1. Materials

a. Junction and pull boxes shall be sized to accommodate the conduits indicated and to facilitate pulling in the conductors required. Minimum depth shall be 40mm.

b. Junction and pull boxes shall be of steel with covers attached by screws and shall be provided with earth terminal and screws.

c. All junctions on lighting, power, signalling, communications, alarms and control wiring shall be provided with terminal strips. Terminal strips shall have screw type terminals and cable identification strip.

F. Cable Tray and Fittings

1. Materials

a. The cable tray system shall be complete with all necessary trays, risers, elbows, supports, end plates, drop outs and fittings required for the installation. It shall be one manufacturer and shall include factory - made trays, tray fittings, connectors and necessary accessories and supports to form a complete cable support system.

b. Cable trays shall be heavy duty perforated sheets to BS 1449, hot dip galvanized after manufacture to BS EN ISO 1461. All heavy duty trays supporting power cables shall be of folded edge with return flange. Thickness of tray shall not be less than minimum 1.5mm for cable tray width up to 300mm and minimum thickness of 2mm for cable trays above 300mm.

c. Loading of cable tray and of cable ladder shall be in accordance with BS EN ISO 1461.

d. Contractor shall submit loading calculation for the Engineer's review and approval.

e. All supports and fixings shall be hot dip galvanized after manufacture to BS EN ISO 1461.

f. All fixation hardware (bolts, nuts, washers shall be mild cadmium plated for indoor installation and stainless steel for outdoor installation).

g. Cable ladder shall be produced of 2mm hot dip galvanized mild steel.

h. The cable tray shall be sized to suit the proposed cabling requirements with a further allowance for additional cabling to be installed in the future (minimum of 20% spare capacity).

G. Ladder Rack and Fittings

1. Materials

a. The cable ladder rack systems shall comply with BS EN 61537 complete with all necessary ladders, couplers, bends, tees, supports and fittings required for the installation.

b. Cable ladder racks shall be heavy duty type, hot dipped galvanized to BS EN 10346.

c. Loading of ladder rack shall be in accordance with BS EN ISO 1461. Contractor shall submit loading calculation for the Engineer review and approval.

d. All supports and fixings shall be hot dipped galvanized after manufacture to BS EN ISO 1461.

e. All fixation hardware (bolts, nuts, washers shall be mild cadmium plated for indoor installation and stainless steel for outdoor installation).

f. The ladder rack shall be sized to suit the proposed cabling requirements with a further allowance for additional cabling to be installed in the future (minimum 20% spare space capacity).

23 PART 3 - EXECUTION

23.1 EXAMINATION

A. Verification of Conditions: Examine areas for compliance with requirements for installation and conditions affecting performance of the Work. Identify conditions detrimental to a proper and timely completion and notify the Engineer of the unsatisfactory conditions. Proceed with installation only after unsatisfactory conditions have been corrected.

23.2 INSTALLATION

A. Under Ground Duct: Construction

1. Build duct banks on undisturbed soil or well compacted granular fill not less than 150mm thick, compacted to 95% of modified Proctor.

2. Excavate and backfill in accordance with the Excavation and Backfill section.

3. Provide underground pipe bridges to support the duct bank where it crosses previous excavations or other excavations, which are part of this contract.

4. Where additional excavation below the trench bottom is required, slope the walls at 45° along the direction of the trench, and backfill with granular material compacted to 95% of modified Proctor.

5. The trench bottom shall be flat or convex in cross section.

6. Prior to laying ducts, construct a concrete skim slab not less than 50mm thick. Provide base spacers across the skim slab at 1500mm intervals, levelled to the grades indicated for the bottom layer of ducts.

7. Construct a dry well of crushed stone at the low points of the duct bank, and where indicated at manholes. Dry wells shall be pits not smaller than 500mm² x 1200mm deep below the invert elevations of the low points of the duct banks or manholes.

8. Lay ducts with configurations and reinforcing as shown, using plastic or other suitable intermediate spacers to maintain the correct spacing. Maintain spacing between ducts of not less than 40mm horizontally and vertically. Use manufacturer's couplings pulled tight.

9. Install ducts at the elevations and slopes indicated on the Design Drawings, with a uniform grade of not less than 250mm per 100m. The top of any duct bank shall not be less than 700mm below finished grade unless specifically indicated.

10. Provide intermediate spacers at maximum 1500mm centres, and stagger in adjacent layers. Use anchors, ties and trench jacks as required to secure the ducts. Ensure that ducts are not broken, damaged or disturbed during placing of the concrete. Remove weights or wood braces before the concrete has set, and fill the voids.

11. Reinforcing steel and metal ties may encircle all ducts, but shall not encircle any duct or group of ducts in the duct bank.

12. Place concrete carefully and spade continuously to ensure a flow between and under the individual ducts and to provide a solid mass of concrete. Vibrators shall not be used.

13. This Division shall ensure that not less than 75mm of concrete are placed at the top, bottom and sides of the duct bank.

14. Make transpositions, offsets and changes in direction with 5°C. bend sections or couplings to provide turns of not less than 9m radius.

15. Cut, ream and taper ends of ducts in the field in accordance with the manufacturer's recommendations, so that duct ends are equal to factory made ends.

16. Provide bell ends at all duct terminations in manholes, trenches or buildings, except where couplings and plugs for future extensions are indicated.

17. Use rigid aluminium or galvanized steel conduit for bends and for all sections extending above finished grade level. For ducts carrying single conductor cable, use only aluminium conduit.

18. Ensure that a responsible and competent supervisor is present during concreting operations. Advise the Engineer in advance of concreting, so that he may inspect the ducts up to placing. Be present during the pour and inspect the complete duct bank before backfilling.

19. Clean ducts thoroughly before laying. During construction securely cap ends of ducts to prevent the entrance of foreign matter. Immediately after placing of concrete, pull through each duct a mandrel not less than 300mm long and of a diameter of 6mm less than the internal diameter of the duct, followed by a stiff bristle brush to remove all sand, earth and other foreign matter. Work the mandrel through the ducts carefully to avoid disturbing or damaging ducts where concrete has not set completely. Pull a stiff bristle brush and a swab to remove water, mud and fine sand through each duct immediately before pulling in cables.

20. Replace or repair to the approval of the Engineer any completed ducts which are defective or unsatisfactory in any way, at no additional cost to the Contract.

21. Ensure that concrete has attained 50% of its specified strength before backfilling.

22. Provide a 6mm nylon cord in each empty duct to facilitate pulling, and a removable plug or cap to seal each end.

23. Back opening in ducts with asbestos, braid packing and seal the asbestos packing with permanently resilient silicon base no inflammable waterproof compound.

24. Work shall not proceed without approved calculations, and Engineer's review.

25. Provide photographic documentation of all trenches, clearly labelled and showing all relevant construction prior to filling in with backfill materials.

B. In-Screed Trunking System: Installation

1. The Structural floor slabs, on which the under floor ducting and boxes shall be laid, shall be reasonably level and smooth. Humps and protruding cement shall be hacked to level to ensure the ducting’s being laid shall maintain the minimum screed thickness of 25mm over

the ducting. It is recommended that a layer of green screed be laid on the structural slab and the underfloor duct placed on the green screed to prevent air gaps and vacuum while screeding. For screed thickness less than 25mm over the ducting BRC 0.8mm gauge x 12mm square wire mesh shall be laid over the ducting before screeding to prevent screed cracking.

2. The floor slab where junction and service outlet boxes are to be laid shall be marked out.

3. Ducting shall be laid in straight lines between points of junction boxes and parallel to known base lines on each floor. Changes in direction of ducting shall be made with junction boxes.

4. Use steel fixing clips to secure the ducting on to the floor slab prior to screeding. The intervals between two saddles shall not exceed a maximum of 2m.

5. All joints in ducts and terminations of ducts in junction boxes/ vertical access boxes shall be made watertight with approved type sealing compound. Precautions shall be exercised during construction to prevent damage to the duct system and to ensure that the ducts and vertical boxes are free of water, dirt, debris or any other obstruction, which may impede and /or damage the cables during pulling in.

6. Junction and service outlet boxes shall be properly covered with the disposable screeding lids approximately levelled and taped to ensure no cement gets into the boxes during screeding.

7. The frames and traps shall be installed after the screeding and while the floor finishing is laid, to ensure the traps and accessories are clean after hand over. The traps shall not be adjusted to flush with the finished floor. Wires should now be threaded through the ducting and boxes and all accessory plates and accessories shall be installed.

C. Skirting and Dado Trunking System: Installation

1. Contractor shall closely coordinate all trades for the satisfactory installation of trunking systems.

2. The wall on which the trunking shall be laid, shall be reasonably level and smooth. Humps and protruding cement shall be hacked to level to ensure neat installation of the trunking.

3. Mark out on the wall where trunking are to be laid.

4. Trunking shall be laid in straight lines between each 3m lengths along with the necessary trunking couplers, and changes in direction to be made with the help of inside/ outside corners as instructed in the Installation Guide to be supplied by the supplier.

5. All joints between trunking and the accessories along with the service outlets shall be properly secured to prevent loosening.

6. All accessories are hard wired to respective positions as indicated in the

7. Installation guide to ensure a clean and neat hand-over.

D. Conduits/ Trunking and Fittings: Installation

1. Make bends and offsets with a hickey or power bender, without flattening or denting the conduits.

2. Surface conduits shall be supported by distance spacing saddles fixed at intervals not exceeding that set out in the IEE Wiring Regulations (Guide).

3. Attach clamps to masonry walls by means of expansion shields. Use beam clamps or Erico 'Caddy Fasteners' or acceptable equivalent to attach conduits to exposed steel work.

4. Provide expansion couplings with bonding jumpers and clamps for all conduits crossing building expansion joints. Expansion couplings shall be Crouse-Hinds Type XJ or equivalent Bonding jumpers and earthing clamps shall be Crouse-Hinds Type GC or equivalent.

5. Provide conduit fittings with suitable covers on runs of exposed conduit. Each conduit fitting shall be of a type suitable for its particular use. Covers shall be located so that they shall not be blocked by the future installation of additional conduits.

6. Running couplers with lock nuts shall not be permitted only three-piece conduit unions shall be accepted.

7. Run conduit in finished areas concealed in building fabric and above suspended ceilings.

8. Install conduits in block walls as the walls are being erected and not by cutting after erection of the walls.

9. Conduits shall not run exposed in any finished area. All areas shall be considered finished unless indicated otherwise. Electrical Rooms and Mechanical rooms shall be classed as unfinished areas.

10. Run exposed conduits in groups, parallel to building lines, and accurately in line and level.

11. Install conduits so that there is no interference with access openings in ceilings, removal of ceiling tiles, or access to equipment in the ceiling space.

12. Install conduit to avoid proximity to water or heating pipes. Do not run within 150mm of such pipes. Where crossings are unavoidable, maintain a minimum distance of 150mm from the pipe covering.

13. Do not run conduit through structural steel members, concrete beams or columns except as permitted by the Engineer. Structural concrete shall not be chased to allow the passage of conduits without consent of the Engineer. In in-situ concrete walls, floors screeds the conduits and boxes shall be held firmly but without deformation, in an approved manner, so that they are absolutely rigid until and while the concrete is poured and/ or vibrated.

14. Requirements governing the installation of conduits apply equally to surface or exposed cable installations.

15. Do not run conduits larger than 25mm in structural floor slabs. Do not run any embedded conduit, in floor slabs less than 100mm thick.

16. Protect conduit stub-ups from damage during construction, and seal the ends to prevent the entrance of foreign material with plastic plugs or other approved devices. Taping or similar protection is not acceptable.

17. Where conduits pass through a waterproof membrane, install sleeves with a 50mm wide collar continuous welded all around, at membrane level. Ensure that the membrane is dressed over the collar. Sleeves shall be sized large enough to allow free passage of the conduits. Make the sleeves watertight sealer after the conduits are installed.

18. Where conduits pass through other floor slabs or firewalls, seal into the concrete or pass through a sleeve. Sleeves shall be high density plastic, with flange for attaching to form work or structure. Pack the sleeve with fireproof packing and seal approved by the Engineer's safety department.

19. Where runs of conduit are shown, only the general routing and location are indicated. Install all conduits so as to provide a maximum headroom and minimum interference with the space. Install conduits as close to the structure as possible, so that furring can be kept to a minimum.

20. Take out and replace at no change to the contract price any conduit or cable which is not installed properly in the opinion of the Engineer.

21. Install a nylon fish cord in each empty conduit, complete with cap and bushing at each end. No wiring draw in wires, cables or wires of any description are to be drawn into the conduits until the section of conduit system involved is completed.

22. Where conduits are concealed in plaster walls, conduits shall have a minimum 15mm cover along its whole length Horizontal runs shall be avoided.

23. During construction identify all conduits with sprayed on colour at both terminations immediately after installation. The following colour code shall be used:

    a. Electric power: Black

    b. Fire alarm and smoke detection: Red

    c. E.L.V. (Extra Low Voltage systems): Yellow

    d. Isolated or ungrounded systems: Orange

    e. Earthing: Green

24. Where conduits are connected to trunking, steel boxes, panels, switchgear, or any item not having a tapped entry (or having a tapped entry of 6mm or less), the connections shall be made by long threaded male brass bushes with a coupling and serrated spring washer after removing a paint with a purpose made tool.

    a. Bushes shall be tightened with a tool specifically designed for that purpose - pliers or toothed wrenches shall not be allowed.

25. Sufficient draw-in boxes shall be provided to permit easy wiring.

a. The following shall also apply:

1). For any absence of right-angled bends maintain minimum distance between draw boxes of 10m.

2). For at least 1 No of right-angled bends maintain minimum distance between draw boxes of 10m.

3). For at least 2 No of right-angled bends maintain minimum distance between draw boxes of 6m.

b. For the purposes of this Specification a double set constitutes the equivalent of one right-angled bend.

c. Not more than two right-angled bends or 10m length of conduit shall be permitted between draw boxes, and vertical conduit runs more than 3m shall provide cable support using a draw box.

d. Each bend, set, adaptable box, conduit box, etc, shall be supported at 150mm (approx.) from each side.

e. Saddles and boxes shall be secured by sherardized Class 1 or stainless-steel screws of a minimum size of 30mm x No.8 or equal.

f. A separate Green and yellow insulated protective conductor shall be installed within the trunking system for each circuit and services.

g. Conduit capacity shall be in accordance with IEE Wiring Regulations such that the space occupied by the wires shall not exceed 40% of the conduit area.

h. Separate conduit shall be provided for each circuit.

E. Metal Trunking Installation

1. Trunking runs shall be installed neatly on the surface and be truly vertical, horizontal or parallel with the features of the building.

2. Trunking shall be sized in accordance with the IEE Wiring Regulations for sub-main distribution cables, i.e. 600/ 1000 V grade, and a space factor of 45% shall not be exceeded.

3. For sub-circuit wiring, i.e. 450/ 750 V grade to BS 6004, a space factor of 40% shall not be exceeded.

4. Trunking runs shall be mechanically and electrically continuous throughout their length. Brass continuity links shall be fitted to all trunking joints exterior to the trunking, utilizing brass bolts and shake-proof washers.

5. Multi-compartment trunking shall be used where segregation of services is required, and shall

consist of earthed steel partitions of no less than 0.5mm thickness greater than that of the trunking and be a minimum of 1.0mm thickness.

6. Compartments shall be drilled to allow conduits to pass through to the compartment served.

7. In the situations where tees and junctions are encountered, the multi-compartment fittings shall be of such a depth as to allow for suitable pass-over connections.

8. Fire barriers shall be provided within the trunking at each crossing of fire wall or fire zone.

9. Insulated pin racks shall be provided to support cables in vertical runs exceeding 3m. Removable cable restraining straps shall be 'sprung' into trunking at 600mm centres where trunking covers are fixed on the underside or side of the trunking.

10. Trunking covers shall be of maximum length for the run, drip-proof, close fitting and of similar protective coating as the trunking. Cover joints shall not coincide with trunking joints, but be staggered, thus producing a more rigid construction. Covers shall only be installed on the underside of trunking in unavoidable circumstances, and then only with agreement in writing from the Engineer.

11. Trunking shall lie securely fixed to the building fabric at intervals not exceeding 1.5m.

12. Trunking up to 50mm wide shall have only one screw at each fixing point; trunking over this width shall have two screws. Screws shall be sherardized Class 1 or stainless steel, No. 12 for up to 75mm width, No. 14 for larger sizes.

13. Manufacturer's standard fittings shall be used. only where these are inadequate may fabricated fittings are used. After getting the Engineer approval these shall be finished to the same protective coating standard of the manufactured trunking. Bends and tees shall have gussets or be radiused.

14. Connections to distribution boards shall be made by using flanges giving the full trunking capacity, making due allowance for the future installation of cables from spare ways.

15. Connections between trunking and apparatus shall be by means of a brass male bush coupling and internally serrated washer or alternatively a standard flanged coupling.

16. The cover shall be removable over the whole length of the trunking. Where trunking passes through walls or floors a small length of cover shall be provided on the section passing through to form a sleeve for 25mm on each side.

17. All trunking and accessories shall be by one manufacturer.

18. A separate green and yellow insulated protective conductor shall be installed within the trunking system for all circuits and services.

19. Trunking shall only be installed in lieu of multiple runs of conduit and in areas, which are fully accessible.

20. Make provision in trunking at expansion and settlement joints to allow for movement of building structure.

F. Outlet Boxes: Installation

1. Provide outlet boxes for all lighting fixtures, receptacles or other devices in walls, ceilings, or floors. Wire each fixture from an outlet box, with a maximum of four fixtures per box.

2. Support boxes independently of the conduit system and mechanical ducts.

3. Locate boxes in hung ceiling spaces so that they do not interfere with the removal of ceiling tiles or equipment.

4. Where outlet boxes are installed flush in exposed concrete blocks in finished areas, blocks shall be cut by the Masonry Division on instructions from this Division. Ensure that openings are cut to fit boxes so that edges of openings are not visible after installation of cover plates. The use of mortar to patch oversize or ragged openings shall not be permitted.

5. Do not mount boxes between the same pair of studs, on opposite sides of sound-rated partitions or patient rooms/ areas. Seal spaces between boxes and gypsum board with acoustical sealant.

6. Adjust floor boxes so that closure plates are flush with the surface of the floor tile, or the floor if carpeting is specified. Provide under floor duct fittings and outlets or single flush outlets with waterproof covers, as indicated on the Design Drawings.

G. Pull Boxes: Installation

1. Locate junction and pull boxes so as to be accessible at all times. Boxes may be installed in mechanical, electrical, storage or janitor rooms or in hung ceiling space.

2. Provide access hatches for boxes installed in ceiling spaces unless ceiling tiles are of lay-in or snap-in type.

3. Locate junction and pull boxes so that piping, ductwork or equipment shall not restrict or block access.

4. Cables connected to terminals or passing through boxes shall be identified on the strip and by cable markers.

5. Terminal strips may be omitted where there are less than 3 connections in a junction box, but all conductors shall be identified by cable markers.

6. Terminals may be omitted for through cables, which are not broken at a junction box.

7. Provide pull boxes in conduit runs where required to facilitate the pulling in of cable, as specified.

H. Cable Tray and Fittings: Installation

1. All accessories including bends, intersections, tees, risers and reducing sections shall be purpose-made by the tray manufacturer. only one manufacturer's tray and accessories shall be used.

2. Sizing of cable trays shall allow 30% spare capacity for future cables.

3. Care shall be taken to avoid any electrolytic action between dissimilar metals. Under no circumstances shall any copper cable or fitting be in direct in contact with the galvanizing.

4. Sets and bends shall be sized to allow for the minimum permissible radius of the largest cable on the tray. Cables shall retain their relative positions on bends and sweeps.

5. Earth continuity shall be maintained at all joints with suitable earthing links.

6. Cable trays shall be cut along a line of plain metal and not through perforations. Burrs or sharp edges shall be removed prior to the installation of tray sections or accessories.

    a. Bushes shall be provided through all holes cut in the body of the tray.

    b. The cable tray shall be made good at all joints or holes by first treating the surfaces with a suitable rust proofing agent, then applying finishes comparable to the remainder of the surface.

7. A minimum space of 75mm shall be allowed between the tray and the structure to provide for securing the cable and general maintenance.

8. Cable tray shall be carried on mild steel supports with suitable protective coating, fixed to the structural at not more than 1m intervals, depending on cable tray thickness.

    a. Mid span joints should be avoided. Joints should be positioned as close to the support as is practical. Fixing of supports shall be Rawl bolts or acceptable equivalent.

    b. Alternatively, proprietary steel channel may be used, permitting easy adjustment and modification.

    c. Proprietary clamps fixing onto the flanges of structural beams may be used.

9. All metal work, fixing bolts, etc., shall be suitably primed and painted with two coats of zinc-enriched paint.

10. Cables shall be installed on trays in a single layer and in accordance with the IEE Wiring Regulations, using plastic coated, metal reinforced clips or saddles any by proprietary cleats of a pattern recommended by the cable manufacturer.

11. Not more than four cables shall be secured by a single clip or saddle. Binding tape fixings shall not be used. on vertical tray installations load bearing cleats or saddles shall be used and securely fixed to the tray.

12. Provide cable tray expansion joints at all locations where the tray crosses a building expansion joint and at other locations recommended by the manufacturer.

13. Where cables in tray pass through a floor or fire barrier, interrupt the tray and provide an Electro-tray cable transit with openings sized for the cables.

14. Cable trays shall be provided with standard stand and ventilated cover to protect cables from sun radiation when installed outdoors and to protect cables form mechanical damage where damage is likely to occur during maintenance activities. Also, wherever applicable including indoor but subject to the Engineer decision in this regard.

15. Contractor shall be responsible for resizing cable trays indicated on Design Drawings to comply with allowable fill and low voltage cabling systems to be installed in tray. Submit calculations to the Engineer prior to submitting cable tray

16. Provide barriers as required to separate appropriate systems or voltages as required.

I. Colour Coding for Raceways and Fittings

1. Raceways shall be colour coded as follows:

a. Life Safety = Purple.

b. Critical = Yellow.

c. Normal = Green.

d. Communication = Blue.

e. Low Voltage Devices = Black.

f. Fire System = Red.

J. Raised Floor Trunking System: Installation

1. The structural floor slabs on which the raised floor trunkings shall be laid, shall be reasonably level and smooth.

2. Humps and unlevel structural floor shall be hacked to ensure accurate levelling of the raised floor system.

3. Mark out locations where the raised floor trunking to be laid.

4. The levelling wires are to be strung across, parallel to a known base line of the location for the system.

5. Straight sections should be joint together with couplings supplied by the supplier.

6. When trunking are set in position and levelled, the trunkings should be secured to the structural floor by means of using the floor fixing brackets at an interval of every 2m.

7. The entire raised floor trunking system shall be tested for electrical continuity to the satisfaction of the Engineer and all necessary labour, instruments etc, for such tests shall be included in the Contract Document.

23.3 SITE QUALITY CONTROL

A. Trunking, Cable Trays, Skirting and Outlet Boxes: Certification and Conformity

1. Suitability for the support of Category 6 data cabling should be demonstrated by way of independent test verification.

2. Fire test certification should be published in accordance with the E30/ E90 standard.

3. Electrical continuity across a coupling should be demonstrated by means of a published test method and result.

IX. TRUNKING SYSTEM

24 PART 1 - GENERAL

24.1 CODES AND STANDARDS

A. Materials, equipment, and associated works shall be carried out in strict accordance with the following standards and regulations as applicable:

Code:

BS 4678	Cable trunking Part 1 – Steel surface trunking. Part 2 – Steel underfloor (duct) trunking. Part 4 – Cable trunking made of insulating material.
BS 7671	Requirements for electrical installations. IEE Wiring Regulations.
BS EN 10143	Continuously hot-dip metal coated steel sheet and strip. Tolerances on dimensions and shape.
BS EN 50085-1	Cable trunking systems and cable ducting systems for electrical installations. General requirements.

25 PART 2 - PRODUCTS

25.1 GENERAL

A. Trunking shall be used where required. The size shall be as detailed, but where this is not stated, it shall comply with the requirements of BS 7671 and the size calculated as required in Appendix A of Guidance Note No. 1 published by the IEE after allowing for 25% additional wiring. Cable grouping factors shall be applied. The following requirements must be done in compliance with DEWA and in accordance with the requirements of The Electricity Wiring Regulations Third Edition March 2014 Issued by the Regulation and Supervision Bureau for the Emirate of DEWA.

25.2 CABLE TRUNKING STEEL

A. Steel cable trunking shall comply with BS 4678: Part 1.

B. Cable trunking and lids shall be constructed from sheet steel to the following:

1. Up to but not including 50mm x 50mm - 20 swg

2. Up to but not including 76mm x 76mm - 1.2mm gauge

3. Up to but not including 228mm x 152mm - 1.6mm gauge

C. Sheet steel shall comply with BS EN 10143 and the finish shall be zinc passivated or zinc coated inside and out and unpainted to Class 2 unless otherwise stated.

D. Galvanised trunking shall be designed to be weatherproof and provided with external fixing lugs.

E. Metal partitions in trunking and fittings shall be provided as required by BS 7671. The minimum thickness shall be 1mm. They shall be of the same material and finish as those of the trunking.

F. Steel cable trunking may not, on their own, be used as Circuit Earth Conductor; separate Circuit Earth Conductors must be run inside the trunking.

25.3 CABLE TRUNKING – PLASTIC

A. Trunking shall be installed in accordance with the manufacturer's instructions. The installation requirements of plastic type trunking shall be as specified for steel trunking, but further fixings may be required.

B. Trunking shall comply with BS 4678: Part 4 and of heavy gauge, high impact-grade. All trunking shall be in perfect alignment to avoid any appearance of warping when the installation is complete.

C. Allowance shall be provided for expansion properties of the trunking by using washers at all fixing points to allow movement and gap between each manufactured length.

D. The earthing of the system shall comply with the requirements of BS 7671 and The Electricity Wiring Regulations Third Edition March 2014 Issued by the Regulation and Supervision Bureau using LSF sheathed continuous green/yellow earth wire.

E. Jointing of lengths of trunking and jointing to and from boxes, etc. shall be glued using vinyl cement strictly following the manufacturers' instructions. Where the sliding end of the expansion coupling is to be jointed, a special adhesive shall be used.

F. Where trunking passes through an expansion joint in the structure, the manufacturers' expansion joint shall be used.

G. Plastic trunking shall not be used in situations subject to higher than normal temperature or fire risk.

25.4 FLOOR TRUNKING – METAL

A. Floor trunking shall be heavy duty one, two or three compartment and constructed to comply with BS 4678 Part 2. The minimum standard thickness of the galvanised sheet steel shall be 1.6mm gauge.

B. The trunking shall be either flush floor type or installed within the floor structure.

C. Flush floor trunking shall have the outlet boxes mounted at intervals and purpose made with outlets for mains power, telephone outlets and /or facilities for a third service.

D. Underfloor trunking shall comply with BS 4678: Part 2 and interconnect between purpose made outlet boxes set out at intervals.

E. Outlet boxes shall have hinged lids suitable for the installation of carpet or linoleum tiles and protection for outgoing cables. Before ordering the Contractor shall confirm floor finishes with the Engineer to ensure the correct type.

F. A separate cover shall be provided over the telephone compartment to comply with British Telecommunications requirements.

G. The manufacturers' installation instructions shall be strictly adhered to.

H. The trunking shall be properly and fully protected from damage during installation and shall be inspected by the Engineer prior to covering with screed etc. Any damage shall be repaired prior to covering, to the satisfaction of the Engineer.

I. All accessories for the floor trunking system used shall be from the same manufacturer of the trunking system. The entire floor trunking system including all fixing accessories used shall be supplied and installed strictly in accordance with the recommendations/instructions of the manufacturer.

25.5 FLOOR TRUNKING - PLASTIC

A. Plastic floor trunking shall comply with BS 4678: Part 4 and may be installed in lieu of metal trunking to interconnect floor outlet boxes in accordance with division 19 0000 of this specification.

B. A separate earth wire must be installed between outlet boxes whether they are metal or plastic.

C. The manufacturers' installation instructions shall be strictly adhered to. The trunking system shall be protected from damage during installation works.

D. All accessories for the floor trunking system used shall be from the same manufacturer of the trunking system. The entire floor trunking system including all fixing accessories used shall be supplied and installed strictly in accordance with the recommendations/instructions of the manufacturer.

25.6 SKIRTING TRUNKING – METAL

A. Skirting trunking shall be constructed from 1.6mm sheet steel to BS 4678 Part 1 and be enamel finished inside and out to a colour specified by the Architect. The trunking shall comply with the data cable performance specification where this is required.

B. Where multi-compartment is specified, one compartment shall be for telephone services and one for mains power wiring and socket-outlets and the third for data systems. The trunking shall be arranged such that outlets for all systems can be installed where necessary and all cables will only cross at right angles. All outlets shall have integral back boxes of earthed metal or non-combustible material.

C. The manufacturers' standard fittings shall be used throughout including mounting plates for socket outlets, etc.

D. Cutting and bending of trunking to form flanges and attachments will not be permitted.

E. The installation of metal skirting trunking shall be in accordance with the clause for fixing of Cable Trunking - Steel.

F. Back boxes shall be installed behind all accessories where these enter into any other compartment than that of their own system or where the whole trunking system has to be disassembled for the installation of any further wiring.

G. If cables have to cross other compartments to connect to an outlet they shall cross at 90º and shall be separated by an insulated spacer.

25.6.1 SKIRTING TRUNKING - PLASTIC

A. Plastic skirting trunking shall be manufactured to BS 4678: Part 4, heavy gauge. Multi-compartment trunking shall be provided where required and the same requirements as for metal skirting trunking above will apply.

B. A separate earth wire shall be run inside the trunking to all outlets as required by BS 7671.

C. Skirting trunking shall otherwise be in accordance with the requirements for metal and plastic trunking.

D. Back boxes shall be installed behind all accessories where these enter into any other compartment than that of their own system or where the whole trunking system has to be disassembled for the installation of any further wiring.

E. If cables have to cross other compartments to connect to an outlet they shall cross at 90º and shall be separated by an insulated spacer.

25.7 PROTECTIVE CONDUCTORS

A. A separate circuit protective conductor shall be provided with non-metallic conduits and trunking and where steel trunking is not used as a protective conductor. The conductor shall have green/yellow LSF insulation and shall be sized in accordance with the requirements of BS 7671. A protective conductor may be common to more than one final circuit, providing it is sized for the worst circuit conditions.

B. An earthing terminal shall be provided at every switch and outlet position for connection of a circuit protective conductor as required.

26 PART 3 - EXECUTION

26.1 GENERAL

A. Trunking shall be installed in accordance with the manufacturer's instructions. For surface mounting, lids shall be lipped type fixed with quick release, cam type fasteners, or hank bushes and M6 screws. For flush work, overlapping lids with similar type fasteners shall be provided.

B. Where trunking is modified or adapted, any damage to the finish shall be made good by touching-up with approved quality paint to match the trunking finish.

C. Lengths of trunking shall be efficiently bonded to each other using 2.5 mm² green/yellow cable complete with suitable terminals.

D. All lengths shall be connected by 'sleeve' connectors free of burrs, and the finish of the connectors shall be the same as the trunking.

E. Screws shall be of a brass construction and of the correct lengths to ensure that no protrusions occur into the capacity of the trunking.

F. All trunking shall be supplied with cable retaining straps at 1 metre intervals.

G. Trunking shall be fixed at regular intervals not exceeding 1800mm on straight runs. Where bends or angles occur, additional fixings shall be provided.

H. Where trunking passes through an expansion joint in the structure, the manufacturers' expansion joints shall be used.

I. Trunking run horizontally shall be provided with cable separators with insulated pins at 1 metre intervals. This shall apply to trunking of sizes greater than 100mm x 50mm. Trunking run vertically shall be provided with a cable support unit with insulated pins at 3m intervals.

J. Where trunking passes through floors and walls that constitute fire barriers, fibre glass or approved ceramic fiber packing shall be fixed into the trunking to form an effective fire barrier.

K. Manufacturers' standard fittings shall be used throughout wherever possible, but where special site conditions occur, site fabricated fittings can be used subject to the approval of the Engineer. The practice of cutting and bending trunking to form flanges and attachments will not be accepted. L. Trunking shall be run at least 150mm clear of plumbing and mechanical services.

M. Where trunking passes through a fire barrier, it shall be properly sealed inside and outside the trunking to the required specification of the fire barrier.

X. VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

27 PART 1 - GENERAL

27.1 CODES AND STANDARDS

A. Materials, equipment, and associated works shall be carried out in strict accordance with the following standards and regulations as applicable:

International Code:

IBC International Building Code – Measures to be implemented in accordance with site classification defined within the architectural / structural specifications.

28 PART 2 - PRODUCTS

28.1 HELICAL STEEL SPRING MOUNTS

A. Helical steel spring mounts shall comprise single or multiple spring elements fitted to a plated steel base plate. A rubber/neoprene pad shall be bonded beneath the bottom plate.

B. All mountings shall incorporate a lockable levelling device. There shall be provision for bolting through the base plate in at least two places.

C. The springs shall have an outside diameter of not less than 75% of the operating height and be selected to have at least 50% overload capacity.

D. Vertically restrained spring mounts

1. Mountings shall be as described under the clause for helical steel spring mounts but include a mechanism that provided an adjustable vertical limit stop to prevent spring extension when load is decreased.

2. Mountings used in the external environment shall be adequately protected against environmental and atmospheric degradation.

3. Turret compression mountings - shall comprise a synthetic formulated rubber compound turret in compression between two steel plates with complete lateral freedom for deformation. All metal surfaces must be covered to avoid corrosion and have friction pads to and bottom. Bolt holes shall be provided in the top and bottom plates to facilitate fixing.

4. The rubber turret shall be resistant to oil, sunlight, corrosion and ozone.

5. Turret compression mountings shall not be employed where ambient or equipment temperatures exceed the manufactures recommendations.

E. Helical spring compression hangers

1. Spring compression hangers shall comprise a helical steel spring fitted with acoustic rubber end caps fitted incorporated within a steel hanger box.

2. The lower box hole diameter shall be adequately sized to provide free drop rod movement up to 15° from vertical in any direction in order to compensate lateral movement.

3. The hanger bracket shall be designed to carry five times overload without failure.

4. Where hangers incorporate a positioning device, the adjustment system shall incorporate a locking mechanism to prevent the hanger going out of adjustment as a result of vibration or unauthorised tampering.

5. Spring hangers shall be installed to support all electrical services connected to rotating and reciprocating machinery within electrical plant space or within 30m of the electrical plant equipment whichever is the lesser.

6. The hanger bracket shall be designed to carry five times overload without failure.

7. Hangers shall be colour coded for identification.

F. Neoprene element hangers

1. The hanger shall be essentially as described under the clause helical spring compression hangers except it shall incorporate a neoprene in shear element. The element moulded in special formulated rubber compound shall be resistant to oil, sunlight, corrosion and ozone.

2. Hangers shall be colour coded for identification

28.2 VIBRATION ISOLATORS

A. Noise and vibration isolator types, minimum operating static deflections, and supplemental bases shall be provided for individual electrical equipment units according to selection criteria as tabulated in the equipment schedules of the project drawings.

B. Isolator types are scheduled to establish minimum standards. At the Contractor's option labour saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages, provided isolators supplied incorporate and specified isolator type, and do not degrade the noise and vibration isolation of equipment mounted.

C. Supplemental equipment base types tabulated can be deleted for unitary packaged air handling equipment having a rigid frame and casing providing a distortion free platform for attachment of vibration isolators.

D. Isolators exposed to the outdoors shall have weather-proof finish on all parts with plated bolts, etc.

28.3 VIBRATION ISOLATION BASES

A. Fabricated Steel Bases: Structural-steel bases and rails designed and fabricated by the isolation equipment manufacturer. Include equipment static loadings, power transmission, component misalignment, and cantilever loadings.

B. Fabricate bases to shapes required, with welded structural-steel shapes, plates, and bars conforming to BS ISO 4997. Include support brackets to anchor base to isolation units. Include prelocated equipment anchor bolts and auxiliary motor slide bases orrails.

C. Design and fabricate bases to result in the lowest possible mounting height with not less than 25-mm clearance above the floor.

D. Concrete-Filled Inertia Bases: Weld reinforcing bars to the structural frame. Pour concrete into base with relocated equipment anchor bolts.

E. Weld steel angles on frame for outrigger isolation mountings, and provide for anchor bolts and equipment support.

F. Configure inertia bases to accommodate equipment supported.

G. Factory Finish: Manufacturer's standard corrosive-resistant finish.

29 PART 3 - EXECUTION

29.1 APPLICATIONS

A. Multiple Containment, Busbar or Cable Routes: The Contractor shall secure all containment, busbar and cabling to the appropriate trapeze support with clamps, which are approved for application by the local authority.

B. Hanger Rod Stiffeners: The Contractor shall supply and install hanger rod stiffeners where indicated on the drawings or as detailed elsewhere within the Specification, and where required to prevent buckling of hanging rod due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, the Contractor shall select size of components to ensure that the strength will be adequate to carry the present and future static and seismic loads within the specified loading limits.

29.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.

2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 3.2mm.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. To Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Install flexible connections within runs of containment, cables, wireways, cable trays, and busbars, where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

XI. LABELLING AND IDENTIFICATION

PART 1 - GENERAL

29.3 CODES AND STANDARDS

A. Materials, equipment, and associated works shall be carried out in strict accordance with the following standards and regulations as applicable:

International Codes:

BS 5378	Safety signs and colours.
BS 7671	Requirements for electrical installations IEE Wiring Regulations

30 PART 2 - PRODUCTS

30.1 2.1 LABELLING AND IDENTIFICATION

A. Supply and install all necessary labelling and identification to all equipment, materials, cables, components, terminations, and systems of the electrical services installation.

B. All signs and labels shall be displayed in accordance with BS 5378, BS 7671, The DEWA Electricity Wiring Regulations and as agreed with the Engineer.

C. All signs and labels shall be in both Arabic and English language. Where specific text is identified within this specification, The Contractor shall ensure that the sign/label is also written in Arabic

D. The Contractor shall submit to the Engineer details of all labelling and identification prior to commencement of the installation.

30.2 2.2 LABEL TYPES

A. The following principal colour co-ordination of signs/labels shall apply:

Warning	Yellow background with black lettering.
Mandatory	Blue background with white lettering.
General Information	White background with black lettering.
Emergency	Green background with white lettering.
Prohibition	White background with red lettering.
Fire fighting	Red background with white lettering (except extinguishers that have particular colours).
Equipment/Services	Orange bands of tape or where required orange colour.

routed in common locations with others.

30.3 2.3 WARNING NOTICES

A. All items of equipment or enclosure within which voltages exceeds 250 volts or separate enclosures or items of equipment that allow simultaneous contact with live parts exceeding 250 volts shall be so arranged that before access may be gained a warning of the maximum voltage present shall be clearly visible i.e. 'DANGER 500 VOLTS'.

B. on unit construction switchgear the label shall be centrally placed and preferably on the busbar section. The number of labels shall be determined by the size of the switchboard but at least one label every two metres length of switchboard shall be provided.

C. Each switchboard shall have the primary warning triangle sign denoting ''Caution, Risk of Electric Shock''.

D. Where an disconnector leaves any part of equipment or enclosure ''live'' when in the OFF position a warning notice shall be used indicating that the equipment is not totally isolated and giving instructions for achieving further isolation.

E. Warning labels shall be fixed to high-voltage cables or their protective covering at 1.5 metres (max) intervals with lettering 10mm high in red on a white background.

F. A safety sign shall be fixed to every enclosure associated with a high-voltage discharge lamp installation e.g. inductors, resistors, capacitors and transformers. In addition, a supplementary sign shall be located below the warning sign. This shall be 10mm x 50mm yellow background with 5mm black lettering stating DANGER, plus the highest open-circuit voltage to earth (e.g. 500 volts A.C.).

G. All H.V. and M.V. switch rooms and M.V. cupboards shall have a warning sign and a notice on all doorways or access panels as follows.

H. The warning sign shall be the yellow triangle with black edging and the electrical symbol within the triangle.

I. The warning notices shall be a yellow background with black lettering stating ''NOTICE AUTHORISED PERSONS ONLY'' with ''KEEP LOCKED AT ALL TIMES'' with a minimum letter size of 25mm high.

J. If a switch room has automatic gas suppression protection, a mandatory notice informing the possible discharge of gas shall be displayed on or adjacent all entrances.

31 PART 3 - EXECUTION

31.1 GENERAL INFORMATION/IDENTIFICATION LABELS

A. All electrical equipment shall be labelled to ensure correct identification and give essential operating functions that relate to each other. The labels shall have a white background with black lettering.

B. The main incoming switch shall state: -

1. Main disconnector

2. Rating

3. Phase

4. Voltage

5. Incoming cable size in mm^2 and cable type system earthing C. Individual switch fuse, MCCB, disconnector shall state: -

D. The circuit which it controls with a general description of type of load.

1. Rating

2. Phase

3. Outgoing cable size in mm2 and cable type

E. The main bus bar/main panel construction shall also state: -

1. The British Standards to which it complies

2. Fault rating

3. Classification reference

4. IP rating

F. All distribution boards shall have external labels that state: -

1. Voltage

2. Maximum rating of protective devices uses

3. Type of load connected

G. All distribution boards shall have internal labels that state: -

1. Main cable size in mm2

2. Phase colour indication

3. Circuit number*

4. Description of circuit*

5. Circuit protective device rating*

6. Actual circuit current*

7. Circuit cable*

*This applies to all final circuits and the labels/circuit charts shall be completed in clear printing in black ink on a white background.

H. The individual phases shall be identified with its phase colour of red, yellow, and blue respectively.

I. Where a distribution arrangement incorporates contactors, time switches, relays, indicator lights and push buttons each of these shall be labelled and indicate its function i.e. ON/OFF/AUTO together with what it controls i.e. 'LIGHTING'', OVERRIDE SWITCH'', ''TIME SWITCH FOR EXTERNAL LIGHTING'.'

J. These labels shall conform to a white background with black lettering.

K. Local switchgear/disconnectors and control gear shall have individual labels that shall be black lettering on a white background. These labels shall indicate:

1. Equipment title

2. Current rating, phase, voltage

3. Circuit reference

L. The ON/OFF functions shall be clearly indicated using an appropriate label where the operating positions are not clearly indicated on the equipment itself.

M. All junction boxes that form a marshalling point and junction point for fire alarm system, security systems, and communication systems shall have a label with black lettering and white background. These labels shall indicate:

1. The wiring system enclosed

2. Voltage

3. Circuit(s) reference

31.2 ADDITIONAL INFORMATION/IDENTIFICATION LABELS

A. Where the use is not immediately apparent, identification labelling shall be applied to the following:

1. Identification of socket-outlets

2. Identification of switch/fused spur-outlets

3. Identification of lighting switches

4. Identification of communication systems, special circuits

5. Identification of building management system special circuits

31.3 EMERGENCY LABELS

A. Where an item of equipment and or switchgear is designated for emergency operation, the labelling shall be white lettering on a green background.

B. This labelling shall clearly indicate the item of equipment/function it performs together with the emergency action required to be undertaken.

31.4 PROHIBITION LABELS

A. Where an item of equipment and/or switchgear is designate for prohibited use:

'Danger switch off when not in use'

'Do not switch off'

Emergency stop'

B. This labelling shall be red lettering on a white background.

31.5 FIRE FIGHTING LABELS

A. Where a particular item of equipment and/or switchgear is designated for fire fighting use e.g. a fire alarm switch on a main switchgear panel this shall be clearly and differently indicated with a label with white lettering on a red background.

31.6 LABELLING MATERIAL

A. The material shall be a composite plastic component with three layers of rigid plastic (040 ABS) materials. The letter colour being the centre element of the composite and when engraved the composite shall then expose the colour. The method shall be as commonly referred to as 'TRAFFOLYTE'.

B. All lettering shall be upper case in capitals and generally the height of lettering that shall be used shall be as follows:

1. 6mm for identification labels

2. 12mm for warning notices

3. 12mm for the principle wording of an emergency sign

4. 6mm for the secondary wording of an emergency sign

C. The fixing used for all labels shall be either bolted with gripping washer or riveted with space washers behind each rivet.

D. Two fixings shall be provided for labels with a height up to 25mm. Labels higher than this shall have four fixings, one in each corner of the label.

31.6.1 LABELLING FOR HV SWITCHGEAR

A. Each main switch panel shall have a general label located centrally on the switchboard stating the following information:

1. Manufacturer's name
2. Switchboard designation
3. System voltage, phases, frequency
4. System fault level
5. Busbar rating

B. All feeders switches shall have permanent labels giving the following information:

1. Feeder designation
2. Feeder cable size
3. Transformer connection e.g. Transformer 'A'

C. All incoming switches shall have permanent labels giving the following information:

1. Incomer Designation and Source of the Supply
2. Incoming Cable Size

D. All current and voltage transformers shall have permanent labels giving the following information:

1. Designation/identification
2. Transformation ratio

E. All protective devices shall have permanent labels giving the following information:

1. Designation/identification
2. Type of protection

F. All busbars shall have the required safety labelling.

31.7 WARNING NOTICES

A. All items of equipment or enclosure within which voltages exceeds 250 Volts or separate enclosures or items of equipment that allow simultaneous contact with live parts exceeding 250 Volts shall be so arranged that before access may be gained a warning of the maximum voltage present shall be clearly visible i.e. 'DANGER 500 VOLTS'.

B. on unit construction switchgear the label shall be centrally placed and preferably on the busbar section. The number of labels shall be determined by the size of the switchboard but at least one label every two metres length of switchboard shall be provided.

C. Each switchboard shall have the primary warning triangle sign denoting ‘‘Caution, Risk of Electric Shock’’.

D. Where an disconnector leaves any part of equipment or enclosure ‘‘live’’ when in the OFF position a warning notice shall be used indicating that the equipment is not totally isolated and giving instructions for achieving further isolation.

E. Warning labels shall be fixed to high-voltage cables or their protective covering at 1.5 metres (max) intervals with lettering 10mm high in red on a white background.

F. A safety sign shall be fixed to every enclosure associated with a high-voltage discharge lamp installation e.g. inductors, resistors, capacitors and transformers. In addition, a supplementary sign shall be located below the warning sign. This shall be 10mm x 50mm yellow background with 5mm black lettering stating DANGER, plus the highest open-circuit voltage to earth (e.g. 500 volts A.C.).

G. All H.V. room, M.V. rooms and M.V. cupboards shall have a warning sign and a notice on all doorways or access panels as follows.

H. The warning sign shall be the yellow triangle with black edging and the electrical symbol within the triangle.

I. The warning notices shall be a yellow background with black lettering stating ‘‘NOTICE AUTHORISED PERSONS ONLY’’ with ‘‘KEEP LOCKED AT ALL TIMES’’ with a minimum letter size of 25mm high.

J. If a switch room has automatic gas suppression protection, a mandatory notice informing the possible discharge of gas shall be displayed on or adjacent all entrances.

XII. FIRE DETECTION AND ALARM SYSTEMS

32 PART 1 - GENERAL

32.1 DESCRIPTION

The system shall comprise of a range of analogue addressable, microprocessor based fire alarm control equipment to offer flexibility in both design and operation. The system shall be of modular concept for easy tailoring of system design, to meet the full requirements of this project.

The system shall be designed to provide early warning smoke detection, to quickly identify the location of fire and provide user definable text informing the occupants of the building of potential smoke spread. Simultaneously, the system shall alert and evacuate the occupants, and control all necessary auxiliary command functions such as elevator control, air handling shut down, gas shut off & damper control, as per the cause and effects requirements of the building.

The complete facility shall be protected by a fully analogue addressable fire alarm system. A range of smoke, heat, multi-sensor detectors, manual call point and sounders shall be installed in the building.

32.2 CODES AND STANDARDS

A. Materials, equipment, and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

International Codes:	
NFPA 70	National Fire Protection Association – Electrical Code
NFPA 72	National Fire Protection Association - Fire Alarm & Signalling Code
NFPA 101	National Fire Protection Association - Life Safety Code
UL 864	Control Units and Accessories for Fire Alarm Systems
UL 1425	Standard for Cables for Non-Power-Limited Fire-Alarm Circuits
UL 1424	Standard for Cables for Power-Limited Fire-Alarm Circuits

32.3 QUALITY CONTROL

The specialist shall allow for an internal authorized and certified quality control inspector to ensure that all QA guidelines a being followed. Only IS0 approved specialist will be considered for these works. A certified report shall be forwarded to the professional team.

The addressable type fire detection and alarm system shall be designed installed and commissioned with all the necessary equipment and accessories in accordance with UL/FM standards.

32.4 1.4 ONE YEAR MAINTENANCE

Complete maintenance and repair service for the fire alarm system shall be available from a factory trained authorized representative of the manufacturer of the major equipment for a period of five years after expiration of the guaranty.

The specialist shall submit a proposal for complete and comprehensive service and maintenance for the entire system. The maintenance shall be at least quarterly and a complete detailed report

shall be issued in triplicate following the visit. As a minimum, 25% of all devices shall be tested every quarter.

32.5 OPERATION AND MANUAL

- Installation instructions for use by installing contractor.
- Operational instructions or manual for use by building personnel, including name and phone number of service representative.
- Maintenance instructions as required for use by building personnel.
- Copy of approved shop drawings.

32.6 TRANSPORTATION, HANDLING AND STORAGE

All the components of fire alarm system shall be provided in manufacturer's original new and unopened packing bearing manufacturer's name and label.

Store materials, not in actual use, in covered and well-ventilated area and protect them from dirt, dust, moisture, direct sunlight and extreme temperatures.

For further requirements follow manufacturers written instructions regarding storage and handling.

32.7 WARRANTY

Submit written guarantee signed by the contractor, manufacturer and installer of fire alarm system for the period of 1 year from the date of substantial completion. The guarantee shall cover the repair and replacement of material with manufacturing defects and workmanship as directed by the engineer.

32.8 SYSTEM DESCRIPTION

All major component of fire alarm system shall be product of a single reputable European or USA origin manufacturer.

The fire detection and alarm system shall comprise of Automatic Soft Addressable Modular design main fire alarm control panels, optical smoke & heat, multi Sensor, manual call points, electronic wall- mounted Alarm sounder/flasher/ combined devices, The system shall be fully programmed to accommodate fire alarm zones. The system shall be configured to allow on site modifications with the minimum of disruption using the PC based software to facilitate future changes or alterations to existing buildings/network on site.

The complete Analogue Addressable Fire Detection System shall be located in the Control Room on the Ground Floor. The Main Control Panel will be equipped with sufficient loop cards to meet the need of the entire project. There shall be sufficient spare capacity to cater for at least the full requirement plus 20% spare

The system will be capable of providing fire, fault, action, supervisory, disable and monitoring facilities In the event of a fire alarm the FACP unit shall operate the alarm signal throughout the building in accordance with the cause and effects and any additional requirements lay down by the Civil Defence:

- Signal the local authority fire brigade via Auto Dialler
- Activate all control by event function related to the alarm
- Signal to graphic monitoring station
- Release door with hold open device shall be signal to release.
- Operate fire dampers, shutdown HVAC, and general exhaust fan.
- Signal to elevator

33 PART 2 - PRODUCTS

33.1 FIRE DETECTION & ALARM SYSTEM

A. Fire detection and alarm system shall be designed and installed in accordance with the requirements of NFPA 72, NFPA 101 and DCD Authority. All components shall be manufactured, tested and certified compliant with the relevant UL Standards.

B. The category and level of the fire detection system to be provided shall be as detailed elsewhere within the Contract Documentation.

C. The installation of the fire detection and alarm system shall be undertaken by Dubai Civil Defence Authority Approved Company.

D. The Contractor shall ensure that all system components, wiring, cabling, and terminals are clearly identified as detailed elsewhere within the Contract Documentation.

E. System Operation / Performance Requirements

F. The following system parameters are general only and the exact details of the system operation is detailed elsewhere within the Contract Documentation.

33.2 SYSTEM DESCRIPTION

A. Non-coded, addressable system; multiplexed signal transmission dedicated to fire alarm service only.

B. Non-coded, analogue-addressable system; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only.

33.3 PERFORMANCE REQUIREMENTS

A. Fire alarm signal initiation shall be by one or more of the following devices:

- Manual stations.
- Heat detectors.
- Flame detectors.
- Smoke detectors.
- Beam detectors.
- Verified automatic alarm operation of smoke detectors.
- Automatic sprinkler system water flow.
- Fire extinguishing system operation.
- Fire standpipe system.

- Other, as detailed elsewhere within the Contract Documentation.

B. Fire alarm signal shall initiate the following actions:

- Alarm notification appliances shall operate continuously.
- Identify alarm at the fire alarm control panel (FACP).
- De-energise electromagnetic door holders.
- Transmit an alarm signal to the remote alarm receiving station.
- Unlock electric door locks in designated egress paths.
- Release fire and smoke doors held open by magnetic door holders.
- Operate fire and smoke shutters.
- Open Gate Barriers (if applicable)
- Activate voice/alarm communication system.
- Switch heating, ventilating, and air-conditioning equipment controls to fire alarm mode.
- Switch lift/elevator equipment controls to fire alarm mode.
- Close smoke dampers in air ducts of system serving zone where alarm was initiated.
- Record events in the system memory.
- Record events by the system printer.
- Other, as detailed elsewhere within the Contract Documentation

C. Supervisory signal initiation shall be by one or more of the following devices or actions:

- Operation of a fire-protection system valve tamper.
- Other, as detailed elsewhere within the Contract Documentation.

D. System trouble signal initiation shall be by one or more of the following devices or actions:

- Open circuits, shorts and grounds of wiring for initiating device, signalling line, and notification appliance circuits.
- Opening, tampering, or removal of alarm-initiating and supervisory signal-initiating devices.
- Loss of primary power at the FACP.
- Ground or a single break in FACP internal circuits.

- Abnormal ac voltage at the FACP.
- A break in standby battery circuitry.
- Failure of battery charging.
- Abnormal position of any switch at the FACP or annunciator.
- Fire-pump power failure, including a dead-phase or phase-reversal condition.
- Low-air-pressure switch operation on a dry-pipe or pre-action sprinkler system.
- Other, as detailed elsewhere within the Contract Documentation.

33.4 SUBMITTALS

A. For each type of product required for the execution of the works in accordance with the Contract Documents, the following shall be submitted.

1. Shop Drawings, prepared by persons with the following qualifications:
   Trained and certified by manufacturer in fire alarm system design.
   Fire alarm certified by the DCD and codes listed within the appendices.

2. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
3. Device Address List: Coordinate with final system programming.
4. System riser diagram with device addresses, conduit sizes, and cable and wire types and sizes.
5. Wiring Diagrams: Power, signal, and control wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Show wiring colour code.
6. Batteries: Size calculations.
7. Duct Smoke Detectors: Performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
8. Ductwork Coordination Drawings: Plans, sections, and elevations of ducts, drawn to scale and coordinating the installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, the detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
9. Voice/Alarm Signalling Service: Equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram. Floor Plans: Indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits. Submit Operation and Maintenance Data: For fire alarm system to include in

emergency, operation, and maintenance manuals. Comply with the standard listed within the appendices. Include abbreviated operating instructions for mounting at the FACP.

10. Submit to the local Civil Defence all documentation required by the Authority necessary for them to review and provide approval. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit if required to make clarifications or revisions to obtain approval. on receipt of comments from DCD, submit them to Engineer for review.

11. Submit the following Record Documentation:

a. Approval and Acceptance: Provide the "Record of Completion" form according to the standards listed within the appendices to the Client, Lead Consultant and DCD.

b. Record of Completion Documents: Provide the "Permanent Records" according to NFPA 72 to the Client, Lead Consultant and Local Civil Defence. Format of the written sequence of operation shall be the optional input/output matrix.

i. Hard copies on paper to the Client, Lead Consultant and DCD

ii. Electronic media may be provided to the Client, Lead Consultant and DCD.

B. Quality Assurance

1. Installer Qualifications: Work of this Section shall be performed by a UL-listed company with Personnel certified by the Local Civil Defence.

SPARE MATERIALS

A. Furnish spare materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents:

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of the amount installed, but not less than 1 unit.

2. Lamps for Strobe Units: Quantity equal to 10 percent of the amount installed, but not less than 1 unit.

3. Smoke, Fire, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but not less than 1 unit of each type.

4. Detector Bases: Quantity equal to 2 percent of the amount of each type installed, but not less than 1 unit of each type.

5. Keys and Tools: one extra set for access to locked and tamper proofed components.

6. Audible and Visual Notification Appliances: one of each type installed.

7. Fuses: Two of each type installed in the system.

33.5 PRODUCT AND MANUFACTURER

A. Components of all of the Fire Alarm System shall be sourced from Approved Manufacturers, final selection shall be subject to the Engineers Approval.

1. FACP and Equipment:

2. Wire and Cable:

3. Audible and Visual Signals:

33.6 FIRE ALARM CONTROL PANEL

A. The FACP shall be modular, complete with electronic modules, in accordance with UL 864.

B. The FACP shall communicate with all the addressable initiation devices that communicate device identity and status.

C. Smoke sensors shall additionally communicate their sensitivity setting and allow for adjustment of sensitivity at the FACP.

D. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

E. The FACP shall contain Addressable control circuits for operation of mechanical equipment.

F. Alphanumeric Display and System Controls shall be arranged for interface between an operative at the FACP and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu shall all be available through a liquid-crystal type display with a minimum of one line of 40 characters.

G. The keypad shall be arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke detector sensitivity and other parameters.

H. The power supply shall normally be 24 volts dc derived from the mains via bridge rectifier/transformer equipment, but in the event of a mains failure the system shall operate from a battery system for a minimum of 24 hours, after which sufficient capacity should remain in the batteries to operate the system during a full fire condition for a further period of 3 hours.

I. Circuits shall be as follows, in accordance with the code listed within the appendices:-

i Signalling Line Circuit.

ii System Layout: Install no more than fifty addressable devices on each signalling line circuit.

iii Notification-Appliance Circuit.

iv Actuation of alarm notification appliances, emergency voice communications, annunciation, smoke control, elevator recall, and actuation of suppression systems shall occur within 10 seconds after the activation of an initiating device.

v Electrical monitoring for the integrity of wiring external to the FACP for mechanical equipment shutdown and magnetic door-holding circuits is not

required, provided a break in the circuit will cause doors to close and mechanical equipment to shut down.

J. Smoke-Alarm Verification shall:

i Initiate audible and visible indication of an "alarm verification" signal at the FACP.

ii Activate a listed and approved "alarm verification" sequence at the FACP and the detector.

iii Record events by the system printer.

iv Sound general alarm if the alarm is verified.

v Cancel FACP indication and system reset if the alarm is not verified.

K. Notification-Appliance Circuit in accordance with the code listed within the appendices

L. Elevator Controls: Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shuts down elevators associated with the location without time delay.

M. Power Supply for Supervision Equipment: Supply for audible and visual equipment for supervision of the ac power shall be from a dedicated dc power supply, and power for the dc component shall be from the ac supply.

N. Alarm Silencing, Trouble, and Supervisory Alarm Reset: Manual reset at the FACP and remote annunciators after initiating devices are restored to normal.

i Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.

ii Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.

iii When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.

O. Walk Test: A test mode to allow one person to test alarm and supervisory features of initiating devices. Enabling of this mode shall require the entry of a password. The FACP and annunciators shall display a test indication while the test is underway. If testing ceases while in walk-test mode, after a present delay, the system shall automatically return to normal.

P. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and control of changes in those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity adjustment schedule changes in system memory, and make a print-out of the final adjusted values on the system printer.

Q. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, trouble, and supervisory signals to a remote alarm station through a digital alarm communicator transmitter and telephone lines.

R. Voice/Alarm Signalling Service: A central emergency communication system with redundant microphones, pre-amplifiers, amplifiers, and tone generators shall be provided within a separate cabinet located in the Fire Command Centre / Security office or as a special module that is part of the FACP.

a. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones, or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall be in accordance with the code listed within the appendices.

1 Allow the application of and evacuation signal to indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.

2 Programmable tone and message sequence selection.

3 Standard digitally recorded messages for "Evacuation" and "All Clear."

4 Generate tones to be sequenced with audio messages of the type recommended by the code listed within the appendices and that are compatible with tone patterns of the notification appliance circuits of the FACP.

b. Notification-Appliance Circuits

c. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of fire fighters' two-way telephone communication zones.

d. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

2. Service Modem: Ports shall be RS-232 for system printer and for connection to a dial-in terminal unit. The dial-in port shall allow remote access to the FACP for programming changes and system diagnostic routines. Access by a remote terminal shall be by encrypted password algorithm.

3. Printout of Events: on receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including the same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

4. Primary Power: 24-V dc obtained from 230-V ac service and a power-supply module. Initiating devices, notification appliances, signalling lines, trouble signal, supervisory signal supervisory and digital alarm communicator transmitter and digital alarm radio transmitter shall be powered by the 24-V dc source.

a. The alarm current draw of the entire fire alarm system shall not exceed 80 percent of the power supply module rating.

b. Power supply shall have a dedicated fused safety switch for this connection at the service entrance equipment. Paint the switch box red and identify it with "FIRE ALARM SYSTEM POWER."

5. Secondary Power: 24-V DC supply system with batteries and automatic battery charger and an automatic transfer switch.
   a. Batteries: shall be in accordance with the code listed within the appendices.

   b. Battery and Charger Capacity: shall be in accordance with the code listed within the appendices.

6. Surge Protection:
   a. Install surge protection on normal ac power for the FACP and its accessories. Comply with Section 19 "Transient Overvoltage Protection" for auxiliary panel suppressors.

   b. Install surge protectors recommended by the FACP manufacturer. Install on all system wiring external to the building housing the FACP.

S. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminium frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

33.7 BATTERY BACK-UP

A. The Fire Alarm Specialist/Contractor shall supply and install the Fire Alarm and PA/VA system complete with suitably rated battery back-up facilities. The batteries shall be capable of powering the complete system for a period of at least 24 hours, after which sufficient capacity should remain in the batteries to operate the system during a full fire condition for a further period of 3 hours.

33.8 FRONT END CONTROL UNIT

A. Software shall be provided to enable the system to monitor each fire and fault event and programming of the system to suit future requirements.

B. Software shall be provided to enable each fire alarm panel connected onto the local area network to display all alarm, fault and general information from all other fire alarm panels.

33.9 SYSTEM SOFTWARE PROVISIONS

A. The Fire Alarm Specialist/Contractor shall supply all Fire Alarm system operating and system configurations software data on CD-ROM format on completion of the final testing and commissioning.

B. The system shall be configured to enable all configuration updates to be performed on site by a single competent operative.

C. The Fire Alarm Specialist/Contractor shall note that by submitting their quotation for the project the Specialist has confirmed that he shall provide to the Client or to the Client's Representative at no additional cost the following software configuration items:

1. The control equipment manufacturer's system programming software. This should allow the user to set up the system initially so that it operates as specified and carry out all required changes to the configuration thereafter. The software must provide at least the ability to program text messages, add, subtract or modify the type of addressable modules, change the sounder and output operation and allow the adjustment of sensitivity of detection devices / sensors.

2. Site specific configuration. This is the software that contains the entire programmed configuration specific to the site that is the subject of the system / installation requirements.

3. Details of a suitable portable computer on which the software can be run.

4. The necessary leads for uploading/downloading the control unit where special plugs or leads are required. Alternatively written details of how to make up suitable leads where equipment to do so is readily available.

5. All passwords needed to access all levels of the configuration and all levels of the control unit menu structure.

33.10 MANUAL FIRE ALARM BOXES (MANUAL CALL POINT)

A. UL Listed

B. Manual call point shall be with polycarbonate enclosure and easily resettable.

C. The Manual Break Glass Call Point shall have response time of less than 1 second and shall have a very low standby current, incorporating a status LED, which flashes when, polled or is continuously lit when operated. An additional set of volt free change over contacts shall be incorporated for additional local signalling as required. The addressable code for the device shall be electronically programmed and stored in the sensor and be non-volatile.

D. All circuits used in data communication will be designed and manufactured by the original manufacturer and will be a complete and integral part of the MCP.

E. Each MCP installed on the loop shall have a unique address, set at the commissioning stage by means of a seven-segment DIL switch.

F. MCPs shall contain electronic circuits similar to those in detection equipment, so that the communication protocol and fast response to the alarm state of the device are monitored. The MCP housing and electronic circuits will be supplied by the manufacturer of the detection and interface units.

G. A single alarm LED shall be provided on the MCP. This LED will be controlled, independently of the device, by the CIE.

H. MCPs shall be able to flash their LEDs each time they are polled.

I. MCPs shall be capable of being remotely tested from the CIE by transmission of a single bit in the communication protocol. MCPs shall respond by providing an analogue value of 64

to indicate a healthy test condition. The CIE shall recognize this response as a test signal and should not raise a general alarm.

J. The MCP housing shall be a red plastic moulding and will have dimensions not exceeding 87mm x 87mm x 52mm.

33.11 SYSTEM SMOKE DETECTORS

A. General Description:

1. UL/FM Approved
2. Operating at 24-V dc, nominal, in accordance with code listed within the appendices.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
4. Multipurpose type, containing the following:
5. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
6. Piezoelectric sounder rated at 88dBA at (3 m) in accordance with code listed within the appendices.
7. Heat sensor, combination rate-of-rise and fixed temperature.
8. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plugin module that connects to a fixed base. Provide terminals in the fixed base for connection of building wiring.
9. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
10. Integral Visual-Indicating Light: LED type. Indicating power on status.
11. Remote Control: Unless otherwise indicated within the Contract Documentation, detectors shall be analogue-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
12. Rate-of-rise temperature characteristic shall be selectable at the FACP for 8 or 11°C per minute.
13. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at the FACP to operate at 57 or 68°C.
14. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. UL / FM approved

2. The Photoelectric Smoke Sensor shall operate on a 'Fuzzy Logic Technology', by the use of a minimum of an 8 bit processor, to enable the sensors to store and analyze fire scenarios, thereby reducing susceptibility to false alarms and improve the sensitivity. The sensitivity of the device shall be variable. The device shall compress with remote indicator output. The addressable code for the device shall be electronically programmed and stored in the sensor and be non-volatile

3. The photoelectric (optical) smoke detectors shall be suitable for detecting visible smoke such as is produced by slow smouldering fires including burning PVC. They shall be of the light scattering type using a pulsed internal LED light source and a photo-diode sensor.

4. A clear indicator LED shall be provided on the detector which illuminates red when the detector has reached a pre-set alarm level. The indicator shall be operated independently of the detector from the CIE.

5. Provision shall be made for an output from the detector suitable for operating a remote indicator or other device with a current limitation of typically 4 milliamps. The output shall be operated independently of the smoke detector from the central control panel.

6. Separate mounting bases shall be required which enable ready removal of the detectors for maintenance.

7. The construction of the detector and bases shall be in white self-extinguishing polycarbonate plastic. All circuitry must be protected against moisture and fungus. Smoke entry points must be protected against dust and insect ingress by corrosion resistant gauze. The optical chamber must be of conductive plastic and have a snap-lock fit for ease of removal when cleaning. The detectors must be unobtrusive when installed, having a dimension not exceeding 100mm diameter maximum including the mounting base.

8. The detector shall incorporate a feature enabling it to be locked securely to its base.

9. Data transmissions to and from the CIE from the detector shall be via communications circuitry which is factory fitted to the detector by the original detector manufacturer and forms a complete and integral part of the detector. The detector shall be supplied complete, fully tested and calibrated.

10. The unique address of the detector shall be set by the installer by means of a coded plastic card fitted to the detector base.

11. The detector shall be capable of being remotely tested from the control panel by the transmission of an output command bit to the addressed detector. This shall result in a healthy detector transmitting back an analogue value in excess of the recommended fire alarm threshold. The CIE will recognize this as a test signal and shall not raise an alarm against this signal.

12. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to the code listed within the appendices.

C. Ionization Smoke Detector:

1. UL / FM approved

2. The Heat Sensor shall incorporate a highly linear thermistor circuit. A voltage is produced proportional to temperature which shall be scaled, linearized and transmitted as an analogue value.

3. The heat detector shall be electronic in operation and suitable for connecting to a 24V central system which can operate within the voltage range of 17V -28V DC.

4. The device shall detect temperature by means of an NTC thermistor. A red indicator LED shall be provided on the detector which illuminates when the detector has reached a pre-set alarm level. The indicator shall be operated independently of the detector from the CIE.

5. Separate mounting bases shall be required which enable ready removal of the detectors for maintenance. The bases shall be fitted with dual finger stainless steel contacts.

6. The construction of the detector and bases shall be in white self-extinguishing polycarbonate plastic. Full circuitry must be protected against moisture and fungus. The detectors must be unobtrusive when installed, having a dimension not exceeding 50mm x 100mm diameter maximum including the mounting base.

7. The detector shall incorporate a feature enabling it to be locked securely to its base.

8. Data transmissions to and from the control panel from the detector shall be via communications circuitry which is factory fitted to the detector by the original detector manufacturer and forms a complete and integral part of the detector.

9. The unique address of the detector shall be set by the installer by means of a coded plastic card fitted to the detector base.

D. Beam-Type Smoke Detector: Each detector shall consist of a separate transmitter and receiver, and shall have the following features:

1. Operating at 24-V dc, nominal in accordance with the code listed within the appendices.

2. Adjustable Sensitivity: At least six sensitivity levels, settable at the receiver, measured as percent of obscuration.

3. Two selectable alarm delay settings, allowing each to be associated with a corresponding sensitivity.

4. Trouble signal delay fixed at 20 seconds (minimum).

5. Separate Colour-Coded LEDs: Indicate normal, alarm, and trouble status with remote indicator panels.

E. Remote Air-Sampling Detector System: Includes air-sampling pipe network, a laser-based photoelectric detector, a sample transport fan, and a control unit.

1. Operating at 24-V DC, nominal in accordance with the code listed within the appendices.

2. Pipe Network: Electrical metallic tubing connects control unit with designated sampling holes.

3. Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of three preset values.

4. Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05-inch wg (12.5 Pa) at all sampling ports.

5. Control Unit: Single or multi-zone unit as indicated. Provides same system power supply, supervision, and alarm features as specified for the central FACP plus separate trouble indication for airflow and detector problems.

6. Signals to the Central FACP: Any type of local system trouble is reported to the central FACP as a composite "trouble" signal. Alarms on each system zone are individually reported to the central FACP as separately identified zones.

F. Duct Smoke Detectors:

1. Photoelectric Smoke Detectors

2. Sensor: LED or infrared light source with matching silicon-cell receiver.

   a. Detector Sensitivity: Between 0.008 and 0.011 percent/mm smoke obscuration when tested according to the code listed within the appendices. Verify detector sensitivity with manufacturers selected. Increased and decreased sensitivities are available to meet special environmental requirements.

3. Ionization Smoke Detectors

   a. Sensor: Responsive to both visible and invisible products of combustion. Self-compensating for changes in environmental conditions Operating at 24-V dc, nominal in accordance with the code listed within the appendices.

   b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

   c. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring. Weatherproof Duct Housing Enclosure

4. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.

   a. Integral Visual-Indicating Light: LED type. Indicating Power on status.

5. Remote Control: Unless otherwise indicated, detectors shall be analogue-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.

   a. Each sensor shall have multiple levels of detection sensitivity.

   b. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.

c. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

33.12 HEAT DETECTORS

A. UL / FM approved

B. The Heat Sensor shall incorporate a highly linear thermistor circuit. A voltage is produced proportional to temperature which shall be scaled, linearized and transmitted as an analogue value.

C. The heat detector shall be electronic in operation and suitable for connecting to a 24V central system which can operate within the voltage range of 17V -28V DC.

D. The device shall detect temperature by means of an NTC thermistor. A red indicator LED shall be provided on the detector which illuminates when the detector has reached a pre-set alarm level. The indicator shall be operated independently of the detector from the CIE.

E. Separate mounting bases shall be required which enable ready removal of the detectors for maintenance. The bases shall be fitted with dual finger stainless steel contacts.

F. The construction of the detector and bases shall be in white self-extinguishing polycarbonate plastic. Full circuitry must be protected against moisture and fungus. The detectors must be unobtrusive when installed, having a dimension not exceeding 50mm x 100mm diameter maximum including the mounting base.

G. The detector shall incorporate a feature enabling it to be locked securely to its base.

H. Data transmissions to and from the control panel from the detector shall be via communications circuitry which is factory fitted to the detector by the original detector manufacturer and forms a complete and integral part of the detector.

I. The unique address of the detector shall be set by the installer by means of a coded plastic card fitted to the detector base.

J. Continuous Linear Heat-Detector System: Consists of detector cable and control unit.

1. Control Unit: Two-zone or multi-zone unit as indicated. Provides same system power supply, supervision, and alarm features as specified for the central FACP

2. Signals to the Central FACP: Any type of local system trouble is reported to the central FACP as a composite "trouble" signal. Alarms on each detection zone are individually reported to the central FACP as separately identified zones.

3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

33.13 FLAME DETECTORS

A. Ultraviolet type with solid-state amplifier-switching circuit set for 10-second delay, unless otherwise indicated within the Contract Documentation.

B. Mounting: Adapter plate for outlet box mounting. Plug-in base, interchangeable with smoke-detector bases.

C. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

33.14 NOTIFICATION APPLIANCES

A. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.

B. Bells: Electric-vibrating, 24-V dc, under-dome type; with provision for housing the operating mechanism behind the bell. Bells shall produce a sound-pressure level of 94dBA, measured 3m from the bell. 254mm size, unless otherwise indicated in the Contract Documentation. Bells are weatherproof where indicated, on the contract drawings.

C. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

D. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

E. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90dBA, measured 3m from the horn.

F. Visible Alarm Devices: Xenon strobe lights listed under UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminium faceplate. The word "FIRE" is engraved in minimum 25mm high letters on the lens.
- Rated Light Output: In accordance with standards listed in the appendices.
- Strobe Leads: Factory connected to screw terminals.

G. Voice/Tone Speakers:
- High-Range Units: Rated 2 to 15 W.
- Low-Range Units: Rated 1 to 2 W.
- Mounting: Flush, semi recessed, or surface mounted; bidirectional as indicated.
- Matching Transformers: Tap range matched to the acoustical environment of the speaker location.

33.15 FIRE FIGHTERS TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between the FACP, (Security Office, where installed) and remote fire fighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:

1. Common-talk type for fire fighter use only.

2. Selective-talk type for use by fire fighters and fire wardens.

3. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.

4. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.

5. Selector panel controls simultaneous operation of telephones in selected zones and permits up to six phones to be operated simultaneously. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.

6. Provide digital display to indicate location of the caller.

7. Remote Telephone Cabinet: Flush or surface-mounted cabinet, as indicated, factory-standard red finish, with handset.

8. Install one-piece handset to cabinet with vandal-resistant armoured cord. Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."

9. With "break-glass" type door access lock.

10. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Emergency Phone."

11. Handsets: Provide push-to-talk type sets with noise-cancelling microphone.

33.16 SPRINKLER SYSTEM REMOTE INDICATORS

A. Remote status and alarm indicator and test stations with LED indicating lights. Light is connected to flash when the associated device is in an alarm or trouble mode. Lamp is flush mounted in a single gang wall plate. A red, laminated, phenolic-resin identification plate at the indicating light identifies, in engraved white letters, device initiating the signal and room where the smoke detector or valve is located. For water-flow switches, the identification plate also designates protected spaces downstream from the water-flow switch.

33.17 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door plate.

1. Electromagnet: Requires no more than 3 W to develop 111 Newtons holding force.

2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.

3. Rating: 24-V AC or DC.

4. Rating: 230-V AC.

5. Material and Finish: Match door hardware.

33.18 REMOTE ANNUNCIATOR

A. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble Indications. Also duplicate manual switching functions of the FACP, including acknowledging, silencing, resetting, and testing.
   - Mounting: Flush mounted cabinet.

B. Display Type and Functional Performance: Alphanumeric display same as the FACP. Controls with associated LEDs permit acknowledging, silencing, resetting, and testing functions for alarm, supervisory, and trouble signals identical to those in the FACP.

33.19 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module listed for use in providing a system address for listed alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to the elevator controller to initiate elevator recall.

33.20 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Functional Performance: Unit receives an alarm, supervisory, or trouble signal from the FACP, and automatically captures one or two telephone lines and dials a preset number for a remote central station. When contact is made with the central station(s), the signal is transmitted. The unit supervises up to two telephone lines. Where supervising 2 lines, if service on either line is interrupted for longer than 45 seconds, the unit initiates a local trouble signal and transmits a signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. When telephone service is restored, unit automatically reports that event to the central station. If service is lost on both telephone lines, the local trouble signal is initiated.

B. Secondary Power: Integral rechargeable battery and automatic charger. Battery capacity is adequate to comply with the code listed within the appendices.

C. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

33.21 RADIO ALARM TRANSMITTER

A. Listed and labelled according to the code listed within the appendices.

B. Description: Manufacturer's standard commercial product; factory assembled, wired, and tested; and ready for installation and operation.

1. Packaging: A single, modular, metal enclosure with a tamper-resistant flush tumbler lock.

2. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by the Client.

3. Normal Power Input: 230-V ac.

4. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with the code listed within the appendices for battery capacity; submit calculations.

5. Antenna: Omni directional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 160 km/h with a gust factor of 1.3 without failure.

6. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.

7. Antenna-Cable Connectors: Weatherproof.

8. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.

C. Functional Performance: Unit receives an alarm, supervisory, or trouble signal from the FACP or from its own internal sensors or controls, and automatically transmits signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages correspond to standard designations for the fire-reporting system to which the signal is being transmitted and include separately designated messages in response to the following events or conditions:

1. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.

2. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.

3. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.

4. Local Fire Alarm System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.

5. Local Fire Alarm System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.

6. Local Alarm System Supervisory Alarm Message: Actuated when the building alarm system indicates a supervisory alarm.

33.22 SYSTEM PRINTER

A. Listed and labelled as an integral part of the fire alarm system.

33.23 GUARDS FOR PHYSICAL PROTECTION

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
   - Factory fabricated and furnished by manufacturer of the device.
   - Finish: Paint of colour to match the protected device.

33.24 FIRE RATED CABLE

A. General

Fire rated cable should comply with latest industry standards and tested by LPCB to comply with BS 5839-1:2013 to meet all fire and fume emission testing details. Fire rated cable shall be fully approved to the Low Smoke & Zero Halogen requirements as per BS 5839-:2013 & BS7629-1:2008.

Design and construction of fire rated cable including Outer Sheath, Aluminium Foil, Silicone Insulation and Conductor Cores should be certified by LPCB and meet with BS standard codes BS EN 50200:2006 + Annex E 30 minutes, BS EN 50200 PH30, PH60 & PH120 & BS 6387 CWZ.

The fire rated cable shall have high flexibility and must have ability to bear sharp bends during installation. It should not require any special tool while stripping. The fire rated cable shall withstand stress three times as compared to normal electric cables and shall be highly resistant to damage.

B. Voltage and Design

Cable shall be designated by the rated voltage U0 and U, expressed in the form U0IU. For the purpose of British standard, the rated voltage is 300/500 V.

C. Conductor and Drain Wire

The conductor shall be shall be plain or tinned annealed copper. The uninsulated circuit protective conductor shall be tinned annealed copper and shall be of the same nominal cross-section area as the insulated conductors. The class of conductor shall be the same for all insulated conductors in any cable.

Drain wire shall comprise one or more annealed copper wires with a total nominal cross-section area of not less than 0.5mm2 shall meet the relevant resistance requirements specified in BS 6360.

D. Insulation

The insulation shall be applied closely to the conductor or conductor taping by the extrusion process and cross-linked to form a compact and homogeneous layer. It shall be possible to remove the insulation without damage to the insulation itself, the conductor, or the tin coating, if any. The thickness of any tape(s) over the conductor or over the insulation shall not be included in the measurement of thickness of insulation.

E. Cable Marking

The cable shall be marked with the number of this British Standard1' on the outer surface by printing, indenting or embossing. All cables shall be provided with an indication of origin consisting either of an identification threads or the continuous marking of the manufacturer's name or trademark. The colors shall be easy to recognize or shall become recognizable by cleaning if necessary. The marking of the manufacturer's name or trademark, if used, shall be by printing, indenting or embossing on the sheath.

F. Test Conditions

Fire rated cable shall retain continuity for a minimum of 30 minutes under fire conditions at 830°C, this demands the fire rated cable test include a final 15 minutes under fire & water spray conditions while a mechanical shock is to be applied every 5 minutes throughout the full 30 minute test.

In condition of 950°C temperature, the fire performance cable shall have tendency to withstand for 3 hours and if fire and mechanical shock is applied every 5 minutes at 830°C, it should have stability for a minimum of 2 hours.

33.25 SPARE MATERIALS

A. The Contractor shall furnish spare materials described below that match products installed and that are packaged with protective covering for storage and identified with suitable labels describing contents:-

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of the amount installed, but not less than 1 unit.

2. Lamps for Strobe Units: Quantity equal to 10 percent of the amount installed, but not less than 1 unit.

3. Smoke, Fire, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but not less than 1 unit of each type.

4. Detector Bases: Quantity equal to 2 percent of the amount of each type installed, but not less than 1 unit of each type.

5. Keys and Tools: one extra set for access to be locked and tamperproof components.

6. Audible and Visual Notification Appliances: one of each type installed.

7. Fuses: Two of each type installed as part of the system.

34 PART 3 - EXECUTION

34.1 SMOKE OR HEAT DETECTOR SPACING:

1. Spacing of heat detectors shall be as indicated on the Contract drawings and shall be in accordance with the code listed within the appendices.

2. Spacing of heat detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas, shall be determined according to the code listed within the appendices.

A. HVAC: Locate detectors not closer than 9m from air-supply diffuser or return-air opening.

B. Duct Smoke Detectors: Comply with the code listed within the appendices. Install sampling tubes so they extend the full width of the duct.

C. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

D. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

E. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

F. Audible Alarm-Indicating Devices: Install not less than 150mm below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

G. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 150mm below the ceiling.

H. Device Location-Indicating Lights: Locate in public space near the device they monitor.

I. FACP: Surface mounted with tops of cabinets not more than 1830mm above the finished floor.

J. Annunciator: Install with top of panel not more than 1830mm above the finished floor.

K. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist 160 km/h wind load with a 1.3 gust factor without damage.

34.2 WIRING INSTALLATION

A. The Fire Alarm system shall installed used fire rated cable. The fire rated cable shall be a minimum of 1.5 mm and shall be red Low Smoke and Fume (LSF) outer sheaf. The Fire rated capable shall be clipped directly to the building fabric for single and double cable runs. The Clips shall be fire rated metal with a LSF Coated Red finish. The clips shall be fixed suitably and shall be no greater than 300mm between fixings. Where there are more than 2 cables, the cables shall be installed on suitable galvanized tray or in trunking. Where cables

run below 2.4 meters from finished floor level then all cables shall be installed within galvanized conduit.

B. In the event of a fire it is important that all cables used within a fire alarm system are able to withstand attack by the fire. All cables, including those carrying the mains supply to the control panel, should be fire resistant. BS 5839 recognizes that there may be circumstances in which a higher level of fire resistance is required which only certain types of cable can provide. This is referred to as 'enhanced' fire resistance. It is particularly necessary for tall buildings (over 30m in height) and buildings in which there is phased or delayed evacuation. However, the enhanced grade is not necessary in these situations if the building has sprinkler protection.

C. Not only should fire detection and alarm system cables be able to resist fire, they should also be sufficiently strong to avoid mechanical damage. For some types of cable, this means that they must be provided with additional mechanical protection. However, this is not necessary in the case of steel wire armoured (SWA) and mineral insulated (MI) copper sheath cables. All cables for the fire alarm system should have conductor cross sectional areas of no less than 1sq mm.

D. Standards normally require that there is suitable segregation between fire detection and alarm system cables and cables of other services. The purpose of segregation is to minimize any potential for the other circuits to give rise to malfunction of the fire detection and alarm system as a result of:

1. Breakdown of the cable insulation of the other circuit and/or the fire alarm system circuits.

2. A fire caused by a fault on the other circuit.

3. Damage resulting from the need for other circuits to be installed in, or removed from, conduit, ducts or trunking containing the fire detection and alarm system circuits.

4. Electromagnetic interference to the fire detection and alarm system circuits as a result of the proximity of another circuit.

E. Correct corresponding termination devices and boxes shall be used. All devices shall be terminated using a compression lock gland colored red manufactured in LSF material. Where devices are fixed surface a suitable LSF shroud shall be used.

F. Before any devices are connected the contractor must fully demonstrate and prove the quality of the installation for loop integrity, continuity, resistance and capacitance.

G. The system specialist shall install all devices; this shall include 2nd fix and 3rd fix. Prior to completion of the project the system specialist must demonstrate the entire system to the approval of the Consultant. The entire system shall have been 100% tested independently prior to the demonstration to the Consultant. Should any items fail during the test a new and complete 100% re-test shall be carried. The specialist will be responsible for any costs involved with re-testing of the system.

H. The system specialist will be responsible for providing complete and detailed manuals for the entire system. The manuals shall be fully detailed and shall describe the operation and function of each part of the system.

34.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to the General Technical Specification

B. Install instructions frame in a location visible from the FACP.

C. Paint power-supply disconnect switch red and label "FIRE ALARM."

34.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorised service representative to inspect, test and commission field-assembled components and equipment installation, including connections and to assist in field testing.

B. Testing Agency: The Fire Alarm Specialist/Contractor shall undertake the following field tests and inspections and prepare test reports accordingly:

C. Perform the following field tests and inspections and prepare test reports:

1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in the code listed within the appendices.

2. Include the existing system in tests and inspections.

3. Visual Inspection: Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or non-functional equipment, and correct before beginning tests.

4. Testing: Follow procedure and record results complying with requirements in accordance with the code listed within the appendices.

D. Detectors that are outside their marked sensitivity range shall be replaced.

1. Test and Inspection Records: Prepare according to the code listed within the appendices, including demonstration of sequences of operation by using the code listed within the appendices.

34.5 INTENSIVE TRAINING

The specialist shall allow for onsite and offsite intensive training for a period of 1 week for a minimum of 4 persons. The training procedures shall be submitted to the consultant for approval before training will commence. The training shall be carried out by a professional and approved training manager.

34.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Practical Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

B. Follow-Up Tests and Inspections: After date of Practical Completion, and for a period of one year undertake all testing of the Fire Detection and Alarm System in accordance with the requirements of the Operation and Maintenance Manuals. Test the fire alarm system complying with testing and visual inspection requirements of the code listed within the appendices and as recommended by the equipment supplier.

C. Annual Test and Inspection: one year after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements of the code listed within the appendices. Perform tests and inspections listed for monthly, quarterly, semi-annual, and annual periods. Use forms developed for initial tests and inspections.

34.7 DEMONSTRATION

A. Engage a factory-authorised service representative to train the Client's maintenance personnel to adjust, operate, and maintain the fire alarm system, appliances, and devices.

34.8 TESTING, COMMISSIONING AND DEMONSTRATION

A. The Contractor shall ensure that a factory-authorised service representative is appointed to inspect, test and commission site-assembled components and equipment installation, including connections and to assist with onsite testing.

B. A test certificate shall be issued to the Engineer in accordance with NFPA 72 and shall be incorporated into the operating and maintenance documentation.

C. The Contractor shall appoint a factory-authorised service representative to train the Client's maintenance personnel to adjust, operate, and maintain the fire alarm system, appliances, and devices.

D. The specialist shall fully test the entire system and when satisfied offer the entire system to the Consultant for completes 100% witness testing. Should any failures occur then a complete 100% retest shall be carried out at the cost of the specialist. The test must for the entire integrated system; partial tests will not be acceptable.

XIII. VOICE EVACUATION SYSTEM

35 PART 1 - GENERAL

35.1 GENERALS

A. All major component of voice evacuation system shall be product of a single reputable European or USA origin manufacturer.

B. The System should be designed to provide a networked emergency voice communications for large Facilities such as high-rise buildings and campuses. The system is comprised of one master Control panel and one or more distributed panels. The last panel connects to the first to complete the loop. Remote panels contain amplifier modules for connection to field Speaker loops.

C. The facility shall have an emergency voice communication system. The digital recorded message shall notify occupants of any fire condition that has been reported. The message shall broadcast emergency instructions. System shall have the capability of manual voice override. The voice evacuation system shall be a multiplexed type design allowing smart distributed panels with the features listed below.

D. The system shall include one Master Panel and one or more Distributed Panels. The system shall be microprocessor based, and shall be compatible for use with contact closures from the Fire Alarm Control Panel, (FACP). The system shall have a high-speed communication bus and have the capacity for 6 channels of audio and data on a single pair of wires. The field wiring for the communication bus may be configured for either Style "4" or Style "7" supervision. The system shall have the capacity for Fire Fighters Phones and also have the capacity for Fan & Damper control with monitored feedback. The system shall have a minimum capacity of 1000 monitor and control points.

E. Fire Phone circuits shall be capable of connecting up to 5 phones on a circuit simultaneously. A jack-in of a portable handset or taking a remote station off-hook shall generate a call in signal at the Master Panel. The associated LED will flash until the call is acknowledged; it will then switch to a steady on. Only when the remote party has disconnected will the LED extinguish.

F. Control and Monitor loops will be capable of addressing 64 individual control points. Each control point will be capable of a forced shut down, forced start and be capable of monitoring status of a controlled device. Each control point will remain in standby unless manual or automatic shut down or start is activated. On activation of a shut down, the associated LED will flash red until monitoring acknowledges an actual shut down at which point the LED will change to a steady on. If the device monitored does not shut down within 60 seconds, the associated LED will change to a flashing yellow and a fault condition will result.

G. For a start command, the operation will be identical except the associated LED will flash or go steady green. In standby condition any device will operate normally by its own control.

H. System may be configured for General Alarm All Call operation, Alarm by Zone or Floor Above/Floor Below as required. Contact closures shall allow immediate broadcast of an alarm signal and evacuation message to the appropriate area. Non-Alarm areas may receive alert tones and messages as required or activated by the FACP.

I. System may be configured for General Alarm All Call operation, Alarm by Zone or Floor Above/Floor Below as required. Contact closures shall allow immediate broadcast of an

alarm signal and evacuation message to the appropriate area. Non-Alarm areas may receive alert tones and messages as required or activated by the FACP.

J. To prevent unauthorized tampering, the voice evacuation system shall disable the microphone if the microphone is keyed continuously for 3 minutes or more. Systems that do not have this feature shall not be acceptable.

K. Audio amplifiers shall be electrically supervised. Notification speaker circuits shall be arranged so that any loss of one speaker circuit shall not cause the loss of any other speaker circuit.

L. Speaker circuits shall have 20% space for future expansion. Speaker circuits shall 70/100 VRMS.

M. Speakers shall have field selectable output taps from 0.5-2.0 watts. Minimum sound output of 84 dBA at 10 feet shall be provided.

36 PART 2 - PRODUCTS

36.1 MASTER PANEL

A. The Master Panel shall contain an integral microphone, dual channel digital message repeater, (DMR) and digital tone generator, 230 VAC power supply, and battery charger. The system shall include integral self-diagnostic routines that shall continually monitor system status, and shall indicate the precise type of trouble conditions should they occur in the system. A trouble condition within the system shall cause a trouble indication to be transmitted to the FACP.

B. The Master Control panel provides paging control with a microphone subpanel (MMC) and a Zone selection switch/LED subpanel (SSC & SLC). The microphone subpanel also has an all-call Switch to activate and deactivate all paging zones at once. The switch/LED subpanel also provides other control functions by being allocated in blocks of four in order; Paging, Fire Phone, output control and manual signal and message activation.

C. Pre-recorded fire and evacuation signals and messages are stored in non-volatile memory on the Audio/system controller card (ASC).

D. System supervision indication and control is provided on the microphone subpanel via switches and a simplified alphanumeric display. The two main switches are System Reset and System Trouble Silence. The microphone subpanel provides one programmable switch and an All-Call switch for paging. The alphanumeric display, in conjunction with the Fault LED, provides Simplified fault reporting by indicating which panel has a fault and what the nature of the fault is, in turn.

36.2 DISTRIBUTED PANEL

A. Distributed panels shall provide a minimum of 4 Class "B" speaker circuits, expandable to eight total. Alternately, panel may be configured for up to 4 Class "A" speaker circuits. Panel may be configured for 1 to 8 amplifiers. Panel must provide up to 6 simultaneous audio channels, up to 12 Fire Phone circuits, and up to two Control/Monitor loops. Amplifiers will contain their own power supplies, battery chargers and provide auxiliary power for other components. Speaker circuits shall be supervised for short and open circuit conditions, and shall be able to withstand transient or continuous short-circuit conditions without damage to the system.

B. The distributed panels are networked for control from the master panel, and provide the supervised speaker and fire phone circuits for field wiring connections.

C. Speaker loop supervision and activation is provided by the speaker circuit zone boards (MBR, MBK).

D. Fire phone loop communication to fire phone handset circuits is provided by the fire phone Interface card (FPI).

36.3 SYSTEM ACCESSORIES

A. Fireman’s Phone Jack

The fireman's phone jack station to be located at strategic places in a building for two-way communication to the master station. In operation, a fireman plugs in a handset, which rings in at the master station. The operator can then pick up the master handset, select the switch, and talk with the fireman at the remote station. Construction is simply a single-gang stainless steel plate with a ¼ "phone jack, intended to be mounted to a standard single-gang electrical box.

B. Fireman's Handset

The standard telephone handset with cord and a phone plug. Firemen responding to an incident can carry the handset to another area, plug in to a wall jack, and talk two-way with the operator at the master station.

C. Fireman's Telephone Cabinet

This is simply a storage cabinet for fireman's telephone handsets when not in use. 6 cradles are provided so that 6 handsets can be ready for use in an emergency. Cabinet has a hinged key lock door.

D. Voice Evacuation Speakers

Evacuation speakers shall be dual-voltage transformer speakers capable of operating at 25.0 or 70.7 nominal Vrms with low total harmonic distortion and fidelity-quality sound output.

Evacuation speakers shall have a frequency range of 400 to 4000 Hz and shall be capable of operating between 0°C and 50°C.

Evacuation speakers shall have four field selectable power taps: 1⁄4, 1⁄2, 1, and 2 watts.

The speakers shall generally be flush mounted without the need for extension rings or wall mounted where indicated on the Tender drawings.

The finish shall be white unless otherwise stated in the Technical Schedules.

Speakers installed outdoor shall be IP65 minimum rated and suitable for the particularly harsh expected environmental conditions.

36.4 SYSTEM ACCESSORIES

The voice alarm system shall be fully commissioned, including interfaces with other systems. Demonstrations shall be performed for the Consulting Engineer and if satisfactory shall be repeated for the Fire Officer. Demonstrations shall include:

- Speaker operation
- Audibility tests
- Correct operation in relation to staged evacuation on a smoke zone basis

- Correct operation when switching from Public Address to Voice Alarm mode
- Full cause and effect demonstration and interfaces with other systems

XIV. WIND GENERATOR SYSTEMS

37 PART 1GENERAL

37.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced.

IS/IEC 61400-2 : 2013 IEC 61400-2:2013	Wind Turbines Part 2: Small Wind Turbines
IS/IEC 61400-12-1 : 2017 IEC 61400-12-1 : 2017	Wind Energy Generation Systems Part 12 Electricity Producing Wind Turbines Section 1 Power performance measurements
IS/IEC 61400-12-3: 2022 IEC 61400-12-3:2022	Wind energy generation systems - Part 12: Power performance - Section 3: Measurement based site calibration
IS/IEC 61400-12-4 : 2020 IEC TR 61400-12-4:2020	Wind energy generation systems - Part 12- Power performance - Section 4 Numerical site calibration for power performance testing of wind turbines
IS/IEC 61400-12-5 : 2022 IEC 61400-12-5:2022	Wind energy generation systems - Part 12: Power performance - Section 5: Assessment of obstacles and terrain
IS/IEC 61400-12-6 : 2022 IEC 61400-12-6:2022	Wind energy generation systems - Part 12-6: Measurement based nacelle transfer function of electricity producing wind turbines
IS/IEC/TS 61400-13 : 2015 IEC 61400 : Part 13	WIND TURBINE'S PART 13: MEASUREMENT OF MECHANICAL LOADS
IS/IEC/TS 61400-14 : 2005 IEC 61400-14:2005	Wind Turbines Part 14: Declaration of Apparent Sound Power Level and Tonality values
IS/IEC/TR 61400-21-3 : 2019 IEC TR 61400-21-3:2019	Wind energy generation systems - Part 21: Measurement and assessment of electrical characteristics - Section 3: Wind turbine harmonic model and its application
IS/IEC 61400-21 : 2008 IEC 61400-21 : 2008	Wind turbines: Part 21 measurement and assessment of power quality characteristics of grid connected wind turbines
IS/IEC 61400-22 : 2010 IEC 61400-22 : 2010	Wind Turbines Part 22 Conformity Testing and Certification
IS/IEC 61400-23 : 2014 IEC 61400-23 : 2014	Wind Turbines Part 23 Full-Scale Structural Testing of Rotor Blades
IS/IEC 61400-24 : 2019 IEC 61400-24:2019	Wind energy generation systems - Part 24: Lightning protection
IS/IEC 61400-25-1 : 2017 IEC 61400-25-1 : 2017	Wind Turbines Part 25 Communications for Monitoring and Control of Wind Power Plants Section 1 Overall description of principles and models
IS/IEC 61400-25-2 : 2015 IEC 61400-25-2 : 2015	Wind Turbines Part 25 Communications for Monitoring and Control of Wind Power Plants Section 2 Information model

IS/IEC 61400-25-3 : 2015 IEC 61400-25-3 : 2015	Wind Turbines Part 25 Communications for Monitoring and Control of Wind Power Plants Section 3 Information exchange models
IS/IEC 61400-25-4 : 2016	Wind Turbines Part 25 Communications for Monitoring and Control of Wind Power Plants Section 4 Mapping to communication profile
IS/IEC 61400-25-5 : 2017 IEC61400-25-5 : 2017	Wind Turbines Part 25 Communications for Monitoring and Control of Wind Power Plants Section 5 Compliance testing
IS/IEC 61400-25-6 : 2016	Wind Turbines Part 25 Communications for Monitoring and Control of Wind Power Plants Section 6 Logical node classes and data classes for condition monitoring
IS 61400 (Part 25/Sec 71) : 2019 IECTS 61400-25-71:	Wind energy generation systems - Part 25-71: Communications for monitoring and control of wind power plants - Configuration description language
IS/IEC 61400-27-1 : 2020 IEC 61400-27-1:2020	Wind energy generation systems - Part 27: Electrical simulation models - Section 1: Generic models
IS/IEC 61400-27-2 : 2020 IEC 61400-27-2:2020	Wind energy generation systems - Part 27: Electrical simulation models - Section 2: Model validation
IS/IEC 61400-50 : 2022 IEC 61400-50:2022	Wind energy generation systems - Part 50: Wind measurement - Overview

37.2 SUBMITTALS

37.2.1 Pre-Construction Submittals

- Commissioning Plan
- Commissioning Schedule

37.2.2 Shop Drawings

- Site Plan Drawings
- Riser Diagram and General Notes
- Complete Wind Turbine PV System components and interconnection wiring diagrams
- Installation and Assembly Details

37.2.3 Product Data

- Wind Turbine
- Inverters
- Disconnects
- Combiner Boxes
- Monitoring Equipment

- System Wiring
- Mounting Structures
- Sample Warranty Certificate

37.2.4 Design Data

- Design Calculations
- Calculated / Projected Energy Annual Production
- Towers / Support Structure
- Foundations
- Visual Impact Analysis and Mitigation
- Static Loading and Dynamic Response Analysis
- Noise Analysis & Mitigation
- Wildlife Impact Analysis & Mitigation
- Groundings System Analysis

37.2.5 Certificates

- Commissioning Procedures
- Certificate of Completion
- Commissioning Agent Certification
- Seismic Certifications
- Wind Certification
- Test Reports
- Inverter Start-up Test
- Functional Performance Testing Procedures
- Certificates Materials
- Wind Certification
- Manufacturer's Instructions
- Operation and Maintenance Data Package
- Operating Instructions / Corrective & Preventive Maintenance Manuals
- Special Tools and Equipment
- System Startup, Shutdown, and Emergency Procedures

- Definition and Use of All System, Command, and Application Software
- Staff Training Documentation
- Commissioning Reports
- Warranty Certificates
- As Built Drawings

37.3 QUALITY ASSURANCE

37.3.1 Regulatory Requirements

Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of the Authority Under Jurisdiction unless more stringent requirements are specified or indicated.

37.3.2 Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

37.3.3 Drawings

Submit minimum of A1 size, three (3) hard copies of drawings for government approval prior to manufacturing and equipment construction or integration.

37.3.4 Product Drawings

Submit complete detailed product drawings for the wind turbine system consisting of Shop Drawings, Drawings, Schedules and Manufacturer Data Sheet. Include in the shop drawings wire diagrams, utility interconnection diagrams, switchboard and switchgear drawings, equipment enclosures, conduits, monitors, meters, and all other accessories associated with the installation of the wind turbine system. Provide equipment dimensions, weights and structural mounting details.

Include nameplate data, size, and capacity of each wind turbine. Include all assumptions such as applicable wind speed, snow and seismic loads.

37.3.5 Installation and Assembly Drawings and Details

Submit site plan drawings, Riser Diagram and general notes and Installation and Assembly Drawings and Details prior to start of construction. Include sufficient drawing detail for all parts of the work to enable the Government to check conformity with the requirements of the contract documents. Include in the site plan drawings: topographic and utility survey; bore logs; soils report; site plan(s); site construction details; structural drawings; structural construction details; site electrical plan; and site electrical construction details. Include in the installation and assembly drawings and details: parts lists; assembly drawings; interconnection wiring diagrams; wire and cable schedules; wire and cable termination schedules; instrument plan; instrument and control wire, conduit and cable schedules; instrument wire and cable termination schedule; control diagrams; control sequence of operation; seismic restraint details; and wind restraint details.

37.3.6 "As-Built" and Record Drawings

After completion of construction, submit As-Built Drawings prepared and certified by the construction contractor, showing in red ink, on-site changes to the original construction details and all underground utilities measured from field benchmarks, accurate to within 20mm of centerline of the utility. Immediately record for inclusion into the as-built drawings all modifications to original drawings made during installation. Indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Prepare "as-built" on a minimum of A1 Size.

After submittal and approval of "As-built" Drawings, submit Record Drawings, prepared and by the project engineer(s) and architect(s), of the original design drawings reflecting all design changes and contractor noted changes in the "As-Built" drawings.

37.3.7 Factory Acceptance Testing

Prepare Work Plan and Factory Test Plan. Conduct Factory Acceptance Testing during manufacturing of the wind generators as follows:

- Tower: mil certificate for steel plates, dimensional inspection report, non-destructive test report, coating inspection report, non-conformance reports, inspection certificate from certifying agency;
- Electrical Parts: generator, wind turbine generator transformer, converter system, and controller;
- Nacelle: gear box, lubrication system, main shaft installation, yaw drives and system; blade pitch system, cooling system; and major castings.

37.3.8 Prepare Factory Test Reports after completion of testing.

37.3.8.1 Work Plan

Submit 6 copies of schedules of dates for factory tests, installation, field tests, and operator training for the wind Turbine system. Furnish a list of instrumentation equipment for factory and field test reports.

37.3.8.2 Factory Test Plan

Submit 6 copies of factory test plans and procedures at least 21 calendar days prior to the tests being conducted. Provide detailed description of test procedures, including test equipment and setups, to be used to ensure the Wind Turbine meets the performance specification and explain the test methods to be used. As a minimum, the test procedures to include the test required under the paragraph entitled "Factory Testing."

37.3.8.3 Factory Tests Report

Submit 6 copies of factory test report within 45 calendar days after completion of tests. Receive approval of test prior to shipping unit. Factory test reports must be signed by an official authorized to certify on behalf of the Wind Turbine manufacturer of that the system meets specified requirements in accordance with the requirements set forth in paragraph entitled "Factory Testing". Provide test reports in booklet form tabulating factory tests and measurements performed, upon completion and testing of the installed system. Reports to state the Contractor's name and address, the name of the project and location, and list the specific requirements which are being certified.

37.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

37.5 PROJECT/SITE CONDITIONS

37.5.1 Environmental Requirements

The wind turbine system must conform to applicable state, regional, and local regulations regarding visual impact, noise pollution control, and wildlife impact. Perform and submit Noise Analysis & Mitigation, Visual Impact Analysis & Mitigation, and Wildlife Impact Analysis & Mitigation to Client for review and approval prior to mobilization.

Elevation	14 meters above sea level.
Temperature Range	16.8 deg C to 34.2 deg C
Average Humidity	55% percent
Lightning	500,000.00 annual average strikes (cloud to ground)
Rainfall	2185 mm mean total annual rainfall

37.5.1.1 Wind Resource Data

The prevailing wind is from the [compass direction] with average annual wind speeds estimated to be 9 m/s at 50 meters above ground level at the preferred locations for these new wind turbines. Peak average wind has been recorded from the [compass direction]at 26.22 m/s. Summary average annual wind data results from past wind resource assessments are included indicated in Table 1.0 of this specification. Validate the site(s) wind resource characteristics and design wind turbine system specifically for site conditions.

Table 1.0 Wind Speed Range in m/s at 50 meters Range from Year 2015 to 2022, Source: https://power.larc.nasa.gov/

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2015	7.41	5.2	6.23	5.48	5.8	11.93	10.79	11.65	8.17	11.91	7.1	7.3
2016	7.38	6.38	5.69	7.84	8.12	12.65	8.93	5	5.77	7.57	5.25	6.7
2017	7.26	7.23	7.34	4.79	10.11	11.55	7.95	9.2	9.99	8.93	11.55	19.85
2018	7.98	8.14	11.71	6.55	15.28	11.11	7.97	10.93	6.47	10.62	10.54	5.78
2019	6.39	7.4	6.38	8.91	5.76	16.92	11.26	11.02	12.96	15.27	7.98	8.65
2020	7.49	7.67	7.55	6.1	9.98	11.25	8	12.6	12.3	9.55	14.33	7.56
2021	7.34	7.09	5.66	6.67	26.22	11.11	8.38	9.34	8.95	10.17	12.33	6.59
2022	6.71	6.73	5.79	7.16	9.79	9.97	11.57	13.76	9.48	7.48	9.84	7.62

Validate the Wind Farm system's components and design parameters with respect to wind loading and survival wind speed. The wind turbine system will be designed to maintain structural integrity and safe operation under specified environmental conditions, without damage to life or property for the 20-year life of the wind turbine system.

37.5.1.2 Site Equipment Limitations

Identify and provide any special crane requirements for shipping, off-loading and erection of the wind turbine and its components.

37.6 WARRANTY

Wind turbine system must provide reliable operation, free from breakdowns for the design life of the wind turbine system 20 years.

37.7 CERTIFICATIONS

Provide Seismic Certification and Wind Certification, prepared by a licensed Structural engineer for all components and assembled systems in accordance with state and local building codes. Seismic and wind certifications shall demonstrate system shall withstand wind and seismic requirements as installed and remain online and functional after a seismic or wind event.

38 PART 2PRODUCTS

38.1 SYSTEM DESCRIPTION

The wind turbine system must be furnished as totally coordinated assemblies which, after site installation and testing, shall comply with the design and performance requirements of this specification.

38.2 DESIGN REQUIREMENTS

38.2.1 General Requirements

General requirements for the wind turbine system includes:

a. The wind turbine system should consist of a horizontal / vertical. axis, upwind active yaw control configurations, with a minimum of three rotor blades.

b. Rotor controls must be supplied to provide an active variable pitch (power/torque) air-foil design.

c. Operational RPM's must be variable, no less than minus 10 percent to plus 5 percent of synchronous RPM's.

d. Low-voltage ride-through capability (see IEEE draft standard and/or European REE and EON grid code requirements.)

e. Reactive power support capability of 0.96 inductive to 0.98 capacitive power factor range, or approved equal.

38.2.2 Controls

The wind turbine controls will utilize standard "soft start" technologies to minimize the impact to electrical power systems. The design must include active power factor and load leveling controls to help reduce the need for supplemental active VAR control and to stabilize and/or minimize the system frequency/power changes due to wind variability respectively. The design requirements for the wind turbine subsystem components must be as described below.

38.2.3 Enclosures

All wind turbine equipment, controls, terminations, etc., supplied with the wind turbine system, which are intended to be located outside the nacelle, must be located in NEMA 12 (or equal) gasketed minimum rated enclosures for improved corrosion and environmental protection. If temperature control is required within the wind turbine control enclosures, provide all equipment, devices, and controls necessary to maintain the required temperature.

38.2.4 Rotors

Wind turbine rotors must consist of nonmetallic composite airfoils of a design resistant to abrasion related efficiency losses and must be non-EMI conductive/reflective. The rotor design must be optimized to provide maximum wind turbine output performance based on the specific wind regime characteristics. Further, the rotor controls must be designed to provide a minimum of one level of safety beyond the primary systems.

38.2.5 Reduction Gear Assemblies

High-efficiency, reduction gear assemblies (if required) must be supplied that are designed for low temperature rise, low levels of vibration, long life, and low noise emissions. Further, the gear assembly designs must provide reliable operation, free from breakdowns (not excluding normal maintenance), for the design life of the wind turbine system 20 years.

38.2.6 Bearings and Seals

The drive train must utilize tapered roller bearing technology, wherever possible, to maintain parallelism and axial tolerance of the drive train during all operating conditions.

Maintenance-free sealing must be installed on all shafts to prevent leaking of gear lubrication and intrusion of dirt and dust.

38.2.7 Foundations

Determine soil and foundation load requirements and comply with applicable requirements of state and local building codes.

38.2.8 Towers/Support Structures

The tower must be a free-standing construction consisting of tubular steel (or approved equal), with provisions for safely climbing and servicing the turbine. The tower must be provided with a catwalk or maintenance platform just below or within the turbine to provide for turbine servicing as per manufacturer's standard design. Determine proper height of tower assembly for optimum operation of the wind turbines. Tower construction using self-erecting crane systems are encouraged, and should be considered in cases where the height limitations of the installation may severely limit the performance of the offered system. Establish and maintain all precautions with regards to wind turbine installation and safeguarding the cranes for all possible wind conditions. Comply with IEC 61400-SER and wind turbine manufacturer's standards.

All tower components including, but not limited to, or tube elements, anchors, supports, rails, ladders, etc., will be of a corrosion resistant steel construction, or coated with certified [10]-year surface coatings.

38.2.8.1 Wind Ratings

The wind turbine system must be capable to withstand winds of Category 4 as defined by the Saffir-Simpson Hurricane Wind Scale. Provide wind certifications for all components and assemblies.

The tower assembly (and all associated components subject to fluctuating/cyclic loading) must be designed to withstand all operating conditions for the specific wind region characteristics based on, but not limited to, the supplied wind data. Static loading and dynamic response analysis must be submitted for review, for all loads imposed on the wind turbine system. The analysis must also include all required erection equipment loadings (i.e., on gin poles, winches, cranes, cables, earth anchors), as required for erection and/or maintenance purposes.

38.2.8.2 Seismic Ratings

All structures and structural elements must be suitable for Seismic Zone 4 in accordance IS 1893 2002, and all other applicable building codes and standards pertaining to the erection of such structures.

All bolted connections must meet AISC 325 standards or equivalent for loading and torque specifications.

38.2.9 Brakes

A brake system, active yaw control, and/or airfoil system, in combination with brakes, must be supplied as required to support:

a. Manual shutdown during design wind conditions;

b. Over-speed shutdown;

c. Parking for maintenance; and

d. Loss of electrical grid power during rated wind operations.

Main shaft type braking is the preferred technology, although other types of technologies are not excluded provided, they can be shown to meet the functional and performance requirements defined herein. The braking system must provide maintenance-free braking operations for a minimum of five years (i.e., no new brake pads), with significant use of pitch and yaw controls to minimize braking requirements. The braking system must be configured to prevent any type of runaway conditions that could exist whether grid power is available or not. The braking system must be capable of providing sufficient braking force for parking, normal stopping, and emergency stopping of the wind turbine system, as described below. A braking system other than those described below may be submitted for "or equal" substitute based upon performance.

38.2.9.1 Parking Brakes

A parking brake must be supplied capable of preventing rotor rotation at wind speeds up to the survival wind speed and/or as required for maintenance support, and capable of being used when there is no power.

38.2.9.2 Normal Stopping Brake System

A normal stopping brake system (or equal) must be supplied to dissipate the kinetic energy of the rotating machinery at the design over speed condition, while suffering no irreparable damage. The braking system must include fail-safe automatic operational mode in the event of a power out condition (i.e., loss of utility power while operating at rated wind speed).

38.2.9.3 Emergency Brake

An emergency brake must be supplied that is designated to meet the same requirements of the normal stopping brake above. In addition, upon activation, the emergency brake must alarm and require manual resetting prior to resuming automatic operation of the wind turbine.

38.2.10 Electrical Systems

Perform an independent stability and reliability study with a focus on determining the impacts to the installation's site facilities. Operate the wind-farm in strict adherence to IEEE 519 guidelines or equivalent for controlling voltage, current, and harmonic distortions. Operate the wind-farm with all the power conditioning equipment necessary to maintain a stable power factor. Operate the wind-farm in a manner that does not diminish the capacity of existing installation facilities. Operate the wind-farm with appropriate controls and equipment that will automatically separate the wind-farm from the installation, or the installation and the Utility so that installation's site operations are not compromised in the event of equipment, and/or system failures. Operate the wind-farm with standing agreements cooperating jointly in maintenance processes and procedures.

38.2.10.1 Equipment

All generators, motors, and related electrical systems must meet the requirements of IS/IEC 61400 and/or IEC requirements for all construction. Wind turbine generators must be high-efficiency, continuous rated machines, with a minimum of Class F insulation and temperature rise. The generator efficiency will be a minimum of 90 percent for all loads greater than 10 percent of rated load. The generator must include embedded temperature protection with solid state sensors.

38.2.10.2 Power Distribution

Isolation breakers must be provided for key system assemblies to facilitate maintenance without interruption operation of other wind turbine systems. All fuses, circuit breakers, power supplies/regulators, and line conditioners necessary for wind turbine operations within the specified service conditions must be provided for all wind turbine equipment and assemblies. Power to the wind turbine control and monitoring subsystems must be distributed from a central point within one of the wind turbine system cabinets located

within each nacelle. Voltage and current requirements must be identified and documented in the submittals to facilitate the design and transformer sizing.

38.2.10.3 Overcurrent Protection and Disconnect

A circuit breaker / switch] must be installed as the primary means disconnecting the wind turbine incoming power cables/lines from the wind turbine system. The circuit breaker / switch must be capable of being locked in the open position and located conveniently for maintenance and operating personnel. The rating of the circuit breaker / switch must be sized per IS 732 for the maximum rated load current expected at the wind turbine. All electrical equipment supplied must be rated or protected to withstand and/or interrupt (without damage) the maximum available fault current expected at the point of connection to the wind turbine system.

The fault current available at the wind farm site is initially estimated at approximately 35 kAIC symmetrical at each tower base, to be more closely determined during wind farm electrical modeling and design.

38.2.10.4 Step-up Transformer

A step-up transformer may be required and must be provided by others if the wind turbine output does not match the planned collector/distribution system voltage of 11 kV (where the turbine is to be interconnected), or if the planned system is not suitable for the wind turbine standard design requirements.

38.2.10.5 Surge Suppression

External power input connections must be surge protected against IEEE C62.41 Category B transients or equivalent.

38.2.10.6 Harmonics

The wind turbine generated harmonics measured at the wind generator system ac output must not exceed the levels required to conform with IS 15395, IEEE 519 and IS/IEC 61400.

38.2.10.7 Grounding

IS 3043, IEEE 80, IEEE 142, IEEE 242, and IEEE C2 Or equivalent, except that grounds and grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

Provide ground grid for maximum permissible touch and step voltages as per IEEE 80 and/or IS 3043.

Provide inner ring electrode around the foundation and bond it through the foundation to the turbine tower. Provide additional ring electrodes of gradually increasing depth and diameter in order to reduce touch and step voltages at the edges of the system. Provide a Groundings System Analysis.

38.2.10.8 Equipment Labeling

Install permanent labels on all major switches, controls, electrical panels, cabinets, disconnects, motor starters, major equipment, or components. Weatherproof labels must be either laminated black phenolic plastic with white engraved letters, or engraved (or embossed) stainless steel nameplates. Lettering for panels and equipment must be minimum 12 mm high. Labels must be permanently installed by gluing or screwing to equipment covers. Labels must show panel or load name and circuit fed from.

38.2.10.9 Power Factor (PF) Correction

Active pf control must be installed as an integral portion of each wind turbine electrical system, and must include control provisions to maintain a minimum power factor of 0.95 at rated load (adjustable range of 0.9

to 1.0). Additional (supplemental) pf correction equipment utilizing capacitor technologies is not excluded (i.e. must be integrated and cannot be included in lieu of active pf control); however, the capacitors must incorporate provisions for disconnection and safe controlled bleed off of electrical energy to support safe maintenance, as required.

38.2.11 Control and Monitoring Systems

Wind turbine control and monitoring system electronics (both local and remote) must be microprocessor-based, provide control of all critical functions, and include (but not be limited to) fail-safe automatic shutdown in the event of any component malfunction, rotor over speed condition, or excess vibrations. The system must be designed with on-line diagnostic capabilities to allow technicians to trouble-shoot subsystem problems down to the module or board level. Provide controls for manual and automatic indicated wind turbine starts. Contractor control panels will be supplied both at ground level and within the nacelle control compartment; and each will be equipped with all the vendor standard control switches, indicators, and metering necessary to support normal wind turbine operations. In addition, the Contractor panel(s) will include a serial communications interface or Ethernet port to communicate directly to the wind turbine microprocessor control system via IBM compatible, portable laptop computer.

The wind turbine control system must provide normal operations monitoring to start and stop the wind turbine based on available wind, and to support automatic shutdown in the event an abnormal operating condition occurs.

Automatic shutdown must be provided for the system failures identified above as a minimum.

38.2.11.1 Control System Modularity

All system controls and indicators must be solid state, modular, plug-in construction, so that any module may easily be removed from the system and replaced without breaking or making solder type connections.

Sub-assemblies and modules performing identical functions must be interchangeable without making wiring changes. The number of types and sizes of modules must be kept to a minimum, in order to reduce the extent and cost of required spare parts.

38.2.11.2 Variable Speed/Load Leveling

To maximize reliability, impact on energy security, and reduce life cycle costs, the wind turbine generator control systems are preferred that include active variable speed technologies (variable rotor, pitch, and/or rotor-generator speeds) and active machine damping to reduce/limit peak torque effects due to wind gusts and/or grid supply fluctuations.

38.2.11.3 Assembly Wiring

Internal assembly wiring, including jumpers, must be color coded or permanently labeled using heat shrinkable, sleeve type markers Brady B321 or approved equal, as indicated on system schematics. Label identifications must be typed or printed. Wiring terminal strips must be provided and clearly identified for all equipment. Power and signal terminal strips must be separated. Provide 20 percent spare terminals for all electrical connections where possible.

Label all furnished cables, cable terminations and connections. Cables and connections must be located in easily accessible areas. Signal and power wiring must be routed in separate bundles and kept separate by providing separate terminal blocks and connectors. Wires must be terminated using calibrated crimp ring lugs. Internal wiring and cabling must conform to IS 732 and IS/IEC 61400-SER.

38.2.11.4 Ground Level Controls

Provide a standard ground level control panel(s) with the following functional characteristics as a minimum:

a. Allow local manual isolation of, or set it in a safe maintenance mode for, the wind turbine unit both from the normal power supply and from remote Contractor initiated controls to support safe maintenance activities.

b. Allow local ground level manual controls to initiate shutdown of the wind turbine system.

c. Supplied to allow the Contractor to access the standard diagnostic functions, provide software and interface to allow direct connection of a portable, laptop computer to directly access the master microprocessor system or control interface/PLC, etc. The new system must be capable of being integrated with (i.e., interface directly to) Integrated Building management System.

d. Allow ground level monitoring (without the need of the serial communications interface) of the following status and metered functions as a minimum (or equivalent functions):

(1) Discrete indicators (lights or approved equal),

(a) Wind turbine system READY,

(b) Wind turbine system FAULT,

(c) Wind turbine system ON LINE;

(2) Meters/selectable Liquid Crystal Displays (LCDs) (for approval);

(3) Grid Voltage,

(a) Line to Line volts - Phases AB, BC, and CA;

(4) Wind turbine output power,

(a) Kilowatts and kilowatt hours;

(5) Power Factor,

(a) Percent PF showing 0.5 - 1 - 0.5 (both leading/lagging);

(6) Rotor RPM;

(7) Pitch monitoring for active pitch turbines;

(8) Manual start/stop;

(9) Emergency stop (latching mushroom head switch with shield);

(10) Automatic and emergency shutdown indicators (lights or approved equal) with shutdown/manual reset; and

(11) Local/remote selector.

38.2.11.5 Remote Monitoring and Control Work Stations

Wind farm remote monitoring and control (SCADA) workstations are to be installed at the remote facilities/rooms as shown in the contract drawings as part of the wind farm/turbines project. The remote monitoring system must include two desktop computers, with modems, running Windows operating systems, and interfacing with the wind turbines using standard turbine manufacturer's supplied software. The new wind turbines must have remote control and monitoring software installed on the wind turbine workstations,

and must be able to be accessed via fiber optic connection to support internet access through the SCADA computer for monitoring and reporting of Wind Farm power production. The workstations must be able to access the wind turbines for remote monitoring and control via fiber optic cable system. No DOS based software allowed in the installation of the new systems.

The new wind turbines must also have communications accessibility via dedicated external fiber optic cable, DSL connection, satellite connection, or other for manufacturer's warranty purposes, depending on the requirements of the wind turbine manufacturer. Determine, supply and define the SCADA system, for the Installation Contractor to install, to support the above wind turbine communications and monitoring hardware and software (Procure the fiber optic cable and related components). Provide Definition and Use of All System, Command, and Application Software.

38.2.11.6 Local Nacelle Monitoring and Controls

Provide manufacturer's standard wind turbine system monitoring, controls, and alarms within the nacelle/base at the Contractor control panel with ability to remote monitor as required. All controls, meters, LCD displays, etc., must be located within NEMA 12 (or equal) gasketed enclosures. The nacelle Contractor panel will include service switches to prevent the operation of the turbine from the base control panel when service personnel are in the nacelle, as well as the basic Contractor functions identified in subparagraph, GROUND LEVEL CONTROLS of this section. In addition, system failures, malfunctions, and/or warning indications must be provided as identified below (as a minimum):

a. Loss of enclosure cooling (if cooling is required);

b. Under/over voltage;

c. Under/over frequency;

d. Out of phase sequence;

e. Phase current unbalance;

f. Excess vibration;

g. Generator problem,

- Generator excess power,
- Generator over current,
- Generator over temperature,
- Generator over speed,
- Generator cooling failure;

h. Yaw system failure;

i. Cable over twist (if cables are used);

j. Hydraulic system failure;

k. Loss of gear box oil pressure;

l. Gear box over temperature;

m. Pitch control system failure (as required); and

n. Communications systems failure.

38.2.12 Cable Over Twist Protection

If the proposed system utilizes cables between the yaw deck and the tower, the wind turbine system must incorporate the necessary cable twist sensors to detect and determine the net number of nacelle rotations to prevent cable damage due to over twist. In the event a cable over twist is sensed, the wind turbine system controls must operate to safely bring the rotor to a complete stop, untwist the cable by counter yawing, and restart the wind turbine system. This system must be tolerant of total power outages and not lose track of previous twist information.

38.3 PERFORMANCE REQUIREMENTS

The wind turbine system output performance must meet the minimum criteria given in paragraph, DESIGN REQUIREMENTS of this section (less 2.5 percent tolerance). The minimum annual gross energy production required to meet this specification was estimated to be 60kWh/year for a single 10kW wind turbine and with long-term annual average wind speed of 8 m/s at 50 meters.

38.4 TESTS, INSPECTIONS, AND VERIFICATIONS

Perform pre-performance and performance tests, inspections, and verifications in accordance with IS/IEC 61400.

Submit all manufacturer's standard airfoil performance and mechanical stress/strength tests data under the maximum expected operating conditions.

All wind turbines controls must be tested to standard manufacturing and systems tests and must include but not be limited to:

a. Rotor controls (if required);

b. Yaw control (if required;)

c. Cooling system controls (if required);

d. Safety and shutdown systems; and

e. Braking systems.

Prepare and submit for review and approval a test plan and procedures for factory and site testing. Tests must include an integrated control systems test where a minimum of the wind turbine generator and associated controls must be tested as a complete or mock assembly. These tests must be subject to witness by the Client (or designated representative). Notify the Client at least 30 working days in advance of the tests. Should the Contracting Officer elect not to have a representative present during factory tests conducted by Contractor, the Contractor must still conduct such factory tests and inspections and submit test data and reports.

Data must be reported as taken during testing. Data format must be such that it can be included in performance test data submitted to the Contracting Officer.

Furnish the Client two copies of all shop and field test reports and/or certificate of compliance and two additional information copies of these reports, clearly identified as such.

39 PART 3EXECUTION

39.1 SITE PREPARATION

Evaluate and ensure site is accessible for the size and weight of planned equipment and facilities. Coordinate transportation routes to site. Prepare site and lay down areas in accordance with approved contract documents.

39.2 WIND TURBINE SYSTEM PREPARATION

Ensure the wind turbine systems, remote work stations, control, power monitoring equipment, and all ancillary installed equipment are operational in accordance with this specifications section. All testing, both on site and at the factory, must be organized and supported by approved Commissioning plans. Submit a Commissioning Plan and procedures to the Contracting Officer for approval no later than 20 business days after approval of the final design. The plan must state what equipment configuration will be tested, when it will be tested, which tests will be run, any special test equipment required, any required simulation software, and who will conduct and witness the tests as a minimum. The test procedures must define the operating steps and expected results to demonstrate compliance with the requirements of this specifications section. The Commissioning Report must record all test results and describe nonconformance events and corrective actions.

Ensure that the wind turbine components and associated subsystem must be tested by the manufacturer before shipment to verify proper assembly and function of all components/subsystems, and to ensure that the final assembled unit meets or exceeds the requirements of this specifications section. Component tests will be performed and/or Manufacturer's Factory certificates of compliance will be submitted indicating the equipment has been fully tested and meets the manufacture's standard design requirements. These tests must include (as a minimum):

a. Full Load Generator Tests - Full load test must be performed using the full load nameplate rating of the wind turbine generator unit. Full load testing must validate the vibration, temperature rise, and voltage and current outputs are within standard manufacturing limits (and/or meet) the manufacture's specifications.

b. Generator Insulation Tests - Generator insulation resistance and high potential tests must be performed with an insulation tester. Stator readings must be taken at the generator circuit breaker/switch. All results of insulation tests must be recorded. Readings must be within the standard manufacturing limits specified by the generator manufacturer.

c. Gearbox/Transmission Full Load Tests - Full load testing must validate the vibration, temperature rise, sealing, audible noise, gear tooth patterns, and lubrication systems are within the limits specified by the manufacturer. Full load test must be performed using the full load nameplate rating of the transmission or wind turbine generator unit (whichever is greater).

All factory component tests described above may be performed at the manufacturing facility.

39.3 ERECTION

Determine all hoisting and rigging and other installation requirements, and must make arrangements, if appropriate, for rent or purchase of any of these special installation tools.

Comply with local state regulations for Fall Protection Code during all construction, operations, and maintenance actions.

39.4 INSTALLATION

Install, test and commission wind turbine system. Provide detailed instructions and necessary oversight for installing all wind turbine system equipment. Notify the Client of any errors in installation ensure that any and all installation errors are corrected in accordance with the manufacturer's instructions and specifications. Certify that the wind turbine system and wind turbine equipment are ready to operate. The Contracting Officer must receive 30 working days' notice of the scheduled start up of the wind turbine system, with validation of the final schedule 21 days prior to startup.

The scope of the Contractor's installation of the wind energy system must include, but not be limited to, the following activities:

a. Wind towers installation and setup support, including for hoisting, rigging, leveling, etc.;

b. Nacelle and rotor installations;

c. Control, monitoring, and terminal cabinet installations; and

d. Wiring connections/hookup.

39.5 SYSTEM INTERFACES

Wind turbine control and monitoring system is not authorized to interface with installation information network without approved software and hardware, and either an Authorization to Operate (ATO), Interim ATO (IATO), or Interim Authorization to Test (IATT). Permanent connection is not allowed without an Approval to Connect (ATC) or Interim ATC (IATC) authorization from Local Electricity Utility.

39.5.1 Power System Interface

The wind farm generator connections to the site power grid will be field located as shown in the contract drawings. Validate proper voltage drop of system after completion of the wind turbine Contractor submittals.

Locate the wind turbine system ground level controls to enable safe manual ground level shutdown.

39.5.2 Dispatch Interface

The remote monitoring and control system must be integrated to allow the UTILITY / User's power dispatch, via the master workstations at the remote facilities, to monitor and control Wind Farm status and record aggregate power output and wind turbine status from the Wind Farm system.

39.5.3 Control System Interface

The wind turbine system must be supplied with a standard fiber optic, DSL, satellite or 56 kbit/s to 115 kbit/s minimum serial interface communications interface to link standard wind turbine control and monitoring functions with the existing remote monitoring/control system. The wind turbine communications interface will be capable of driving control signals, from the final locations recommended for the wind turbines to the remote facility workstations. The communications interface must include all the standard software drivers, installation and operation documentation, and programming support necessary to allow easy integration directly with the Client’s / User’s workstations located at the remote.

39.6 FINISHING, CLEANING, AND PAINTING

Apply field painting as specified in IS 1477 (Part 1 & Part 2): 1971. All exposed surfaces that protect material must be UV resistant to maintain appearances through the design life of the system.

39.7 EQUIPMENT IDENTIFICATION

Each piece of equipment must be identified so that it can be easily correlated with the documentation. The means of identification must be uniform throughout the system. The identification mark must be permanently affixed to the part it identifies. This requirement includes internal wiring, terminal strips, input/output cables and connectors, input/output modules, power supplies, and other subsystem components and subassemblies.

39.8 NAMEPLATES

Each major piece of wind turbine system equipment must be furnished with a permanently attached 316 stainless steel nameplates, which contains a minimum of the following information:

a. Tag number;

b. Manufacturer name;

c. Model number;

d. Serial number; and

e. Purchase order number.

Each nameplate must be fully visible when the equipment is in operating condition and consist of a self-adhesive label having 6 mm in embossed letters. Shipping container must be labeled with the same data.

39.9 FIELD QUALITY CONTROL

39.9.1 Manufacturer's Field Service

Provide the services of factory trained and approved field service engineer during system installation, testing, and commissioning.

39.9.2 Start Up Services

Carry out a checklist of startup requirements and conduct a series of safety tests to ensure proper installation, safe operation, and performance up to specification. Develop a Commissioning Report detailing all procedures, testing, and results.

After installation, prepare the new wind turbine systems for final testing and commissioning. The wind turbine systems must be fully debugged and operating in accordance with all requirements of this specifications section. Final start-up services must include, but will not be limited to, the following:

a. Final functional checks of all installed wind turbine systems, automated control modes, and associated controls and instrumentation.

b. Final verification and calibration of all wind turbine system control and instrumentation signals and digital readouts.

c. Final verification of the proper operation of all controlled shutdown functions and capabilities; and both automatic and ground level supported operating, monitoring, and related control functions.

d. Alarm systems.

39.9.3 Functional Acceptance Testing

After installation, conduct functional acceptance testing of the equipment and all accessories furnished to verify their proper performance under conditions of actual operation. Notify the Client at least 30 working days in advance of the tests. Compliance with all requirements of this specifications section and all applicable standards (as amended) must be verified by an on-site startup/operational test.

39.9.4 Operational Testing

Support complete on-line operational testing on site to formally commission wind turbine operations, validate warranties, perform training, and initiate maintenance schedules. The wind turbine manufacturer will support the Installation Contractor who will be responsible for developing and implementing approved operational test procedures for testing all of the wind turbine operational and failure/failsafe systems. A certificate of completion must be provided at the conclusion of system's construction, installation, and commissioning. Coordinate all formal correspondence and reporting required for approval of the test plan. Project implementation must require the installation, testing, and operation of the wind turbine generating units in parallel with the installation's 11/0.415 kV distribution system. Installation and start-up support service submittals, test plan documents, and test schedule information must be submitted for review and approval.

Perform and submit field data reports for the following:

a. Verification of proper electrical power connection to all wind turbine system components.

b. Verification of proper termination of all system interconnect wiring and signal transmitter calibrations.

c. Verification of proper wind turbine system monitoring, controls, and environmental support system functionality.

d. Functional checks of all analog and digital signals, modems, and data communications systems associated with the wind turbine system.

e. Verification of wind turbine equipment alignments, torques and adjustments, and vibration block installations.

f. Functional checks (and correction if necessary) of all lubrication and cooling system levels and operations, shaft seals, and or other system fluid leaks.

g. All variations to documentation must be documented and submitted immediately to the Client or its representatives.

39.10 COMMISSIONING

Conduct Commissioning, after the system is installed and is ready for operation. Verify that the completed and installed system meets the requirements of IEEE 1547 or equivalent.

Commissioning Agent Individual qualified in testing protective equipment (e.g., professional engineer, factory-certified technician, licensed electrician with experience in testing protective equipment) must perform or directly supervise commissioning tests. Provide Commissioning Agents Qualifications.

39.10.1 Commissioning Plan and Schedule

Develop and implement a commissioning plan and commissioning schedule. Submit commissioning procedure to Client for review and approval.

39.10.2 Start-up Pre-functional Checklists

Carry out a checklist of startup requirements and conduct a series of safety tests to ensure proper installation, safe operation, and performance conforming to specification.

39.10.3 Functional Performance Testing

Prepare test procedures and conduct functional performance testing of the installed system. Test on completion each individual wind turbine generator and then test on completion the complete wind power

system plant. Test the complete wind power system for a minimum duration of 200 hours, of which 150 hours should be generator time with 85 percent availability.

Provide testing of the following:

a. Collector System

b. Collector and Substation Equipment

c. Ground Grid

d. Main Power Transformers

e. Circuit Breakers

f. Arrestors

g. Switches and Switchgear

h. Instrument Transformers

i. Wind Plant Relays

j. Wind Plant Energization

k. Turbine Transformer

l. Overhead Collection Circuits

m. Fiber Optics and Secondary Cables

n. Medium Voltage Cable Systems

o. Power Performance

p. Nacelle Anemometer Verification

q. Acoustic Noise

r. SCADA and Controls

s. Back Up/Black Start Generator(s)

t. Grid Synchronization and Interface

39.10.4 Functional Performance Testing Results

Coordinate, observe and record the results of the functional performance testing. Coordinate retesting as necessary until satisfactory performance is verified. Verify the intended operation of individual components and system interactions under various conditions and modes of operation.

Document items of non-compliance in materials, installation or operation. Immediately address observed non-conformance and deficiencies in terms of notification to responsible parties, and provide recommended actions to correct deficiencies.

39.10.5 Final Commissioning Report

Prepare and submit final commissioning report. Summarize all of the tasks, findings, conclusions, and recommendations of the commissioning process in accordance with IS/IEC 61400. Include the results of all tests and a listing of the final settings.

39.11 CLOSEOUT ACTIVITIES

39.11.1 Demonstration

Provide hands on demonstration of wind turbine systems and controls as part of the training session. Minimum demonstration areas must include pre-startup inspections, system startup, grid connection; operations, operator-initiated shutdown, emergency shutdown, and extreme conditions procedures.

Demonstrate, upon completion of functional acceptance tests, that all circuits and devices are in proper operating condition and performing as intended.

39.11.2 Training

Provide a 3-day comprehensive training course covering operations and maintenance, critical spares, and unique tools requirements, with complete training materials, at construction completion.

Provide recommendations and sources for advanced maintenance personnel training and certification programs.

39.11.3 Spare Parts

Provide a spare parts list in accordance with the manufacturer's recommendations that will ensure 95 percent system availability for from one (1) year to two (2) years of operation for each wind turbine unit. The list must include/identify all required gaskets, seals, sealing materials required for maintaining the weather tight integrity of the wind turbine tower and nacelle.

39.11.4 Special Tools and Equipment

Identify special tools and equipment designed specifically for the wind turbine equipment operation and maintenance. Special tools and devices, including any metric wrenches or other hand tools that are not standard in the republic of India, required for operation and maintenance of the equipment furnished under this specifications section, must be listed and clearly identified with the name of the equipment.

39.11.5 Site Restoration

Clean and restore temporary work areas to pre-existing conditions.

39.11.6 Decommissioning Plan

Provide a decommissioning plan to Contracting Officer for approval. Decommissioning plan must include actions necessary to restoring site and access roads to natural conditions and option to evaluate structure and components for life extension upgrades.

39.11.7 Warranty

Provide system and major component Warranties.

Warrant the overall system for both parts and labor for a minimum period of 5 years. Provide the following component specific warranties:

a. Wind Turbine: Minimum warranty period of 5-year for linear minimum output and 5-years for workmanship, material, visual, and manufacturing defects from the date of commissioning.

b. Mounting Structure: Mounting structure system hardware to be free from defects in the material and workmanship for a minimum period of 10 years.

c. Combiner Boxes: Combiner boxes to be free from defects in material and workmanship for a period of 5 years.

d. Inverters: Inverters to be from defects in material and workmanship for a minimum period of 20 years.

Provide a list of all applicable warranties for all equipment and components. Include warranty information, names, addresses, telephone numbers, and procedures for filing a claim and obtaining warranty services.

39.12 OPERATION

39.12.1 Normal Operations

The wind turbine system must be operating in an automatic, unmanned mode, unless a failure alarm is detected in the wind farm control system, or maintenance is being performed on the system. Wind turbine system controls must be provided to optimize wind turbine system outputs under normal wind conditions, as described in paragraph, EXISTING CONDITIONS of this section. Standard wind turbine controls must be designed to keep the wind generating system operational within its normal operating limits over the design life of the wind farm system, producing efficient, optimized, electrical power. Should the wind turbine or its control system malfunction, the protection system/safety schemes must maintain it in a non-hazardous condition. Acceptable safety schemes must include braking, blade pitching, spoilers, and active yawing, as required by the turbine generator manufacturer. Provide wind turbine Operations Manuals, Alarms and Alarm Presentation, System Startup, Shutdown, and Emergency Procedures, and Contractor Commands (Control Consoles, Indicating/Control Panels, and Peripheral Devices).

39.12.2 Pre-Startup Inspections

Pre-startup inspections must be performed prior to initiating wind turbine system operations. To support automatic operations, the inspections will only be required following maintenance and/or abnormal shutdowns brought on by the automatic shutdown features of the controls. Pre-starting inspection will be performed using manufacturer's instructions and procedures to ensure that the wind turbine system is ready for on-line operations. The necessary instructions, procedures, checklists, etc. must be supplied as part of the documentation submittals as required herein.

39.12.3 Connection to Grid

To connect grid power to the associated wind turbine unit, coordinate with utility company grid operations to close the wind turbine switchgear breakers either manually at the site or remotely via the Contractor stations. Compliance with interconnection agreement requirements is mandatory.

39.12.4 Initiate Wind Turbine Operations

Once grid power is supplied to the wind turbine, the wind turbine control system will begin its internal system diagnostics, as necessary, to prepare the control system for active operations. All faults normally detected by the control system, or occurring as a result of automatic shutdown, will have to be manually reset prior to allowing active operations. When the fault indications have been reset, the controls will output a wind turbine "READY" indicator to notify that the wind turbine is ready to activate soft start operations.

39.12.5 Normal Operations

Final wind turbine connection to the grid for normal on-line operation will occur when the he ON-LINE command is initiated, either from the Contractor's panel or remotely via the serial communications/control link. Normal operation must include normal pitch, speed, and voltage controls to automatically optimize output while operating within normal wind speed parameters. ON-LINE operations will invoke normal operation where the wind turbines will begin soft start (solid state soft start, reduced voltage starting, or equal) operations (to reduce the impact of connecting the wind turbine to the grid) if adequate wind is available.

39.12.6 Normal Shutdown

All Normal shutdowns must result in immediate orderly shutdown, including a functional disconnect of the wind turbine generator from the grid at the wind turbine output control (or equal). The wind turbine control

system must remain operational to maintain full control of the wind turbine shutdown (application of normal braking, required rotor and blade pitch operations, active yawing, etc.) as necessary to effect safe

(non-damaging) shutdown of the wind turbine unit. Prior to beginning maintenance operations, shut down the system, applying the parking brake, open the switchgear breaker supplying the wind turbine system, open the wind turbine local disconnect breaker, and set the wind turbine operations switch into the LOCAL mode.

39.12.7 Emergency Shutdown

Emergency shutdown procedures/functions must be included as an integral part of the wind turbine basic operating capabilities. The emergency shutdown system must operate to disconnect the wind turbine from the grid and apply appropriate braking actions, require rotor and blade pitch operations, active yawing, etc., as necessary to effect safe

(non-damaging) shutdown of the wind turbine unit in emergency, extreme operating conditions, survival wind speeds or a loss of grid power while operating. These include, but are not limited to, loss of grid power, breaker trip, over speed, contractor control, and other anomalies.

Provide Recovery and Restart Procedures.

39.12.8 Extreme Operating Conditions

Peak wind speed, high temperature, and earthquakes all constitute extreme operating conditions, which may exist whether the wind turbine is in operation or not. The wind turbine system design analysis must consider the effects of extreme operating conditions; and the resulting design configuration must include the necessary safety elements to mitigate damage from the extremes (and still effect safe shutdown). Contractor inspection and manual reset is expected before any operation following an extreme event.

39.13 MAINTENANCE

Contractor to create maintenance schedule and perform system and component maintenance in accordance with equipment manufacturers' recommendation. Provide a Recommended Multi-Year Operations and Maintenance (O&M) Requirements Schedule.

XV. LV SUPPLIES, DISTRIBUTION AND EQUIPMENT

40 PART 1 - GENERAL

40.1 CODES AND STANDARDS

Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

International Codes:

BS 88	Cartridge fuses for voltages up to and including 1000 V A.C. and 1500 V D.C.
BS 3643	ISO metric screw threads.
BS 3924	Pressure sensitive adhesive tapes for electrical insulating purposes.
BS 4345	Slotted angles.
BS 4921	Sherardized coatings on iron and steel articles.
BS 5378	Low voltage switchgear and control gear assemblies
	Part 1 Colour and design
	Part 11 Particular requirements for fuse boards.
	Part 12 Particular requirements to type-tested miniature circuit breaker boards.
	Part 13 Specification for particular requirements of consumer units
BS 7211	Thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire.
BS 7671	Requirements for electrical installations IEE Wiring Regulations
BS EN ISO 1460	Metallic coatings. Hot dip galvanized coatings on ferrous materials. Gravimetric determination of the mass per unit area.
BS EN 10210-2	Tolerances, dimensions and sectional properties.
BS EN 60044	Instrument transformers.
BS EN 60269	Low voltage fuses.
BS EN 60269-1	General requirements.
BS EN 60898	Circuit breakers for overcurrent protection for household and similar installations.
BS EN 60947-2	Circuit breakers.
BS EN 60947-3	Switches, disconnectors, switch-disconnectors and fuse combination units.
BS EN 60947-4	Contactors and motor starters.
BS EN 60947-4-1	Electromechanical control circuit devices.
BS EN 61008	Residual current operated circuit breakers without integral overcurrent protection for household and similar uses (RCCBs).
BS EN 61009	Residual current operated circuit breakers with integral overcurrent protection for household and similar uses (RCBOs).
BS EN 62053-21	Electricity metering equipment (A.C.). Particular requirements. Static meters for active energy (classes 1 and 2)

BS EN 61439-1	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
BS EN 61439-2	Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies
IEC 60439	Low-voltage switchgear and controlgear assemblies

41 PART 2 - PRODUCTS

41.1 RATING

The rated voltage of all switchgear and distribution boards shall be not less than 400 volts ac between phases.

41.2 SWITCHGEAR

A. The switchgear assembly shall be suitable for connection to the supply system as stated within Section 26 00 01 of the Specification.

B. The assembly shall be designed and constructed to withstand both the thermal and mechanical stresses set up by short-circuit conditions from a source fault level as stated within Section 26 00 01 and to operate at an ambient external temperature of 50ºC

C. The numbers, sizes and ratings of units incorporated within the switchgear shall be as indicated on the drawings and schedules and as described elsewhere in this specification.

D. The assembly shall be a CE marked, ASTA/KEMA certified or equivalent, multi-cubicle, type-tested assembly (TTA), with segregation to IEC 61439-1 & IEC 61439-2. The type of Form segregation is stated within Section 26 00 01. A copy of the specific certification shall be provided to the Engineer and included in the operational and maintenance manuals.

E. The assembly shall be manufactured from high grade, machine folded/welded, zinc coated, sheet steel of not less than 2mm thickness and be provided with a 50mm high (minimum), removable rolled mild steel plinth.

F. All steel work shall be subject to a four-stage finishing process together with chemical sprays, degreasing processes, iron phosphating and finally finished with a top coat of polyester powder deposited electrostatically and cured in a high temperature oven to give a strong molecular bonding with the steel. Surface shall be smooth flawless, semi gloss, highly scratch & corrosion resistant

G. The final colour shall be an approved standard RAL shade, 7035 light grey

H. The assembly shall be provided with arc-fault containment facilities to IEC 61641 or equivalent.

I. The assembly shall be capable of supporting the weight of a person walking on the enclosure without damage.

J. Doors shall be provided with neoprene gaskets and door mounted equipment shall be restricted to instruments, control switches and switch operating handles. Door handles shall have an integral cylinder lock and two keys shall be provided for each lock. Keys shall be fully labelled and handed to the Engineer at practical completion.

K. Each section of the assembly shall be divided into compartments on a modular basis, to ensure that future alteration and/or additions of equipment can be accomplished without difficulty (i.e. bolted removable divisions, not welded).

L. The assembly shall be readily extendible at either end, with pre-drilled busbars and removable busbar chamber end panels. The layout shall be selected to provide the shortest practicable switchboard length.

M. Removable un-drilled gland plates not less than 3 mm thick shall be provided. Gland plates for single core cables shall be non-magnetic.

N. Connections from the busbars to the live side of functional units shall be shrouded to IP 2X minimum, with warning labels.

O. Outgoing circuits shall be arranged and separated such that connections can be made and maintenance carried out on any piece of equipment, without disturbance to another.

P. Removal of any covers for cabling outgoing circuits shall not expose any live parts. An integral secondary barrier shall be provided.

Q. Full segregation shall be maintained between circuits operating at different voltages. All terminals shall have clear covers marked with the operating voltage.

R. Heavy duty, galvanised cable tray shall be provided to support cables at the rear of the enclosure (refer to separate containment section).

S. The assembly shall include air circuit breakers, moulded case circuit breakers, fuse-switch disconnection, and switch-fuse-disconnect or disconnect, as specified elsewhere. Unless otherwise stated, feeders shall be triple-pole with removable bolted link neutral.

T. All feeder equipment shall be ASTA certified, independent operated, capable of being locked in the OFF position and suitable for uninterrupted duty in the closed position at rated loads.

U. Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the distribution board, except for the horizontal bus bar compartment. The front of the compartment shall be provided with the hinged single leaf door, with locking facilities.

V. Wherever, two breaker compartments are provided in the same vertical section, insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

W. If necessary, the board shall be arranged for delivery to site in section which can be easily placed into positions and then bolted together. Lifting lugs shall be provided for each section. However, the board is to be shipped from a factory with assembled bus bar system, apparatus group and metering system.

41.3 BUSBARS

A. The assembly busbar and dropper/riser system shall be housed in a separate earthed metal chamber, with the main busbar located at the top of the switchboard. Busbars and droppers shall be ASTA certified for the fault rating and continuous rating stated.

B. As a minimum, the neutral busbar shall have the same rating as the phase busbars. However, subject to confirmation from the Engineer the busbar may be uprated to cater for the potential presence of harmonic currents.

C. Where specified, the busbar system shall be arranged for the neutral earthing of the supply transformer to be made within the switchboard. Removable links shall be provided for testing purposes.

D. Busbars shall be manufactured from hard drawn, high conductivity copper.

E. Where specified, busbars shall be insulated throughout their length by PVC tape or sleeving with industry standard colours. Tape shall comply with BS 3924 and sleeving with BS 2848, Type 3, Class 85T.

F. All busbar joint surfaces are required to be tinned. If plated joints are desired then the contractor is to seek approval from the Engineer. All joints shall be bolted with vibration resistant fixings.

G. Busbar supports shall be non-hygroscopic, anti-track, and flame retardant. Busbar supports shall be strong enough to withstand, without damage, the forces set up by any thermal expansion and forces created by fault currents.

H. Means shall be provided to prevent arcs or arc products occurring on one busbar from affecting the other busbars.

I. Access to busbars and connections shall only be possible by the use of tool and covers shall be fitted with engraved laminated labels with the legend 'BUSBARS' in 10mm (min) black lettering.

J. The cross section of the busbars shall be according to the latest IEC 60865-1 recommendation, uniform throughout the length of switchgear and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents.

41.4 EARTHING

A. A suitably rated copper earth bar in accordance with BS EN 60439-1 shall be provided throughout the length of the switchboard. It shall be pre-drilled to each end for future extension and removable end plates shall be provided.

B. The earth bar shall be drilled to accommodate all protective conductors and the incoming supply cable earth.

C. All protective conductors shall be connected to the earth bar by brass nuts and bolts, with flat and spring washers. All connections shall be labelled at their termination point at the earth bar.

D. A main earth termination point shall be provided inside each incomer compartment.

E. All equipment and metalwork, including gland plates, shall be connected to the switchboard earth bar. All hinged doors and removable covers shall be bonded by separate flexible earth conductors.

F. An earth connection shall be made to each gland and/or armour clamp where cables terminate at the assembly.

G. The earth bar shall be manufactured from HDC Copper.

H. The cross-section of the earthing bus shall be according to latest IEC 60865-1 recommendation and shall have sufficient cross-section to carry the momentary short circuit and short time fault currents to earth without exceeding the allowable temperature rise.

41.5 AIR CIRCUIT BREAKERS

A. All air circuit breakers (ACB) shall be ASTA certified and in accordance with BS EN 60947-2. ACB's shall be horizontal, draw-out type, with stored-energy, independent, quick make and break, trip-free operation, with anti-pump. ACB operating mechanisms shall be manual or motor loaded with manual loading facilities, spring stored energy type, as specified in the Particular Specification. Trip circuits shall typically operate at 24 or 48 Volt DC.

B. Air Circuit breakers shall be either triple-pole and neutral or four-pole, as specified elsewhere.

C. Air Circuit breakers shall have service, test and isolated positions and be capable of being locked in the OFF position. In the isolated position, all circuits shall be isolated. In the test position, only the control circuit shall be made.

D. Automatic, lockable safety shutters shall be provided to prevent access to live terminals in the disconnected or test positions. Interphase barriers shall be provided to prevent arc propagation. Interlocks shall be provided to ensure that the circuit breaker is open during connection and disconnection.

E. A test block shall be provided at the unit front to allow secondary injection testing of all relays and tripping circuits without the disconnection of any wiring.

F. Air Circuit breakers shall be complete with auxiliary contacts and terminals for the required controls and indications, together with all appropriate transformers and fuses.

G. Air Circuit breakers shall have mechanically operated ON/OFF and CHARGE/DISCHARGED indication.

H. ACB's of the same rating shall be interchangeable. ACB's of a different rating, but of the same frame size shall not be interchangeable.

I. The main air circuit breakers shall incorporate Castell interlocks as necessary.

J. Protective relays shall be provided for each incoming ACB. Overcurrent protection shall be inverse definite minimum time (IDMT) relays. Restricted earth fault protection shall be by high-stability circulating current relays and Class X current transformers, of suitable characteristics. The installer shall allow for the full setting up and testing to the satisfaction of the Engineer of all protective relays.

K. Where the associated power transformer is cast resin or silicone insulated type the ACB shall trip on high winding temperature.

L. Each ACB shall be provided with an operating handle for racking the ACB in and out for isolation, etc.

M. All ACB's shall be clearly labelled.

41.6 DISCONNECTORS AND FUSE-SWITCH DISCONNECTORS

A. Each feeder device shall be in a separate compartment with a hinged door interlocked with the disconnect or, so that the door cannot be opened when the device is closed or locked open.

B. Positive drive ON/OFF indicators shall be provided.

C. The following mechanical interlocks shall be provided on all compartments or enclosures equipped with a disconnector: -

a. It shall not be possible to open the door with the disconnector in the 'ON' position.

b. It shall not be possible to open the door with the disconnector padlocked 'OFF'.

c. The door may be opened only when the disconnector is fully opened and the operating handle is in the 'OFF' position.

d. When the door is open, clear, unambiguous indication of the disconnector position shall be given on the fixed parts of the device.

D. The ON/OFF positions of operating handles shall be identical for all types of disconnector on the assembly

E. All exposed live terminals shall be shrouded to IP2X and provided with warning notices. Opening the device shall not expose any live parts. An integral secondary barrier shall be provided.

F. Spare space on assembly tiers shall be arranged to allow the simple addition of a feeder device in the future.

G. All disconnect shall be clearly labelled.

41.7 MOULDED CASE CIRCUIT BREAKERS

A. All MCCB's shall be to BS EN 60947-2 and of the current limiting type.

B. MCCB's shall be of the quick-make and break, independent, trip-free type with mechanical ON/OFF/TRIPPED indication.

C. Protective Devices for Life Safety systems shall be provided with Earth Link switches with audio and visual alarm, no shut trip and shall be monitored by BMS.

D. For switchboard mounting MCCB's shall be the cubicle mounting type with door mounted padlock able, rotary type operating handle. They shall be of the fixed pattern with fully shrouded fixed contacts. Interlocks shall be provided to prevent the opening of the front cover with the operating handle in the 'ON' position.

E. The operating mechanism shall operate all poles simultaneously during opening, closing and tripping operations.

F. Each pole of the MCCB shall be provided with thermal element for inverse time delay protection and magnetic element for short-circuit protection. The thermal release shall be adjustable and fitted with a lock-off facility.

G. Ensure that full discrimination is achieved between the up and down stream devices. Selection of MCCB's on the cascade principle will not be accepted.

H. MCCB’s shall be of a type suitable for the fitting of motorised operators or shut trip devices.

I. All MCCB’s shall be clearly labelled.

41.8 CONTACTORS

A. Contactors shall comply with BS EN 60947-4 and be rated AC3.

B. Contactors shall be of the multi-pole double-break, fully shrouded, block pattern, with replaceable main and auxiliary contacts. Operation shall be from a separate source. Each contactor shall incorporate auxiliary contacts and the control circuit shall operate at a voltage not exceeding the phase/neutral voltage. Where more than five triple-pole contactors are used, a separate control transformer shall be provided.

C. Where contactor noise is required to be minimal D.C. operated contactor coils shall be used.

D. Where contactors are independently mounted, they shall be totally enclosed in a metal case with hinged and/or bolted on covers. Contactors mounted within a cubicle shall be housed within a separate compartment.

E. All contactor control wiring passing through any adjacent switchgear shall be contained within an internally mounted metal duct/conduit.

41.9 FUSES

A. Cartridge fuse-links shall comply with BS EN 60269-1 (BS 88). Cartridge fuse-links shall have a Utilisation Category of G for general applications, including motor circuits. Category M fuses shall only be used on motor circuits. Category ‘a’ breaking range fuses shall not be used. B. Fuses are only to be used for capacitor banks.

41.10 IRONWORK FOR SWITCH FRAMES

A. Framework for the mounting of loose switchgear, distribution boards and similar equipment shall be of mild steel plate, section and bar or hot rolled hollow sections complying with BS EN 10210-2, or slotted angles complying with BS 4345.

B. Black hexagon bolts, screws and nuts complying with BS 3643 may be used.

C. Framework mounted within a building shall be wired-brushed or shot-blasted, cleaned and given a brushed coat of zinc chromate primer and two coats of finish to match the switchgear. Manufacturers' standard finishes will be accepted for slotted angles, but all metal exposed by cutting shall be prepared and finished to match the paint finish applied by the manufacturer.

D. Framework mounted outside a building shall be of galvanised mild steel plate, section and bar or hollow section, or galvanised slotted angles complying with BS 4345. Bolts, nuts and screws shall be galvanised or zinc plated (electro-galvanised). Untreated areas of metal, e.g. cut ends, holes and areas damaged by welding, shall be given a coat of zinc rich paint.

41.11 ENCLOSURES

A. Unless stated otherwise the enclosure protection shall be at least:

Internally IP44

Externally IP65

B. Ferrous parts of indoor enclosures shall be adequately rust protected and shall be finished with an electrostatically applied, powder coated finish.

C. Outdoor enclosures shall be provided with a hot-dip galvanised coating complying with BS EN ISO 1460 or a sherardised coating complying with BS 4921. A decorative finish is not necessarily required.

D. Provision shall be made for locking or padlocking of enclosure covers as necessary.

E. Fixing holes in indoor type enclosures of apparatus may be inside or outside the enclosure. Outdoor type enclosures shall have external fixing lugs.

41.12 CONSUMERS ELECTRICITY SUPPLY UNITS

A. Consumers' electricity supply units shall comply with BS EN 60439-1 and BS 5486 Part 13. The number of outgoing circuits and their respective current rating(s), the current rating of the main switch and form of protective device(s) required, i.e. cartridge fuses or miniature circuit breakers and the form of the enclosure, i.e. all-insulated or metal-clad shall be as indicated elsewhere.

B. Where combined MCB/RCD devices (RCBO) are to be used, these shall be double pole and an adequate number of ways shall be provided.

41.13 BUSBAR TRUNKING SYSTEMS

A. Busbar trunking systems shall be ASTA certified, conform to BS EN 60439-2 and be capable of withstanding the prospective short circuit currents specified within Section 26 00 01.

B. Busbar trunking systems shall be designed for use as a rising main and horizontal distribution system. The trunking shall be located such that the tap-off unit locations are within 500mm of the equipment they are to supply.

C. Where busbar trunking is used as a rising main, a 100mm high concrete curb shall be provided by the Contractor at each opening where busbar rises through floor slabs

D. Busbar trunking systems shall comprise a sheet metal enclosure, hard drawn, high conductivity copper busbars and be complete with busbar supports, expansion joints, thrust blocks, fire resisting barriers, and cable terminations.

E. Busbar trunking systems shall incorporate an integral earth conductor, be electrically continuous throughout their length and have a degree of protection to IP41 minimum.

F. All busbars shall be full rated for operation as specified at 50°C, 100% RH

G. Purpose made fittings shall be used for all changes in direction.

H. Power tap-off units shall have 'finger safe' automatic shutters operated by insertion or removal of a tap-off unit. The design of the units shall ensure that no live metalwork is exposed during insertion or removal and that the unit is connected to earth before contact is made with live busbars. The unit shall remain earthed during removal until all live conductors are disconnected.

I. Tap-off units shall incorporate MCB's, MCCB's or socket-outlets as specified Section 26 00 01.

J. The Contractor shall note and allow for, where identified, that busbars shall form part of the essential network serving life support items, smoke control, lifts, etc. and require fire protection measures as noted within Section 26 00 01.

41.14 DISTRIBUTION BOARDS

A. All distribution boards shall be type-tested and comply with BS EN 60439-1 and BS 5486 Parts 11 and 12. All distribution boards shall be fully rated to operate at 50ºC. They shall be suitable for surface mounting, have lockable doors (supplied with two keys) and be controlled by an on-load integral disconnector. Keys shall be labelled and handed to the Engineer at practical completion.

B. All distribution boards shall be fitted with miniature circuit breakers as specified within Section 26 00 01 of the Specification. Where spare ways are provided they shall be fitted with blanking pieces.

C. All neutral and earth connections shall be made to bars within the distribution board, each connection having an individual terminal. The neutral shall have a removable link to facilitate testing, and it has a sufficient number of terminal points of adequate size for largest cable expected to be used.

D. Three phase & single phase Final Distribution Board with 12 or more ways must have at least two bus bar section so as to provide for different level of earth leakage protection (e.g. 100mA and 30mA RCD).

E. Where specified a separate isolated 'Clean' earth bar shall be provided within the enclosure. This earth bar shall be of similar size to the protective earth bar but shall be insulated from the remainder of the assembly.

F. The connections to the neutral and earth bars shall be made to correspond with the order of the phase connections.

G. All conductors terminating at distribution boards shall be appropriately marked with cable ring markers indicating the circuit number and where appropriate phase connection.

H. All covers, doors and access plates into the distribution boards shall be gasketed to achieve a minimum protection as follows: -

1. Internally IP41

2. Externally IP65

I. Access for cabling shall be from the front only. Shrouding to IP2X shall be fitted to prevent accidental contact with live parts. Warning labels shall be provided.

J. Each distribution board shall be provided with a circuit schedule identifying each individual circuit giving reference, description, rating of protective device and connected load.

K. The schedule shall be typed on an A4 sheet protected by a clear plastic envelope securely fixed to the inside face of the distribution board door.

L. An engraved designation label shall be fitted to the front of the board.

41.15 POWER FACTOR CORRECTION

A. Power factor correction equipment shall be suitable for operation from the supply voltage and frequency, including the tolerances as specified.

B. Power factor correction equipment shall be provided to correct the power factor to between 0.9 lagging and unity.

C. The complete power factor correction equipment assembly shall comply with all applicable requirements of this specification and shall incorporate adequate provision for connection to the general earth system.

D. Power factor correction equipment intended to be applied centrally or to specific groups of motors shall comprise a sufficient number of capacitor units to make up the specified capacitance, accommodated in a suitable cabinet or in a series of modular cubicles assembled together to form a composite unit, together with a control relay, switching equipment, protective fuses and means of isolation, all assembled and connected to as to control automatically the switching 'on' and 'off' of the capacitors in response to changes in the load power factor.

E. Each assembly and all of the equipment within it shall be so arranged that every item of apparatus is readily accessible for adjustment where this may be necessary, and for maintenance.

F. Each assembly shall be complete with incoming isolating switch of appropriate rating, HRC fuses, a set of insulated copper busbars rated for the total capacitive load, suitably rated contactors for the automatic switching of the capacitors in stages and a suitable control relay of approved design. Connection links shall be provided to permit easy removal or relocation of units and provision shall be made for extension at one or both ends of the busbar system.

G. Capacitors shall be of an established, proven design and two copies of type-test certificates shall be submitted to the Engineer for comment.

H. Each capacitor unit shall comprise a balanced three-phase system of capacitors.

I. Each capacitor stage shall be protected by BS EN 60269 fuses and be switched by a separate, block type contactor rated for capacitor switching duty (BS EN 60947-4-1 AC-6b).

J. Capacitors shall be self-healing type to IEC 60831-1. Capacitors shall consist of elements wound from metallised polypropylene film, vacuum processed and encapsulated in hermetically sealed containers. Each capacitor shall have overpressure operated disconnect fuse elements, in addition to overcurrent protection.

K. Capacitors shall be provided with discharge resistors to achieve full discharge within 60 sec. of disconnection. Capacitors shall have low loss per kVAr and be rated for 1.5 to 1.8 times the normal rated current of the capacitor and shall isolate all three phases on switch off. Means shall be provided to identify a failed capacitor or bank of capacitors. Units of equal capacitance shall be interchangeable

L. Space shall be left in the power factor correction equipment for the installation of de-tuning reactors should their use prove necessary in the future.

M. The control relay shall be suitable for operation from the existing current transformer(s) installed for the purpose in the main low-voltage switchboard as required by the P.F.C. manufacturer.

N. A microprocessor based reactive power controller shall be provided to control switching of the capacitor banks and allow rotation of use of the banks to uniformly distribute usage. O. The controller shall ensure:

1. Automatic disconnection of all capacitors in the event of mains failure, with a two minute delay before re-connection

2. Target power factor setting adjustable from 0.8 lag to unity

3. Time delay between switching of stages to ensure capacitors are sufficiently discharged before reenergisation and to prevent hunting

4. Push button operated manual override incorporating time delay as above

5. Adjustable switching programmes

6. Incorporate normally open volt-free contacts for BMS indication of common alarm

7. Visible LED indication of capacitor stages

8. Disconnection on mains-failure.

P. Shrouding and large, clearly visible warning labels shall be provided within the enclosure to warn personnel of the need to discharge the equipment prior to any work.

Q. Cable glands or sealing boxes shall be provided for the connection of incoming supply and control cables as specified.

R. Harmonic filters shall be provided where required to protect against damage from harmonic currents.

S. For further information refer to Section 26 35 00 Power Filters and Conditioners.

42 PART 3 - EXECUTION

42.1 INSTALLATION OF SWITCHGEAR AND ASSOCIATED EQUIPMENT

A. Where individual items of switchgear are to be grouped together, or where it is reasonable to do so, they shall be formed into a composite switchgear panel. Floor mounted units are preferred.

B. All apparatus (including associated equipment and accessories) shall be fixed independently of the system or wiring. All fixing screws or bolts shall be of steel. Where the apparatus has a protective coating of zinc, or is mounted outside a building, the bolts or screws shall be zinc plated (electrogalvanized) complying with BS 1706, Class B coating.

C. The Contractor shall supply and install expansion joints for all busbar trunking systems. The expansion joints shall be installed for every 40m length or as per the manufacturer's recommendations.

42.2 IDENTIFICATION OF SWITCHGEAR AND DISTRIBUTION BOARDS

A. Identification and warning labels shall be in accordance with BS 5378: Part 1.

B. Switchgear and distribution boards shall be permanently identified. Labels shall be of a laminated plastic material attached to the apparatus by screws. Lettering shall be black on white labels and the wording shall be agreed with the Engineer.

C. The main control switch or circuit-breaker shall be labelled, 'DISCONNECTOR' and numbered 1, 2, etc., if there are two or more incoming supplies. The characters shall be at least 10mm high and 1.5mm thick.

D. on all other labels the characters shall be at least 4mm high and 0.5mm thick.

E. A warning label shall be fixed to the front of the switchgear and distribution boards.

42.3 CIRCUIT-BREAKERS (MINIATURE CIRCUIT BREAKERS)

A. Circuit-breakers (MCB) shall comply with BS EN 60898, and have a rated short capacity (Icn) of 10kA unless otherwise specified.

B. Three-phase MCB shall trip all phases on any fault condition.

C. Provision shall be made to enable the operating mechanism to be padlocked in the 'OFF' position.

42.4 RESIDUAL CURRENT DEVICES

A. Residual current circuit devices (RCCD) shall comply with BS EN 61008 (RCCD) or BS EN 61009 (RCBO).

B. The units shall be double or triple-pole as required and mounted enclosed within the distribution board panels or purpose made enclosure.

C. The RCCD/RCBO shall automatically open the protected circuit on an earth leakage fault between phase and earth equal to or greater than the fault current sensitivity rating of the device.

D. The sensitivity ratings of the RCCD/RCBO shall be as indicated on the schematic diagrams and where specified shall be adjustable between the ranges stated.

E. The operating mechanism shall be independent trip-free and shall not be able to be held closed against an earth fault. The units shall be complete with a test button and trip re-set device.

F. The RCCD/RCBO shall have positive contact indication whereby the opening of the device is clearly indicated by a mechanical indicator. This indicator shall be linked to the device main contacts to show the positive opening of all poles.

42.5 METER TAILS

A. Meter tails shall comply with BS 7211, be no longer than 1 metre (unless specifically agreed with the Electricity Supplier) and be XLPE insulated LSF sheathed of the size and rating noted in the schedules or on the drawings. The meter tails shall also comply with the requirements of the local supply authority DEWA.

42.6 ELECTRICITY METERS

A. Each feeder section on a switchboard shall be provided with an electronic metering system that measures and records at least:

B. Line current – instantaneous and maximum of each phase

1. Line and phase voltages

2. Active, reactive and apparent power

3. Power factor

4. Harmonics

5. Time and data

C. The meter shall be of a type with a clear display and easy to operate, cycle through controls. The display shall be backlit for easing reading. The meter shall be provided with an integral battery backup that will maintain the recorded data memory for at least forty-eight hours.

D. The meter shall be capable of being connected to a BMS system for remote interrogation, monitoring and recording and have the facility to download its data records to the BMS system computer.

E. The meter shall be installed at a convenient location in the switchboard section, suitable for easy reading and be complete with all CT's selector switches etc.

F. Electricity meters shall comply with BS EN 62053-21, of the whole current type.

G. Energy meters shall be of the credit type and the energy register of the meter shall indicate total power passed.

H. Meter boards, where required, shall be of 20mm thick resin bonded wood chipboard.

42.7 LABELS AND DIAGRAMS

A. All switchgear/ fuse gear/ disconnectors and distribution units, etc., shall be clearly marked with engraved laminated plastic labels, secured by screws to the cases, clearly indicating the service, voltage and phase of the circuit or apparatus controlled.

B. A diagram showing the details, rating and function of each switch, size and number of cores of all outgoing cables, location, size and rating of all distribution boards fed from that switchboard and the phase of each outgoing circuit shall be provided at each switchboard.

C. These diagrams shall be mounted in glazed frames or similar of an approved design and the layout and mounting shall be approved by the Engineer prior to installation.

D. Refer to separate section of this specification for more information on labelling.

42.8 INSTRUMENTATION

A. Unless specified elsewhere, the main LV switchboard shall be provided with the following minimum instrumentation on the main incoming switch:

1. one voltmeter with line voltage and phase voltage selector switch.

2. one ammeter with line selector switch.

B. The instrumentation shall be flush mounted within the panel front of the switchboard, located immediately above the switches with which it is associated.

C. Current and voltage transformers shall be mounted within separate chambers within the switchboard. Transformers shall conform to BS EN 60044.

D. All instruments shall conform to BS 89, accuracy Class 1.5 (min) and to DIN 43700 style, minimum size 72mm square.

E. Ancillary fuses shall be labelled with the functions and operating details including fuse type and rating. All auxiliary wiring shall be labelled by permanent slip on numbered ferrules. Terminal blocks and terminations shall be similarly identified.

42.9 NOTICES AND LABELS

A. An “electric shock treatment” notice is to be supplied and installed in each switch room, along with a schematic diagram of the installation. Each notice shall be framed and mounted at locations to be agreed with the Engineer.

B. All switchgear and control gear is to be fully identified and labelled as detailed within Section 26 05 53.

XVI. MOTOR CONTROL PANELS

43 PART 1 - GENERAL

43.1 CODES AND STANDARDS

Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

International Codes:

BS 7671	Requirements for electrical installations IEE Wiring Regulations
BS EN ISO 1460	Metallic coatings. Hot dip galvanized coatings on ferrous materials. Gravimetric determination of the mass per unit area.
BS EN 10210-2	Tolerances, dimensions and sectional properties.
BS EN 60076-6	Power transformers. Reactors
BS EN 60044	Instrument transformers.
BS EN 60269	Low voltage fuses.
BS EN 60269-1	General requirements.
BS EN 60529	Specification for degrees of protection provided by enclosures (IP code)
BS EN 60664-1	Insulation coordination for equipment within low-voltage systems. Principles, requirements and tests
BS EN 60898	Circuit breakers for overcurrent protection for household and similar installations.
BS EN 60831-1	Shunt power capacitors of the self-healing type for A.C. systems having a rated voltage up to and including 1kV. General. Performance, testing and rating. Safety requirements. Guide for installation and operation
BS EN 60947-2	Circuit breakers.
BS EN 60947-3	Switches, disconnectors, switch-disconnectors and fuse combination units.
BS EN 60947-4	Contactors and motor starters.
BS EN 60947-4-1	Electromechanical control circuit devices.
BS EN 62053-21	Electricity metering equipment (a.c.). Particular requirements. Static meters for active energy (classes 1 and 2)
BS EN 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
BS EN 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies

44 PART 2 - PRODUCTS

44.1 MOTOR CONTROL PANELS (MCP)

A. General

1. The rated voltage of all switchgear and distribution boards shall be not less than 400V AC between phases.

2. MCP's shall, wherever possible be located within dedicated rooms / areas, and shall, in all cases be appropriately segregated and protected from water services.

B. Construction

1. All MCPs shall be based on a unit grid system. The top and bottom frames of 1.5 mm thickness and of bolted construction. These frames shall be fitted with gland plates or cover plates depending on the cable entry. The top frame with provision for fitting lifting eye-bolts and the bottom frame with mounting holes for fixing to foundation bolts.

2. The bolted frame shall be mounted in multi-tier modular assemblies / compartments that are prefabricated to accept the complete range of manufacturers products. Minor adaptations to the mounting assemblies shall enable a host of other products to be mounted.

3. Mounting assemblies, together with their functional units shall be bolted to the basic structure which is also modular. The basic structure shall be 16 modules high and capable of accepting mounting assemblies that are in multiples of a basic module.

4. The compartment front doors shall be folded at the edges and bolted at the corners with concealed hinges and with rotary front operating handles accessible externally. Side and rear covers shall completely enclose all live parts and complete switchboard shall present a neat flush and aesthetic appearance.

44.2 PAINT FINISH

A. All steel work shall pass through a four stage finishing process. Chemical spray, decreasing, iron phosphating and finally an electrostatically applied top coat of polyester powder coating which is cured in a high temperature oven to give a strong molecular bonding with the steel. The top coat shall be white RAL9001.

44.3 BUSBARS

A. The main horizontal busbars shall be HDHC tinned copper running the full length of the MCP. Current rating shall be as shown on the drawings rated for the ambient temperature specified. Supports shall be fibre glass reinforced moulded type material. Current ratings shall units suit the loads connected on each vertical busbar.

B. The dimensioning of the horizontal and vertical busbar system shall be as per the rated current, the short circuit current, the maximum admissible temperature at permanent operation < 110°C and the ambient temperature around the busbars. Busbar sizing shall also comply to the local authority regulations and the configuration and size of busbars used should have been type tested by the original manufacturer. Busbar supports should be supplied by the original manufacturer of enclosure and components and provided at the

distances as recommended by the original manufacturer. C. Neutral shall be of same size as the phases for busbar assemblies.

D. The earth bar shall be of minimum 300mm^2 and run the entire length of the MCP.

E. Metering, Indication, Control

1. Meters shall be square flush mounting pattern minimum of 72 x 72mm use of smaller meters shall be subject to specific approval.

2. Indicating lamps, push buttons, control and selector switches shall be neatly and logically flush mounted on the front of the respective equipment compartment doors.

44.4 AIR CIRCUIT BREAKERS

A. All air circuit breakers (ACB) shall be ASTA certified and in accordance with BS EN 60947-2. ACB's shall be horizontal, draw-out type, with stored-energy, independent, quick make and break, trip-free operation, with anti-pump. ACB operating mechanisms shall be manual or motor loaded with manual loading facilities, spring stored energy type, as specified in the Particular Specification. Trip circuits shall operate at 30 Volt DC.

B. Air Circuit breakers shall be either triple-pole and neutral or four-pole, as specified elsewhere.

C. Air Circuit breakers shall have service, test and isolated positions and be capable of being locked in the OFF position. In the isolated position, all circuits shall be isolated. In the test position, only the control circuit shall be made.

D. Automatic, lockable safety shutters shall be provided to prevent access to live terminals in the disconnected or test positions. Interphase barriers shall be provided to prevent arc propagation. Interlocks shall be provided to ensure that the circuit breaker is open during connection and disconnection.

E. A test block shall be provided at the unit front to allow secondary injection testing of all relays and tripping circuits without the disconnection of any wiring.

F. Air Circuit breakers shall be complete with auxiliary contacts and terminals for the required controls and indications, together with all appropriate transformers and fuses.

G. Air Circuit breakers shall have mechanically operated ON/OFF and CHARGE/DISCHARGED indication.

H. ACB's of the same rating shall be interchangeable. ACB's of a different rating, but of the same frame size shall not be interchangeable.

I. The main air circuit breakers shall incorporate Castell interlocks as necessary.

J. Protective relays shall be provided for each incoming ACB. Overcurrent protection shall be inverse definite minimum time (IDMT) relays. Restricted earth fault protection shall be by high-stability circulating current relays and Class X current transformers, of suitable characteristics. The installer shall allow for the full setting up and testing to the satisfaction of the Engineer of all protective relays.

K. Where the associated power transformer is cast resin or silicone insulated type the ACB shall trip on high winding temperature.

L. Each ACB shall be provided with an operating handle for racking the ACB in and out for isolation, etc.

M. All ACB's shall be clearly labelled.

44.5 DISCONNECTORS AND FUSE-SWITCH DISCONNECTORS

A. Each feeder device shall be in a separate compartment with a hinged door interlocked with the disconnect or, so that the door cannot be opened when the device is closed or locked open.

B. Positive drive ON/OFF indicators shall be provided.

C. The following mechanical interlocks shall be provided on all compartments or enclosures equipped with a disconnector: -

a. It shall not be possible to open the door with the disconnector in the 'ON' position.

b. It shall not be possible to open the door with the disconnector padlocked 'OFF'.

c. The door may be opened only when the disconnector is fully opened and the operating handle is in the 'OFF' position.

d. When the door is open, clear, unambiguous indication of the disconnector position shall be given on the fixed parts of the device.

e. The ON/OFF positions of operating handles shall be identical for all types of disconnector on the assembly

D. All exposed live terminals shall be shrouded to IP2X and provided with warning notices. Opening the device shall not expose any live parts. An integral secondary barrier shall be provided.

E. Spare space on assembly tiers shall be arranged to allow the simple addition of a feeder device in the future.

F. All disconnect shall be clearly labelled.

44.6 MOULDED CASE CIRCUIT BREAKERS

A. All MCCB's shall be to BS EN 60947-2 and of the current limiting type.

B. MCCB's shall be of the quick-make and break, independent, trip-free type with mechanical ON/OFF/TRIPPED indication

C. For switchboard mounting MCCB's shall be the cubicle mounting type with door mounted padlock able, rotary type operating handle. They shall be of the fixed pattern with fully shrouded fixed contacts. Interlocks shall be provided to prevent the opening of the front cover with the operating handle in the 'ON' position.

D. The operating mechanism shall operate all poles simultaneously during opening, closing and tripping operations.

E. Each pole of the MCCB shall be provided with thermal element for inverse time delay protection and magnetic element for short-circuit protection. The thermal release shall be adjustable and fitted with a lock-off facility.

F. Ensure that full discrimination is achieved between the up and down stream devices. Selection of MCCB's on the cascade principle will not be accepted.

G. MCCB’s shall be of a type suitable for the fitting of motorised operators or shut trip devices.

H. All MCCB’s shall be clearly labelled.

44.7 CONTACTORS

A. Contactors shall comply with BS EN 60947-4 and be rated AC3.

B. Contactors shall be of the multi-pole double-break, fully shrouded, block pattern, with replaceable main and auxiliary contacts. Operation shall be from a separate source. Each contactor shall incorporate auxiliary contacts and the control circuit shall operate at a voltage not exceeding the phase/neutral voltage. Where more than five triple-pole contactors are used, a separate control transformer shall be provided.

C. Where contactor noise is required to be minimal D.C. operated contactor coils shall be used.

D. Where contactors are independently mounted, they shall be totally enclosed in a metal case with hinged and/or bolted on covers. Contactors mounted within a cubicle shall be housed within a separate compartment.

E. All contactor control wiring passing through any adjacent switchgear shall be contained within an internally mounted metal duct/conduit.

44.8 FUSES

A. Cartridge fuse-links shall comply with BS EN 60269-1 (BS 88). Cartridge fuse-links shall have a Utilisation Category of G for general applications, including motor circuits. Category M fuses shall only be used on motor circuits. Category ‘a’ breaking range fuses shall not be used.

B. Fuses are only to be used for capacitor banks.

44.9 PUSH BUTTONS

A. All push buttons shall be one unit momentary contact START/STOP with normally open or normally closed contacts as required by wiring diagrams and with lockout attachments. Heads to be color-coded and STOP button to be protected. Push buttons controlling one piece of equipment to be housed in separate enclosure.

B. All push buttons shall be of the non-retaining type made of non-hygroscopic materials, non-swelling and fitted to avoid any possibility of sticking.

44.10 RELAYS

A. Relays to be multi-pole with normally open or normally closed contacts, electrically operated at 110 V maximum, and magnetically held. Contacts to be double break silvered type, interchangeable from normally open to normally closed without additional parts. Relays are to be rated at 10 A, 600 V.

B. Relays installed on relay bases shall have retaining clips.

44.11 ENCLOSURES

A. Unless stated otherwise the enclosure protection shall be at least:

1. Internally IP44

2. Externally IP65

B. Ferrous parts of indoor enclosures shall be adequately rust protected and shall be finished with an electrostatically applied, powder coated finish.

C. Outdoor enclosures shall be provided with a hot-dip galvanised coating complying with BS EN ISO 1460 or a sherardised coating complying with BS 4921. A decorative finish is not necessarily required.

D. Provision shall be made for locking or padlocking of enclosure covers as necessary.

E. Fixing holes in indoor type enclosures of apparatus may be inside or outside the enclosure. Outdoor type enclosures shall have external fixing lugs.

45 PART 3 - EXECUTION

45.1 INSTALLATION

A. Where individual items of MCPs are to be grouped together, or where it is reasonable to do so, they shall be formed into a composite switchgear panel. Floor mounted units are preferred.

B. All apparatus (including associated equipment and accessories) shall be fixed independently of the system or wiring. All fixing screws or bolts shall be of steel. Where the apparatus has a protective coating of zinc, or is mounted outside a building, the bolts or screws shall be zinc plated (electrogalvanized) complying with BS 1706, Class B coating.

45.2 IDENTIFICATION

A. Identification and warning labels shall be in accordance with BS 5378: Part 1.

B. MCPs shall be permanently identified. Labels shall be of a laminated plastic material attached to the apparatus by screws. Lettering shall be black on white labels and the wording shall be agreed with the Engineer.

C. The main control switch or circuit-breaker shall be labelled, 'DISCONNECTOR' and numbered 1, 2, etc., if there are two or more incoming supplies. The characters shall be at least 10mm high and 1.5mm thick.

D. on all other labels the characters shall be at least 4mm high and 0.5mm thick.

E. A warning label shall be fixed to the front of the switchgear and distribution boards.

45.3 LABELS AND DIAGRAMS

A. All MCPs shall be clearly marked with engraved laminated plastic labels, secured by screws to the cases, clearly indicating the service, voltage and phase of the circuit or apparatus controlled.

B. A diagram showing the details, rating and function of each switch, size and number of cores of all outgoing cables, location, size and rating of all distribution boards fed from that switchboard and the phase of each outgoing circuit shall be provided at each switchboard.

C. These diagrams shall be mounted in glazed frames or similar of an approved design and the layout and mounting shall be approved by the Engineer prior to installation.

D. Refer to separate section of this specification for more information on labelling.

45.4 NOTICES AND LABELS

A. An "electric shock treatment" notice is to be supplied and installed in each switch room/plantroom, along with a schematic diagram of the installation. Each notice shall be framed and mounted at locations to be agreed with the Engineer.

B. All MCPs shall be fully identified and labelled as detailed within Section 26 0553.

45.5 CONTROL WIRING INSTALLATION

A. The Contractor shall appropriately physically support wiring within all enclosures.

B. The Contractor shall protect circuits with high rupturing capacity fuses or circuit breakers.

C. Auxiliary supply for controls other than from main power circuit shall be effectively isolated by auxiliary contacts on the main isolator.

D. Connect hand-off-automatic switch and other automatic control devices according to an indicated wiring diagram or one that is manufacturer approved, where available as follows:

1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.

2. Connect selector switches with motor control circuit in both hand and automatic positions for safety-type control devices such as low and high-pressure cut-outs, high-temperature cut-outs, and motor-overload protectors.

XVII. INSTRUMENTATION AND CONTROL FOR ELECTRICAL SYSTEMS

46 PART 1 - GENERAL

Conform to the description of works for the electrical service's particular specification in Section 26 00 01 of this specification.

46.1 SUMMARY

A. General: Read this Section in conjunction with other related Sections, Division 01 General Requirements, the Design Drawings and the Contract Conditions.

B. Section Includes

1. Instrumentation and controls for electrical system including connection to BMS.

C. Definitions

1. CT: Current Transformer.

2. NIC Network Interface Card.

3. BMS: Building Management System.

46.2 QUALITY ASSURANCE

A. Acceptable Manufacturer

1. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products. The standard products shall have been in satisfactory commercial or industrial use for 5 years prior to bid opening. The 5-year use shall include applications of equipment and materials under similar circumstances and of similar size. The 5 years' experience shall be satisfactorily completed by a product that has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogues, or brochures.

    a. Products having less than a 5-year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be indicated.

    b. Products shall be supported by a service organization.

B. Standards and other Codes of Practice: In addition to the requirements indicated on the Design Drawings or indicated in the Specification, the Work shall be in accordance with provisions of the following standards and codes. The current editions of the publications listed below form a part of this Section.

1. American Society for Testing and Materials, ASTM International Standards.

2. BSI Group, (BS) British Standards.

3. Underwriters' Laboratories, UL Standards.

4. International Electro technical Commission, IEC Standards.

5. Consumer Electronics Association, CEA Standards.

6. Lightning Protection Institute, LPI Standards.

7. Institute of Electrical and Electronics Engineers, IEEE Standards.

8. International Electrical Testing Association, NETA Standards.

9. Telecommunications Industry Association, TIA Standards.

10. National Electrical Manufacturers Association, NEMA Standards.

11. National Fire Protection Association, NFPA Standards.

C. Preconstruction Testing/ Reports

1. Submit reports of independent tests demonstrating that the products and systems are in accordance with the specified performance requirements.

2. Where test results for a material or product are not available, undertake testing to show compliance with the Specification at an independent testing laboratory acceptable to the Engineer.

3. The provision of testing data or the carrying-out of tests does not relieve the Contractor of his responsibilities regarding the performance requirements, durability or service life requirements.

46.3 PROJECT CONDITIONS

A. Project Climatic Conditions

1. The climate in Dubai, UAE in the summer months is hot and humid and a humidity of 100% at 50°C has been recorded.

2. Climate

   a. Violent sand and dust storms of several hours' duration occur and even on comparatively still days, fine dust is carried in suspension in the atmosphere.

   b. All apparatus and equipment shall therefore be so designed and constructed that they operate satisfactorily and without any deleterious effect for prolonged and continuous periods in the conditions stated above.

B. Civil Work Coordination

1. Take into account all of the Civil/ Mechanical Work performed by all other Subcontractors associated with installation of electrical, mechanical, plumbing and other facilities.

46.4 COORDINATION

A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions.

47 PART 2 - GENERAL

47.1 SUMMARY

A. Scope of Work

1. Work of this Section includes but is not limited to meters and instruments.

    a. Connection to Building Management System (BMS), including interface elements such as relays, transducers, etc. as detailed in other Sections, BMS schedules and/ or indicated on the Design Drawings. Provide network interface card (NIC) to allow remote monitoring of all available data parameters (objects) by a third-party Integrated Building Management System (BMS). NIC shall provide standard protocols of Modbus/ RTU or BACnet MS/ TP over an EIA485 network, or Modbus/ TCP or BACnet/ IP over an Ethernet TCP/ IP network. A NIC shall be provided integral to each device or shall act as gateway to multiple devices physically located within the same room. Provide all necessary networks wiring internal to the equipment and the NIC. Provide a complete register mapping of all available data objects for each device. Provide full documentation of protocol parameters (baud rate, parity), device addressing and data object registers for each NIC to BMS Subcontractor.

2. Coordination: Coordinate the work with that of other Trade Subcontractors to ensure proper execution of the work of both trades. Examine Contract Documents for requirements that directly affect or are affected by Work of this Section.

    a. The Design Drawings, General and Particular Condition of Contract, including full specification

47.2 PRODUCT SELECTION

A. Manufacturers: Provide systems and products from one of the listed manufacturers within the approved manufacturer list.

47.3 DESIGN CRITERIA

A. Requirements,

General

1. Instruments: All indicating and recording instruments shall be analogue/ digital type. MDB panel meters and those for connection to the BMS shall be off the digital type. All instruments shall be of a similar style/ size and appearance. Unless otherwise indicated, they shall be of the flush mounted pattern with dust and moisture proof covers and shall be fitted with non-reflecting glass. Where hinged covers are necessary, they shall be provided with locks. Refer the Design Drawings and schedules for indication of meter type.

2. Energy Meters: Shall be of the withdraw able flush mounting, switchboard pattern in accordance with IEC 62052-11 and IEC 62053-11. Meters shall be back connected and have a register of the cyclometer drum type.

3. Tariff Meters: Requirements: The metering equipment shall be precision grade for the purpose of measuring kilowatt-hours and kilowatt-hours for operational information and for tariff metering.

4. Indicators/ Indicating lamps: Shall be of the LCD/ LED type and all colours shall be to acceptance by the Engineer.

5. Switchboard Meters: Instruments are to be housed in enamelled, square, metal cases for flush installation. Scales and markings are to be protected and sealed. Accuracy of instruments is to be within 2% unless otherwise indicated. All metering instruments shall be with low glare window and potential terminals shall be covered against accidental contact and consequent damage.

6. Motor Control Center Metering Instruments: Housed in metal cases for flush mounting, with scales and markings fully protected and scaled meters shall have accuracy within 2% unless stated otherwise.

7. Individual metering of the following final circuits is required: lighting, plug load. This means that all final distribution boards shall have at least 2 No. energy meters.

8. Energy metering is required on any piece of equipment or plant installed that uses more than 100kWh of power per day or exceeds 10kW of demand.

9. All meters shall be able to communicate, via open communication protocol, with the BMS.

B. The entire LV distribution system shall be designed, installed, tested and commissioned in accordance with the requirements of the latest edition of The Electricity Wiring Regulations issued by the Regulation and Supervision Bureau for the Water, Wastewater and Electricity Sector. This is based on the IEE Wiring regulations (17th Edition BS 7671+A1).

47.4 MATERIALS

A. Instruments

1. All indicating and recording instruments shall be analogue/ digital type. All instruments shall be of a similar style/ size and appearance. Unless otherwise indicated, they shall be of the flush mounted pattern with dust and moisture proof covers and shall be fitted with non-reflecting glass. Where hinged covers are necessary, they shall be provided with locks.

2. Meter display shall be of LED or LCD type having guaranteed long life. Measuring circuits shall be self-contained. The power supply shall be self-contained or rated in accordance with the available station supply. The power consumption has to be very low. The CMR and read out range shall be 1.2 times the nominal rating. Internal circuits shall remain unaffected for any kind of vibration. The size (not less than 11mm and clarity of the characters shall be such that they can be clearly read from different angles and distance. Adjustable brightness option shall be there. If lighted with lamp bulb, the life of it shall be at least 10,000 working hours. If circular graph display is used the segments shall be clearly marked and the scale shall be linear. The accuracy of the meter shall be 0.5% fsd or ±1 digit. It shall have IP55 hose proof enclosure or standard DIN case protected to IP54.

3. All indicating instruments shall be in accordance with IEC 81 and unless otherwise indicated, shall have 100mm dials. Instrument dials in general shall be white with black markings and shall be reversible where double scale instruments are specified. Scales shall be of such material that no peeling or discoloration shall take place with age under humid tropical conditions.

4. The movements of all electrically actuated instruments shall be of the dead-beat type.

5. All instruments and apparatus shall be capable of carrying their full load currents without undue heating. They shall not be damaged by the passage of fault currents, within the rating of the associated switchgear, through the primaries of their corresponding instrument transformers. Interposing current transformers shall be used in all instances where the instruments and transducers are not designed to carry full fault current. All instruments and apparatus shall be back connected and the metal cases, supports and bases thereof shall be earthed. Means shall

be provided for zero adjustment of instruments without dismantling.

6. All voltage circuits to instruments shall be protected by a fuse in each unearthed phase of the circuit placed as close as practicable to the instrument transformer terminals, or, where instruments are direct-connected, as close as practicable to the main connection. All power factor indicators shall have the star point of their current coils brought out to a separate terminal which shall be connected to the star point of the instrument current transformer secondary windings.

7. All indicating instrument scales shall be long, clearly divided and indelibly marked and the pointers shall be of clean outline. The marking on the dials shall be restricted to the scale marking. Instrument transformer ratios, maker's name, accuracy grades, etc., shall not appear on the dials but shall appear on the rear of the instrument case. Voltmeters shall be calibrated while hot.

8. Instrument scales shall be submitted for acceptance by the Engineer. All instruments shall have 240° circular scales and shall be calibrated to 1.2 x maximum primary rating of the instrument transformers.

B. Energy Meters

1. Energy meters shall be of the withdrawable flush mounting, switchboard pattern in accordance with IEC 62052-11 and 62053-11. Meters shall be back connected and have a register of the cyclometer drum type.

2. All integrating meters shall be suitable for measuring three-phase, three-wire, unbalanced loads. The speed of the rotor shall not exceed forty revolutions per minute at full load. Unless otherwise approved, the bottom rotor bearing shall be fitted with a diamond jewel which shall be enclosed so as to exclude, as far as possible, dust and other impurities.

3. All integrating meters shall be fitted with a ratchet or other approved device to prevent reverse rotation.

4. The meter cases shall be designed such that the meter elements are independently withdrawable and that during withdrawal and when withdrawn the current transformer connections are shorted out.

5. Front of panel test blocks shall be provided for all meters.

6. Other than for tariff metering, energy meters shall be of Class 1 accuracy.

7. Maximum demand indicating ammeter shall have 15 minimum time lag thermal movements and a self-contained current limiting transformer to prevent damage to the thermal movement due to high overloads. A red slave pointer shall show the highest point reached and has a wire sealable reset knob. The MDI shall have 1 No. pair of normally open adjustable contacts connected to terminals for indication to BMS.

C. Electronic meters

1. Each feeder section on a switch board or panel shall be provided with an electronic metering system that measures and records at least:

   a. Line current - instantaneous and maximum of each phase

   b. Line and phase voltages

   c. Active, reactive and apparent power

   d. Power factor

   e. Harmonics

   f. Time and data

2. The meters shall be of a type with a clear display and easy to operate, cycle through controls. The display shall be backlit for easing reading. The meters shall be provided with an integral battery backup that will maintain the recorded data memory for at least forty-eight hours.

3. Meters shall be installed at a convenient location in the switch board section or panel, suitable for easy reading and be complete with all CT's selector switches etc.

4. Electricity meters shall comply with BS EN 62053-21, of the whole current type.

5. Energy meters shall be of the credit type and the energy register of the meter shall indicate total power passed.

D. Tariff Metering Equipment

1. Requirements: The metering equipment shall be precision grade for the purpose of measuring kilowatt-hours and kilovar-hours for operational information and for tariff metering.

2. Meters: Meters for Tariff metering shall conform to "Technical Specification for Electric Meters". All tariff meters shall be fitted with output pulse contact for KWH and KVARH registering at BMS.

3. Tariff Metering Calibration and test Certificates:

   a. All tariff integrating meters shall be calibrated with the instrument transformers to which they are to be connected. The Contractor shall supply Certificates of Test giving details of all tests carried out together with the Serial Numbers of the meter and instrument transformers. The Certificates shall be in an approved form and at least 6 No. copies shall be supplied for each meter.

b. If the test location for the Instrument Transformers and Meters is different, then CT and VT test certificates shall include for errors at rated burden in addition to those required by IEC.

c. The normal working range shall be between 50 and 75% of the full movement of the pointer.

4. Chart Recorders:

a. When specified in Schedule `G' recorders shall be provided for flush mounting on the Station Summation Metering panel.

b. The operating mechanism shall accept an input range of 0-10mA or -10mA to 0 to + 10mA

c. Chart drive shall be by synchronous motor from a non-break battery inverter supply. Each of the chart recorders shall have at least 2 no. speeds of approximately 60mm/hour and

d. Chart movement shall be vertically downward with the recorded quantity increasing in magnitude as the pen moves from left to right.

E. Indicating Lamps and Fittings

1. Indicators shall be of the LED neon type and all colours shall be to acceptance by the Engineer.

2. Where possible, indicators shall be easily replaceable from the front of the panel and, where fitted into the facials of switch and instrument cubicles or panels, shall be adequately ventilated.

3. LED indicators shall operate at not less than 20 mille-ampere and red LED indicators shall be of the high brightness type.

4. The lamps shall be clear and shall fit into a standard form of lamp holder. The rated lamp voltage shall be 10% in excess of the auxiliary supply voltage, whether AC or DC.

5. The lamp glasses shall be in accordance with BS 1376 and BS EN 60073 and shall be in standard colours, red, green, blue, white and amber. The colour is to be in the glass and not applied coating and the different coloured glasses are not to be interchangeable. Transparent synthetic materials shall be used instead of glass, provided such materials have fast colours and are completely suitable for use in tropical climates.

6. Normally energized indicating lamps, if employed, shall preferably be energized from the station LVAC supply.

7. Lamp test facilities shall be provided so that all lamps on 1 No. Panel can be tested simultaneously by operation of a common key. Where alarm facials are specified, all alarm and monitoring indications (apart from circuit-breaker and disconnect or position indications) shall be incorporated in the facial.

F. Switchboards Metering Instruments

1. Generally: Instruments are to be housed in enameled, square, metal cases for flush installation. Scales and markings are to be protected and sealed. Accuracy of instruments is to be within 2% unless otherwise indicated. All metering instruments shall be with law glare window and potential terminals shall be covered against accidental contact and consequent damage.

2. The following metering devices are to be provided:

    a. 3 ammeters 144mm x 144mm required with expanded scale in operation area and compressed scale at ends and maximum demand indicating pointer which can be set.

    b. Incomers shall have 3 phase sensors to provide automatic switching in case of phase loss, phase reversal or under voltage and automatic restoration on normalization to prevent loss of supply.

3. Voltmeters: Moving iron type, with center zero adjuster, range 1.25 times nominal system voltage, 90° angle, size 76 x 76mm.

4. Voltmeter Selector Switch: 7-position rotary type.

5. Ammeters: Moving iron type, with center zero adjuster, range 2 times nominal circuit amperage, degree angle, size 144 x 144mm. To be provided with maximum demand indicator needle.

6. Current Transformer (CT): Indoor dry type, rated secondary current 5 A. Rated primary current, core size and accuracy are to be determined in accordance with nominal current of plant protected, short-circuit level and burden. Current transformers shall conform to IEC 60044 or equivalent standard. CTs shall have type test certificate. All CTs shall be subject to routine and specific tests according to IEC 60044.

7. Voltage Transformer (VT): Provided where required, complete with primary and secondary fuses and disconnecting device.

8. Maximum Demand Indicator (MDI): Shall be equipped with 15 minutes time log capability, complete with reset knob.

9. Microprocessor Based Monitoring Device: Provide complete electrical metering (kW, kVA, THD, car, power factor, frequency, Amp. per phase, single phase and composite phase voltage, etc.) and is to be connected with BMS for monitoring of all parameters (PQM).

G. Motor Control Centers Metering and Instruments

1. Metering instruments: to be housed in metal cases for flush mounting, with scales and markings fully protected and scaled meters shall have accuracy within 2% unless stated otherwise.

2. Ammeters. Moving iron type with zero adjuster range, 2 times nominal circuit amperage, 90°angle, size 144mm x 144m.

3. Metering instruments to be certified to withstand transients up to 2 kV in accordance with IEC 61000-4-5 and EMC standards suitable to operate in industrial environments in accordance with IEC 61000-4-5.

4. Current Transformers: shall be indoor dry type conforming to IEC 60044 or equivalent and manufactured by approved internationally reputed manufacturers. All CTs shall have 5A rated secondary with primary rating, core size and accuracy to be determined in relation to the specific application. All CT's shall have type test certification and subject to routine tests and special tests in accordance with IEC 60044.

5. Control Terminals: All control terminal blocks shall be made from halogen free, high temperature non corrosive self-extinguishing material in accordance with IEC 60216.

6. Indicating lamps shall be LED type.

7. All Instrumentation panels such as direct digital controllers (DDC) shall be provided with integral fan/ventilation, and internal light point for panel illumination. Pocket for wiring diagram on the door shall also be provided.

8. All Direct Digital Controllers (DDC) shall have field marshalling with end to end cross-ferruling to ensure that both end of the cables are terminated.

48 PART 3 - EXECUTION

48.1 EXAMINATION

A. Verification of Conditions: Examine areas for compliance with requirements for installation and conditions affecting performance of the Work. Identify conditions detrimental to a proper and timely completion and notify the Engineer of the unsatisfactory conditions. Proceed with installation only after unsatisfactory conditions have been corrected.

48.2 INSTALLATION

A. General

1. Install equipment according to manufacturer's written instructions.

2. Mount metering devices according to manufacturer's written instructions and requirements of

B. Control Wiring Installation

1. Install wiring according to manufacturer's written instructions.

2. Connections: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

C. Identification

1. Identify components and power and control wiring according to Section 260100 Operation and Maintenance of Electrical System.

48.3 SITE QUALITY CONTROL

A. Schedule visual and mechanical inspections and electrical tests with at least 7 days' advance notice.

B. Inspect control components for defects and physical damage, testing laboratory labelling and nameplate compliance with the Contract Documents.

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

D. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

48.4 CLEANING AND ADJUSTING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers and repair damaged finishes.

48.5 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within 1 year of date of Taking-Over, provide up to 3 No. Site visits, when requested, to adjust settings.

XVIII. WIRING ACCESSORIES

49 PART 1 - GENERAL

49.1 CODES AND STANDARDS

Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:
International Code:

BS 67	Ceiling Roses
BS 546	Two-pole and earthing-pin plugs, socket outlets, and socket outlet adaptors for circuit supply to 250 volts.
BS 1322	Amino plastic moulding materials.
BS 1361	Specification for cartridge fuses for A.C. circuits in domestic and similar premises.
BS 1362	Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs).
BS 1363	13A fused plugs, and switched and unswitched socket outlets.
BS 2950	Cartridge fuse-links for telecommunications and light electrical apparatus.
BS 4177	Specification for Cooker Control Units
BS 4568	Steel conduit and fittings with metric threads of ISO form for electrical installations.
BS 4573	Specification for two-pin reversible plugs and shaver socket outlets.
BS 5733	Specification for general requirements for electrical accessories
BS 7671	Requirements for electrical installations IEE wiring regulations.
BS EN 60238	Edison Screw Lamp Holders
BS EN 60309	Plugs, socket-outlets and couplers for industrial purposes.
BS EN 60309-1	General requirements.
BS EN 60400	Lamp holder for tubular fluorescent lamps and starter holders.
BS EN 60669	Switches for household and similar fixed electrical installations.
BS EN 60730	Specification for automatic electrical controls for household and similar use
BS EN 61058	Switches for appliances.
BS EN 61184	Bayonet lamp holders.
BS EN 61558-2-5	Safety of power transformers, power supply units and similar. Particular requirements for shaver transformers and shaver supply units

50 PART 2 - PRODUCTS

50.1 WIRING ACCESSORIES

A. Electrical accessories shall comply where applicable with all relevant British Standards and in particular the standards detailed within Part 1 of this Section of the Specification.

B. Ensure there is no physical or electrical damage to accessories when they are removed from their packaging and during installation.

C. The Contractor shall provide masking covers for surface mounted accessories to protect surface from paint.

D. Where accessories are flush mounted install front plate after painting is finished.

E. Align accessories horizontally and vertically. Where accessories are grouped, mount horizontally in line and parallel to each other and equidistant.

F. Fix cover plates to boxes with brass fixing screws.

50.2 LIGHTING SWITCHES

A. All lighting switches shall have interiors of the AC ‘quick-make, slow-break’ pattern, shall be suitably rated to suit the circuit protection device and manufactured in accordance with BS EN 3676 where relevant.

B. Surface switches shall be mounted in steel boxes and switches shall be of the rocker-operated type, complete with drawn steel boxes.

C. Flush switches shall be mounted in steel boxes and shall have adjustable grids. They shall be of the rocker-operated type with front plates of the type as detailed elsewhere. All grid plates shall be earthed to the mounting box by means of a short green/yellow PVC sheathed bonding wire

D. All switches shall be 1 way, 2 way, or intermediate, as required, and in cases where they are grouped together and connected to the same phase, they shall be ganged together and mounted in a multigang box with a common switch plate.

E. Where two or more phases of the supply are connected to a single switch assembly, switch units finished as above shall be provided complete with the necessary phase barriers and identifications, in order to comply with the relevant clauses of BS 7671.

F. For all exterior situations, and in roof plantrooms, watertight switches shall be used comprising AC quick make and break pattern interiors with galvanised exteriors.

G. All switch plates shall be positioned from finished floor level in accordance with the mounting heights stated elsewhere.

H. Lighting switches must not be installed in bathrooms, toilet, or other locations where normal body resistance is reduced due to presence of water.

I. For outdoor locations, damp or wet areas, weather-protected switches must be used (BS 3676).

J. For areas with higher than normal risk of fire or explosion, gas sealed switches must be used (BS 5345), i.e. storage areas, battery room, etc.

50.3 CEILING ROSES

A. Ceiling roses shall be the plug-in type suitable for fixing to a conduit box complying with the requirements of BS 4568. The plug shall be the three pin type providing live, neutral and earth connections. The plug shall be retained in the rose by a screw type cover plate.

B. Where a mains sensing conductor (unswitched live) is required, i.e. for emergency lights, the Contractor shall include for the provision of any 4 pin ceiling plug and socket device required. Roses serving emergency lighting shall be coloured red and final connections banded with red ferrules.

50.4 LAMP HOLDERS

A. Lamp holders for use with general service tungsten filament lamps or domestic type compact fluorescent lamps shall be category T2 to BS EN 61184 and shall be suitable for use with the type of lamp cap specified. Ceiling roses shall comply with BS 67 and shall be complete with halo. BS lamp holders shall be of the type that has isolated contact pins when the lamp is removed.

B. Lamp holders for use with tubular fluorescent lamps shall be bi-pin type complying with BS EN 60400.

C. Pendant drops prepared by the installer shall include moulded insulated cord grip and skirted lamp holders. The cable terminals shall be fixed in lamp holder so that the operation of the 'plunger' contacts shall not move the terminals. Home Office type skirted lamp holders shall be used in all situations. All lamp holders and ceiling roses shall be self-finished in white.

D. All lamp holders incorporated in enclosed luminaires shall be porcelain pattern with fixed plungers.

50.5 SHAVER SOCKET OUTLETS & SHAVER LIGHTS

A. Shaver sockets shall be of the dual voltage type each contained in a flush mounted pressed steel box, finished in a white moulding with overlapping cover trim to match the lighting switches. Each unit shall be an approved sample

B. The sockets shall fully comply with BS 3535: Part 1 (EN 60742) and Section 553 of BS 7671 (IEE Regulations) to be suitable for use in a room containing a fixed bath or shower, or where the outlet is positioned immediately adjacent to a wash hand basin.

C. Each socket assembly shall incorporate a double wound isolating transformer rated 20VA at 230 or 115 volts, arranged such that the insertion of the shaver plug automatically switches on the transformer and removal automatically switches it off.

D. The transformer shall be protected against overload by an automatic solid-state overload device with automatic resetting. The socket shall accept razor plugs to British, Australian, European, and American standards and be the shuttered pattern.

E. The cover plate of the shaver socket shall be inscribed SHAVERS ONLY in both English and Arabic with the addition of a pictogram symbol. Samples shall be provided to the Engineer for approval prior to installation.

F. Unless otherwise stated, shaver lights shall comprise of a combined light unit with dual voltage shave socket incorporating the technical standards described above. Each shaver light shall be complete with a pull cord switch to control the light only. Shaver lights shall comply with BS 4533: Section 102-1 and the Contractor shall earth bond the fittings in accordance with the requirements of BS 7671 (IEE Wiring Regulations).

G. Where the shaver unit is an integral part of guest suite furniture, the Contractor shall allow for the connection of these devices to the circuit wiring

50.6 SOCKET OUTLETS – 13 AMP GENERAL PURPOSE

A. 13 amp socket-outlets shall comply with BS 1363 and, unless otherwise specified, shall be switched. They shall be of the three-pin shuttered type mounted in steel boxes. The moulding shall possess high track-resisting qualities and conform to BS 1322.

B. Where socket outlets are to be installed to supply computers (e.g. within floor boxes in an office environment), they shall have high integrity earth connections complying with the requirements of Section 607 of BS 7671 (IEE Wiring Regulations).

C. Where socket outlets are to be installed to supply equipment outside the zone created by the main equipotential bonding of the installation it shall be supplied from a circuit with a residual current protective device (not exceeding 30 mA rating). A notice of durable material which will remain legible throughout the life of the installation must be fixed on or near the socket outlet stating FOR EQUIPMENT OUTDOORS in both English and Arabic.

D. Alternatively the socket shall be a combined unit consisting of a socket outlet and residual current circuit breaker (not exceeding 30 mA rating). Again a similar notice to the above is required.

E. Where sockets for use outdoors are specified, provision shall be for 13 amp weatherproof switched socket outlets in accordance with BS 1363 with an IP rating no less than IP 55.

F. No socket outlet shall be installed in a bathroom except for a socket outlet complying with BS 3535 (shaver socket outlet).

50.7 SOCKET OUTLETS – INDUSTRIAL

A. Round pin socket outlets shall be 16, 32, or 63 Amp 230 or 400V, 50 Hz pattern as required, manufactured in accordance with BS EN 60309-2/BS 4343 and/or IEC 309.

B. The socket outlets shall generally be surface mounted with polycarbonate body, spring cover, and top/rear conduit entry facilities, as appropriate, unless specified otherwise. Panel mounting type shall be employed where outlets are fitted to steel cable trunking, enclosures and such like.

C. Outlets for use on single phase supplies shall be of the 2-pole and earth pin type and those for use on three-phase supplies shall be 4-pole and earth.

D. All outlets and associated plugs shall be splash proof to IP54, unless otherwise detailed. The Contractor shall include for a matching plug, to BS EN 60309-2BS 4343/I.E.C.309, for each socket outlet installed but final confirmation of the quantity shall be agreed with the Engineer prior to ordering.

50.8 CONNECTION UNITS

A. Connection units shall comply with BS 5733 and unless otherwise specified shall be double-pole switched and incorporate a BS 1362 fuse. They shall be mounted as required in the appropriate steel box.

B. All outlets shall incorporate red pilot lights. The pilot lights shall be recessed into the front plate of the outlets and shall comprise red lens, neon tubes, and resistors in completely sealed units.

C. Connections for use with flexible cord shall have a cord outlet hole in the front or side of the font plate, with suitable flexi-grip enclosing for the cord.

50.9 DOUBLE POLE SWITCHES

A. 20 amp rated double pole shall be suitable for use on 240V 50 Hz supply.

B. Each 20 amp DP switch shall be manufactured in accordance with BS 3676.

C. Each unit shall be either flush mounted complete with recessed pressed steel box or surface mounted, as appropriate, with front plate matching the local lighting switch and small power outlets.

D. The switch plate shall incorporate, where shown on the drawings, flex outlet, and/or indicator light units in addition to the 20 amp double pole switch assembly.

E. Where switches are installed for the control of local fixed items of equipment, the switch plate shall be engraved with a description of that item of equipment in both English and Arabic to clearly identify that item being controlled (e.g. WATER HEATER)
Wiring terminals shall each be capable of accepting a minimum of 2 No. 4mm2 conductors.

50.10 FLEX OUTLET PLATES

A. Flex outlet plates shall be suitable for flush or surface mounting, as required, and be complete with pressed steel box and cover plate.

B. The flex outlet plates shall be finished to match the local lighting switch and small power outlets, as indicated.

C. Each unit shall be fitted with three pairs of terminals, each being able to accommodate the required size of conductor. A cord grip shall be fitted into each unit.

D. Where flex outlets are to be installed in exposed, damp, or similar areas the outlets shall be of a galvanised steel pattern or other heavy duty protection.

50.11 COOKER CONTROL UNITS

A. Cooker control unit shall be constructed in accordance with BS 4177 and shall comprise a 45 amp double pole switch and neon indicator.

B. The complete unit shall have a metal or plastic plate to match the other accessories in the area and shall be installed adjacent to the cooking appliance (not directly behind nor above).

C. The final wiring shall comprise of high temperature LSF insulated cables installed in conduit to a low level flex outlet plate to which the appliance tails shall be connected.

50.12 LOCAL ISOLATION

A. Every circuit shall be provided with a means of isolation from each of the live supply conductors. For circuits supplying fixed equipment terminating a local isolation device the isolator shall comply with the following requirements:

1. have a reliable or visible indication of the open or off position;

2. be designed to make a positive action to close the isolation device;

3. be capable of switching the full load current;

4. the mechanism shall be suitably designed to prevent unintentional re-closure;

5. be clearly marked indicating the circuit/equipment which it shall isolate.

B. The isolation device shall be positioned to be readily operated in the event of an emergency.

50.13 ROOM THERMOSTATS

A. Room thermostats shall comply with BS EN 60730 and BS EN 61058.

B. The rated voltage of thermostats shall be 240V unless otherwise indicated and the rated current shall be as required.

C. Room thermostats shall be of the adjustable pattern, having a nominal range of 7°C to 27°C unless otherwise required. Provision shall be made in the design of thermostats to prevent alteration of the indicated temperature by unauthorised persons.

D. Provision shall not be made in the design of thermostats to permit manual overriding of the thermal switching action, unless so required or as directed by the Engineer.

E. Thermostats shall be suitable for controlling circuits comprising a resistive load only or a combined resistive and reactive load.

50.14 TIMER SWITCHES

A. Time switches shall be of the self-starting, self-winding, synchronous-motor-driven, spring reserve, plug-in type, or fully digital with a battery standby of at least 30 hours.

B. The rated voltage shall be 230 volts and the rated current shall be 20 amperes unless stated elsewhere or as directed by the Engineer.

C. Time switches shall, unless otherwise indicated or as directed by the Engineer, incorporate the following:

1. A 30-hour spring or battery reserve to drive the mechanism during electricity supply interruptions.

2. An easily replaceable cartridge fuse link complying with BS 2950 inserted in the motor circuit.

3. A day-omitting device to render the switch in operative.

4. An ON/OFF manual switch to enable the circuit to be controlled at will without affecting normal dial operation.

5. A 24-hour dial with two ON and two OFF levers and a single pole, single throw, switch.

50.15 FLOOR BOXES

A. Floor boxes shall be rigidly constructed in accordance with the relevant standards and shall be suitably robust for the particular application generally as detailed within Section 26 0001 of this specification.

B. The general mounting frame and box base shall be constructed from min 0.9mm thick galvanised steel and lid and trim mouldings shall be constructed from precision engineered, scuff resistant nylon/plastic typically grey coloured.

C. The lid shall be reinforced with a mild steel plate, again min 0.9mm thick and shall be suitable for acceptance of carpet up to 6mm deep.

D. The minimum number of compartments shall be 3 No or as scheduled separately and all compartments shall be fitted with accessory plates or blanking plates where no accessory is scheduled.

E. Each compartment shall have a min number of 2x20mm and 2x25mm conduit entries.

F. The lid shall be capable of being closed when power or data cables are plugged into the box with cables exiting the lid via cable outlets with sponge rubber fillers.

G. Where “plug-in” type boxes are specified all components shall be of the same manufacturer and shall form part of a composite under floor distribution solution using plug-in busbar trunking, tap off units etc generally as detailed elsewhere.

H. Where a screeded floor system is utilised all screeded floor trunking serving floor boxes shall be of the same manufacturer as the floor boxes and the Contractor shall only use manufactured cable entries to enter the floor box.

I. Floor box depths shall be selected to suit the floor void and screed depths available whilst maintaining the minimum cable bending radii for the provisions/accessories within the floor box.

J. Floor socket outlets may be used where there is no undue risk of water ingress or flooding.

50.16 CONNECTING OF APPARATUS

A. Tubular heaters

Tubular heaters shall be connected to the permanent wiring using a double-pole switch unit with an outlet for a flexible cord, and a length of heat resistance flexible cord.

B. Thermal storage electric water heaters

Thermal storage electric water heaters shall be connected to the permanent wiring using a 20 ampere double-pole switch unit with outlet for flexible cord, pilot lamp, and a length of heat resistant flexible cord. The DP switch shall be located so as to be easily accessible, but clear of water and splashing

C. Sanitary towel disposal units and hand dryers

The permanent wiring shall be taken direct into the apparatus with heat resisting final connections. A non-switched fused connection unit shall be sited at high level above the apparatus to control the electricity supply.

D. Kitchen waste disposal units

The permanent wiring shall terminate in a 20-ampere double-pole switched connection unit with fuse and the final connection by 3 core flexible cable to the motor terminals.

E. Electric motors

The permanent wiring shall be taken direct into the apparatus. A length of flexible steel conduit shall be used to make the final connection to apparatus subject to vibration or movement.

F. CCTV cameras

Each camera shall have a 13 Amp single phase socket outlet or fused connection unit mounted within 0.5 m of the camera position.

For external cameras the socket outlet shall be IP65 rated.

Each camera shall also have a signal cable connection junction box also located within 0.5 m of the camera. For externally mounted cameras this junction box shall be suitably weatherproof.

51 PART 3 - EXECUTION

51.1 EQUIPMENT MOUNTING HEIGHTS

A. Unless particularly detailed elsewhere the following accessory mounting heights shall be taken from the finished level of floors to the centre line of the particular item of equipment/accessory. Mounting heights are scheduled in Section 26 00 01 of this specification.

B. Mounting heights shall be in accordance with the requirements of the latest editions of the Americans with Disabilities Act, Appendix A16 of The Electricity Wiring Regulations Issued by the Regulation and Supervision Bureau for the Emirate of DEWA and all other relevant standards.

C. All final mounting heights shall be agreed with the Engineer prior to commencement of the Works.

D. All outlets, switches and controls, including two-way switching, should be positioned consistently in relation to doorways and corners within a building and in a logical sequence to suit passage through the building. Preferably, light switches should align horizontally unless otherwise indicated.

E. Unless otherwise indicated switches for use by the general public shall align horizontally with door handles within the range 900 to 1100mm, for ease of location when entering a room.

F. TV sockets should be located at least 400 but not more than 1000 mm above the floor.

G. Switches for permanently wired appliances (e.g. fused spurs or reset switches for alarm calls) should be mounted within the range between 750 and 1200 mm.

H. Meters should be mounted between 1200 and 1400 mm from the floor so that the readings can be viewed by a person standing or sitting. Pre-pay meters should be accessible, but protected so children cannot tamper with them.

I. All switches and controls that require precise hand movement/dexterity, e.g. for heating installations, ventilation etc., should be in a zone 750 to 1000 mm from the floor so that wheelchair users and those standing can operate them

J. The maximum height of simple push button controls, including isolator switches and circuit breakers, that require limited dexterity should be 1200 mm

K. Outlets, switches, and controls should be at least 350 mm from room corners.

L. Pull cords for emergency alarm systems are coloured red, located as close to a wall as possible, and have two red 50mm diameter bangles, one set at 100mm and the other set between 800mm and 1000mm above the floor.

M. Generally, switchboards and distribution boards shall be installed so that any item, to which easy access is required such as a fuse, circuit breaker, instrument, etc., is not more than 2000mm or less than 300mm above floor level.

N. Where accessories or equipment are to be installed in hazardous areas the installer shall ensure the equipment selected is suitable for installation in the hazardous area and installed at the appropriate height in accordance with the relevant regulations.

XIX.LOW-VOLTAGE CONTROLLERS

52 PART 1 - GENERAL

52.1 CODES AND STANDARDS

Materials, equipment, and associated works shall be carried out in strict accordance with the following standards and regulations as applicable:

BS: 88	Cartridge Fuses for voltages up to and including 1000V AC and 1500V DC
BS 7671	IEE Wiring Regulations
BS EN 60947-4-1	Low-voltage switchgear and control gear. Contactors and motor-starters. Electromechanical contactors and motor-starters

53 PART 2 - PRODUCTS

53.1 MANUAL MOTOR STARTERS

A. Starters for three phase motors shall be magnetic type to automatically disconnect motor from power supply in case of supply failure, phase failure, excessive voltage drop and overvoltage, phase rotation, overcurrent and lack of balance in phases. Overload trips to be provided for three phases. All starters should preferably be supplied by one manufacturer.

B. Motor Data: Obtain from equipment supplier before ordering any motor starter, or check motor nameplate for full load current rating and allowable temperature rise in order to select proper overload thermal element for motor starter.

C. Short circuit protection device fitted to starter to be independent of controller and overload protection.

D. Control voltage for starters and control circuits shall not to exceed 110V.

E. Step Down Control Circuit Transformers: Two winding isolating type.

F. Control Circuit Protection: Use high rupturing capacity fuses or circuit breakers.

G. Auxiliary supply for controls other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

H. Control devices on starters to be as follows unless otherwise indicated or required by driven equipment: start stop push buttons, one red pilot light for "running", one group pilot light for "stopped" and one reset push button.

I. Starter type A for single phase motors not exceeding 1/2 HP to be surface or flush mounted, manual two pole toggle type, for non-reversing across the line starting, fitted with one overload element.

J. Starter type B for three phase motors not exceeding 7.5 HP to be direct on line, non-reversing, magnetic type, with manual reset, 3 pole overload relay and low voltage protection, unless otherwise required by local regulations.

K. Starter type C for three phase motors over 15 HP to be soft starter or variable frequency drive as applicable, with 3 pole overload relay and low voltage protection, unless otherwise required by local regulations.

L. Individually mounted starters to be totally enclosed in sheet steel enclosure with baked enamel finish. Design is to suit location and application. It is to be impossible to open enclosure door unless isolator is in open position, door interlock shall be defeatable by means of a tool.

M. Nameplates: Starters and controls to have engraved nameplates identifying system or defining its function.

N. Contactors: Comply with BS EN 60947-4, utilisation category AC3 or AC4 as applicable, and be 3phase, 4-pole, magnetic type, 600V rating, capable of interrupting at least ten times rated current inductive or non-inductive loads under normal service conditions and are to

have replaceable main arcing contacts and arc quenching devices. Contactors are to withstand, without welding or burning of contacts, an inrush current of 20 times normal rating for 4 seconds upon closing and are to be capable of closing on the heaviest short-circuit of the system and withstand the short-circuit for period required by upstream short-circuit protective device to operate. Three N.O. and three N.C. spare contacts are to be provided on each contactor.

O. Contactors shall operate without undue noise or vibration. Where two or more contactors are contained in the same cubicle, they shall be separated by barriers. All secondary wiring shall be so arranged and protected as to prevent its being damaged by arcing.

P. Starter Co-Ordination: Motor starter devices shall be of type 2 co-ordination to BS EN 60947-4-1.

Q. All ammeters shall be available with MDI indicators.

53.2 COMBINATION STARTERS SWITCH DISCONNECTORS

A. Components to comprise magnetic starter switch disconnector and short circuit protection devices required by the Standards, in approved sheet metal enclosure to suit application. Starters are to be installed in accordance with starters Clauses of this Specification Section.

B. All starters should preferably be supplied by one manufacturer.

C. Switch Disconnector Operating Mechanism: Quick make, quick break, with external operating handle mechanically interlocked with enclosure cover necessitating disconnecting switch to be in OFF position for access to inside of enclosure. Means are to be provided for by passing interlocks. Position of isolating switch to be clearly indicated on cover.

D. Short circuit protection gear to be HRC fused cartridges or moulded case circuit breakers of appropriate current rupturing capacity. Switch disconnectors are not required if circuit breakers are used for the short circuit protection. In this case the circuit breaker will perform the disconnection function.

E. Operation of circuit breaker to be possible from outside of enclosure. Position of breaker ON/OFF/TRIPPED to be clearly indicated by position of handle.

53.3 PUSH BUTTONS

A. Push buttons to be one unit momentary contact START/STOP with normally open or normally closed contacts as required by wiring diagrams and with lockout attachments. Heads to be colour-coded and STOP button to be protected. Push buttons controlling one piece of equipment to be housed in separate enclosure.

B. All pushbuttons shall be of the non-retaining type made of non-hygroscopic materials, non-swelling and fitted to avoid any possibility of sticking.

53.4 RELAYS

A. Relays to be multi-pole with normally open or normally closed contacts, electrically operated at 110 V maximum, and magnetically held. Contacts to be double break silvered type, interchangeable from normally open to normally closed without additional parts. Relays are to be rated at 10A, 600V.

B. Relays installed on relay bases shall have retaining clips.

53.5 CIRCUIT PROTECTORS AND SWITCHES

A. Motor Circuit Protector: Moulded case, magnetic break type with adjustable instantaneous setting suitable for motor protection.

B. Motor Circuit Protectors are to be in compliance with BS EN 60947-2, utilisation category B, sequence II (service capacity) for Motor Control Panels and sequence III (ultimate capacity) for motor control panels and combination starters unless otherwise indicated on the drawings.

C. Moulded Case Switch: Similar to circuit breakers but without overload/short circuit protection.

D. Short time rating of switches is to be not less than the short circuit current at switch location for 3 cycles. Switches are to have a suitable self-override instantaneous protection and to be in compliance with BS EN 60947-3.

E. Main incoming switches to be equipped to provide earth fault under voltage and phase sequence protection through shunt trip coil. Earth fault detection and interruption to be time coordinated with those of main incoming breaker on the main distribution board.

53.6 CONTROL SWITCHES

A. Float Switch: Level operated, heavy duty, bracket mounted type, suitable for application in open tanks, complete with 178 mm spun copper float, brass rod, two stops, floor mounting stand, lever and counterweight. Switch to have oil tight and dust tight enclosure and 2 pole double throw silver contacts that open on liquid rise.

B. Pressure Switch: Industrial, heavy-duty bellows actuated type, suitable for water service, with contacts to close on falling pressure. Range to be 0.1 to 8 kg/cm2. Switch to be good for 1720kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts and setting adjustment.

C. Low Suction Pressure Switch: Industrial, sensitive, Low range, diaphragm actuated type, suitable for water service, with range of 2 to 20 kPa of falling pressure, preset at factory to 3 kPa. Switch to be good for 690 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts, range adjustment knob, sealing cap and range locking nut.

D. Control Switches shall be operated by shrouded push-buttons or have handles of the spade type. Control, reversing, selector and test switches shall be mounted, constructed and wired so as to facilitate the maintenance of contacts without the necessity for disconnecting wiring.

E. Where necessary, control switches shall be capable of being locked in appropriate positions but control switches for circuit breakers and for motor operated setting devices, etc., shall be of the nonlocking type with spring return to the "neutral" position. Such switches shall be controlled by independent springs, the use of contact springs alone for restoring not being acceptable.

F. Control switches for use in direct control schemes shall be rated for the substation battery voltage.

G. All control switches shall be provided with identification labels, including labels to give clear indication to the direction of each operation, for example, "open", "close", "raise", "Lower", etc.

54 PART 3 - EXECUTION

54.1 INSTTALLATION

A. The Contractor shall install all equipment in accordance with the contract drawings and manufacturers recommendations and manuals.

B. Install enclosed controllers where indicated, in accordance with manufacturer's instructions.

C. Install fuses in fusible switches.

D. Select and install overload heater elements in motor controllers to match installed motor characteristics.

E. Install motor control equipment in accordance with manufacturer's instructions.

F. Adjust all circuit breakers, switches, access doors and operating handles for free mechanical and electrical operation as described in manufacturer’s instructions.

G. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

H. Clean interiors of all enclosed electrical equipment to remove construction debris, dirt and shipping materials.

I. Repaint scratched or marred exterior surfaces to match original finish.

54.2 ADJUSTMENTS AND CLEANING

A. The Contractor shall perform necessary site adjustments to place the equipment in final operating condition. The settings shall be in accordance with the approved protective device coordination study or as directed by the Engineer.

54.3 TESTING

A. Perform factory and installation tests in accordance with applicable British Standard requirements.

54.4 WARRANTY

A. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

XX. MECHANICAL WIRING SERVICES

55 PART 1 - GENERAL

55.1 CODES AND STANDARDS

Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

International Code:

BS 7671	Requirements for electrical installations. IEE Wiring Regulations .

56 PART 2 - PRODUCTS

56.1 MECHANICAL WIRING SERVICES

A. The Contractor shall cross reference his works with the works of the Mechanical Services Engineer (or dept if same Company contracted for MEP services) to establish the extent of the installation and agree principles of wiring and fixing of Mechanical Services Equipment early in the Contract.

B. Division 23 0000 of this specification details the extent of the work associated with the Mechanical services installation and the Contractor shall familiarise himself to the extent of works and coordination of services required.

56.2 CO-ORDINATION/PROGRAMMING

A. Regular co-ordination meetings shall be held between the two parties to ensure continuity of work and avoidance of conflict of services generally.

B. The Electrical Contractor shall also provide all power supplies associated with the Mechanical Services Installation in good time and in accordance with the Main Programme to allow for testing and commissioning at least 1 month in advance of the final contract handover date.

56.3 CABLE CONTAINMENT

A. Cable containment shall be the responsibility of the Electrical Contractor and as such he shall assess all Mechanical Services cable runs and provide suitably sized containment generally in accordance with the containment and wiring sections of this specification.

B. Power (LV) wiring and data/BMS (ELV) cabling shall be physically separated to avoid interference.

56.4 WIRING SYSTEMS

A. All wiring systems shall fully comply with the relevant sections of this specification and the requirements of the local supply authority where applicable.

B. Cables shall be suitable for the environment in which they are installed and shall be suitably de-rated where exposed to high ambient temperatures.

C. Sizing of cables shall generally be carried out as part of the design process however where the Contractor is required to install cables without this information he shall calculate the cable sizes fully in accordance with the requirements of BS 7671 and Appendix A7 of The Electricity Wiring Regulations Issued by the Regulation and Supervision Bureau for the Emirate of DEWA, taking due cognisance of voltage drop, de-rating factors and prospective and earth fault currents as necessary.

D. Final connections to equipment shall be made using proprietary cable glands and termination methods and the Contractor shall assess the likelihood of vibration and provide vibration loops where applicable.

E. BMS cabling shall be carried out by the Contractor and shall be separately contained on either cable basket or within the trunking system. The cabling shall be as specified however

shall be ELV therefore shall be separately contained throughout its length to avoid interference from LV cables etc.

F. The Mechanical Services Contractor shall provide a schedule of BMS wiring points via the BMS/Controls specialist for use by the Contractor in good time to allow BMS wiring to be carried out timeously.

57 PART 3 - EXECUTION

57.1 EQUIPMENT/TERMINATION

A. The Contractor shall obtain free issue loose equipment from the Mechanical Services Contractor for fixing by him i.e. room sensors, thermostats etc. The locations shall be scheduled by the Mechanical Services Contractors so no ambiguity exists in the positioning of the equipment.

B. Final connections to larger, fixed equipment i.e. pumps, air handling plant, condensers, boilers etc shall be carried out by the Contractor after installation by the Mechanical Services Contractor. The Contractor shall co-ordinate the final wiring positions with the Mechanical Services Contractor to ensure wiring is terminated at the correct location.

C. Final connections to equipment shall be made using proprietary cable glands and termination methods and the Contractor shall assess the likelihood of vibration and provide vibration loops where applicable.

D. Termination of BMS cabling shall be carried out by a qualified engineer in this field.

57.2 LOADS

A. The Contractor shall check all equipment loads against the schedule of equipment to be installed and shall advise the Engineer of any discrepancies.

XXI. STANDBY DIESEL GENERATOR

58 PART 1 - GENERAL

This specification covers the design, manufacture, factory testing, marking, packing, shipping, transportation to site, installation, site testing and commissioning of the Emergency Stand-By Generator Unit and related auxiliary equipment for indoor installation.

The Emergency Standby Diesel Generator Unit and related auxiliary equipment to be offered shall be complete in all respects necessary for their effective and trouble-free operation when connected to the system.

58.1 1.1 CODES AND STANDARDS

ASTM	American Society for Testing and Materials
ANSI	American National Standards
BS	British Standards
EIA	Electronic Industries Association
EN	European Standards
IEC	International Electrotechnical Commission
UL	Underwriters' Laboratory
IEC 60044	Instrument transformers
IEC 60269	Low-voltage fuses
IEC 60157	Low-voltage switch-gear and control-gear
IEC 60255	Electrical relays
IEC 60298	AC metal-enclosed switch-gear and control-gear for rated voltages above 1 kV and up to and including 52 kV
IEC 60408	Low-voltage equipment provided by enclosures
IEC 60439	Low-voltage switch-gear and control-gear assemblies
IEC 60529	Degree of protection provided by enclosures (IP Code)
IEC 60664	Insulation co-ordination for equipment within low-voltage systems
IEC 60686	Stabilised power supplies, ac. Output
IEC 60694	Common specifications for high-voltage switch-gear and control-gear standards
IEC 60715	Dimensions of low-voltage switch-gear and control-gear
IEC 60865-1	Short-circuit currents (AC)
IEC 60947	Low voltage switchgear
IEC 61000	Electromagnetic compatibility (EMC)
IEC 61660-2	Short-circuit currents (DC)

59 PART 2 – PRODUCT

59.1 ACRONYMS AND ABBREVIATIONS

CR	Control Room
DGU	Diesel Generator Unit
LCP	Local Control Panel
LFO	Light Fuel Oil

59.2 DIESEL GENERATOR UNIT

A. The engine shall be of the industrial pattern and of adequate capacity to drive the generator specified and shall comply with the continuous rating specified in the Standards for the ambient temperature and altitude.

B. The engine shall be complete with foundation bolts for bolting the engine to the concrete plinth provided by others.

C. The engine shall be of the multi-cylinder compression ignition, pressure charged and inter-cooled, vee form type. The engine shall operate on a four-stroke cycle.

D. The engine shall be provided with an accurately balanced flywheel and shall be flexibly coupled to the alternator. The driving half of the coupling shall be directly attached to the engine flywheel. The driving half of the coupling shall be provided with a suitable boss for the driven unit. The flywheel, couplings and any other exposed moving parts shall be provided with substantial guards.

E. The engine shall be designed to run on gas oil Class D fuel oil.

F. The engine shall have monobloc fuel injection pumps and be complete with a hydraulic governor to maintain the alternator output within the limits specified in this specification.

G. The governor shall be complete with a motorised speed unit suitable for single phase operation and capable of being controlled from the Diesel Alternator Control Panel.

H. The engine shall be supplied complete with a fuel lift pump and daily service tank in room.

I. The engine shall be equipped with the following filters/filter changeover types:

1. Lubricating oil filters of the full flow type.

2. Fuel oil filters of the full flow type.

J. The engine shall be water cooled through a radiator and inter-cooler complete with engine driven fan and centrifugal water pump. The cooling system shall be filled with a suitable anti-corrosion summer coolant solution for protecting the radiator and exposed pipework.

K. The system shall include a thermostatically controlled by-pass valve to assist rapid heating up and to control the rate of water flow through the engine.

L. Electric immersion heaters shall be incorporated in the cooling water systems to maintain a recommended temperature in the engine jacket and the engine sump to ensure the engine is capable of delivering the percentage of full load rating at the time from start as specified. The heaters shall be complete with a controlling thermostat.

M. The immersion heaters and controlling thermostat shall be connected via a switch and fuse to the mains side of the diesel Alternator Control Panel, the fuses being suitably labelled.

N. The engine shall be supplied complete with the following components wired to a common terminal box mounted on the engine under base:

1. High water temperature switch (two stage).
2. Low oil pressure switch (two stage).
3. Mechanical overspeed trip micro switch.
4. Shut-down solenoid.
5. Override solenoid.
6. Centrifugal switch.
7. Governor control run-up device.

59.3 STARTING

A. The engine shall be capable of starting from any crankshaft position. Starting shall be by electric motor or compressed air.

B. Electric starter motor(s) shall be of the pre-engaging, automatic dis-engaging axial type suitable for operation from a D.C. supply. The supply terminals shall be protected by non-conducting shrouds.

59.4 EXHAUST SYSTEM

A. A complete generator exhaust system shall be provided to comply with all necessary external noise criteria. The system shall include primary and secondary silencers to provide a complete system designed to suit the engine back pressure and exhaust requirements. All exposed exhaust pipework & silencers are to be fully insulated and stainless steel clad.

B. Exhaust system shall be certified to provide a minimum 4hr FR protection. Size to suit engine requirements for the given system installation routes.

C. Note the builders work allowance assumes a single exhaust flue, where engines are provide with twin exhaust ports, these are to be combined to a single exhaust or twin exhausts arranged within the limitations of the available builders work.

D. Insulation shall be provided to limit the surface temperature to 60°C under normal operating conditions.

E. The exhaust system to include stainless steel expansion bellows, all necessary couplings, supports, hangers, gaskets and wall penetration sleeves.

F. The complete system and silences shall produce a minimum dB attenuation in accordance with the Acoustic Performance requirements, or a minimum of 30dB.

G. A two-stage catalytic converter shall be provided.

59.5 BATTERIES AND CHARGERS

A. The starter motor batteries shall be supplied on a non-corrodible spill-proof tray or rack and isolated from vibration. They shall be of the nickel-cadmium alkaline type and of sufficient capacity to crank the engine above the minimum firing speed for 3 consecutive 10 second periods, which may be repeated at two hourly intervals. The batteries shall not be used for testing but may be used for commissioning.

B. A suitable dual battery charger shall be provided having facilities for automatic selection of an appropriate rate of charge according to the battery condition, thus ensuring the battery is always maintained in a charged condition.

C. The charger shall be connected to the mains supply via a controlling switch and HRC fuses suitably labelled. The charging circuit shall incorporate an ammeter to show the rate of charge.

D. The transformer and rectifier shall be adequately ventilated and liberally rated.

E. The automatic charger shall be housed in the engine control panel having adequately sized crimped lugs for connection to the battery. The charger shall operate on the constant potential principle and be fitted with an ammeter to measure the charge and discharge current except for the starter motor demand.

59.6 COMPRESSED AIR STARTER

An air compressor system with dual storage cylinders and compressors shall be provided for a minimum of three consecutive 15 second start periods from each storage cylinder. Compressors shall be supplied and controlled from the generator control panel.

59.7 ALTERNATOR

A. The alternator shall be of the brushless, revolving field, screen protected, salient pole, horizontal foot mounting type provided with a direct coupled overhung exciter armature, shaft mounted rotating fused diode rectifier assembly, flange mounted exciter magnet shaft with bare shaft extension suitable for receiving a flexible coupling. Two end frame mounted grease lubricated ball and/or roller bearings shall be provided.

B. The rated output shall be available continuously at any voltage within ± 5% of the rated voltage, at a power factor of 0.8 lagging, and at rated frequency, and for the ambient temperature and altitude.

C. The alternator shall comply with BS EN 60034 having Class H insulation.

D. The alternator shall be complete with anti-condensation heaters.

E. The alternator shall be complete with termination box mounted on the side of the stator suitable for multiple single core cabling from below.

F. All terminal markings shall comply with the relevant Standards. Terminals shall be fitted with compression type cable sockets and shall be housed in suitably earthed metal enclosure, having provision for external flexible cable connections. Locking washers shall be provided on all terminals to ensure that connections shall not loosen under normal working conditions.

G. The phase rotation shall be ABC and a terminal marking and phase rotation diagram shall be provided in the live end terminal box.

H. Radio and television interference suppression shall be provided in accordance with the requirements of the Standard and shall include screening as necessary for the suppression of radiated interference.

59.8 UNDER BASE

A. The engine and alternator shall be mounted on a common industrial type heavy fabricated mild steel baseplate of substantial construction. Mounting faces for the machines shall be accurately machined.

B. The under base shall be mounted on a suitable number of anti-vibration mountings, the floor section of which shall be provided with holding down bolts.

C. The overall under base height shall be sufficient to enable convenient draining of the sump.

D. The standby diesel alternator set shall be constructed so that it can be conveniently dismantled into units of moderate size and weight for major maintenance and repair purposes.

59.9 DAILY FUEL OIL TANK

A. The daily fuel oil storage tank shall have a storage capacity of 960 litres and include bunding to contain fuel spillage for the complete contents plus 10%. The tank shall be constructed from mild steel plate suitably stayed and braced as necessary and tested to 1.5 times the static pressure in accordance with the Standards. For more information refer to mechanical technical schedules.

B. The tank shall be painted with a rust inhibitor and completed with suitable finishing coats to match the diesel alternator set.

C. The tank shall be complete with a fuel oil level float switch having two high limit settings, one set of normally open and normally closed contacts with 20mm conduit entry external to the tank.

D. The sealed tank shall be complete with a 80mm vent and 50mm overflow (with flap) to the catch pit tank. The vent pipe shall be extended to the open air.

E. The tank shall contain provision for termination of a 25mm oil fill pipe and overflow return and dump pipe.

F. The tank shall be complete with a local content gauge, and facilities for remote indication of this content gauge at the Diesel Alternator Control Panel.

G. The tank shall allow for supply feed and return pipes from the tank to the diesel and shall be in black mild steel pipework to BS EN 10255 with welded fittings and incorporating:

1. Isolating valves (within catch pit tank area).

2. Strainer and Fire valve.

3. Engine Isolating valve.

4. Drain (through catch pit tank).

H. The tank shall be supplied complete with a Rupture Basin with float switch having one set of normally open and normally closed contacts with a 20mm conduit entry external to the tank for connection to the diesel Alternator Control Panel, to indicate alarm, isolate Diesel Alternator feed line and lock off supply to fill pump.

I. The tank system shall include a local hand pump system to allow filling from 50gal drums.

59.10 DIESEL ALTERNATOR CONTROL PANEL

A. In addition to the relays, timers, switches, control and instruments necessary to achieve the operation specified and the control panel shall include an Engine Control and Monitoring Unit which shall be self-contained providing the following facilities:

B. Automatic start and stop functions for the engine derived manually either by selected panel mounted push buttons or external push buttons, or automatically by external signal.

C. Protection of the engine by means of a number of monitoring fault channels which provide visual and audible alarm and for serious fault, shut-down and lock-out of the engine.

D. Complete with plug-in relays, delay relays, internal wiring terminals, fuses, etc. with lamps, push button and control switches mounted on the front face of the control panel.

59.11 MAINS FAILURE SENSING

A. Mains supply monitoring units, to indicate automatic starting of the engine in the event of any one or more monitoring units registering a partial or complete failure of a mains supply or sub-main supply.

B. Indicator lamps showing the condition of each of the sensing points and indication of mains failure, testing and alternator on load.

C. A test switch for simulating a mains failure by initiating an engine's auto signal and connection of the alternator to the alternator busbars. One test switch is to be provided for each system or switchboard connected.

D. A switch to give a choice of manual or automatic shutting down of the engine.

E. Mains return manual/auto switch with locking facilities.

F. Clean contacts shall be provided for the remote indication of the above.

59.12 CUBICLE CONSTRUCTION

A. The diesel alternator control panel shall conform to the Standards and shall be finished stove enamelled to an approved colour. The cubicle shall be ingress protected to IP 54 and include anti condensation heaters.

B. The diesel alternator control panel shall consist of sheet metal panels built up on a substantial framework of rolled steel or folded sheet metal sections. All edges or panels shall be radiused and where fabricated the panels shall be dead flat and true. The cubicle shall be constructed in accordance with Form 2 requirements.

C. All necessary stiffeners and supports for the framework shall be provided and where required on the panels. Sheet metal for the build-up of large panels shall be at least 2.0mm thick. For panels not exceeding 1m x 1m, it shall be at least 1.6mm thick. All sheet metal shall be specially selected dead flat, zinc coated mild steel.

D. All hinges shall be concealed and provided with stops and where necessary shall be of an approved pattern, finished in black, hard wearing, non-conductive material. Every door shall be provided with a dust excluding gasket of sponge rubber positively retained in a rebate.

E. Labels in general shall be of "Traffoltye" or similar plastic material finished matt and suitably engraved black on white. The exact details of the lettering and legend, etc., shall be approved by the Engineer before fixing.

F. A label shall be supplied to the effect:

DANGER

ON MAINS FAILURE THIS MAY START UP WITHOUT WARNING.

KEEP CLEAR OF ALL MOVING PARTS ETC. UNLESS DIESEL
ALTERNATOR HAS BEEN ISOLATED BY AN AUTHORISED PERSON.

G. After manufacturer all steelwork other than that manufactured from zinc coated sheets shall be thoroughly cleaned, degreased, de-rusted and primed before any finish is applied.

H. The cubicle shall be divided internally by sheet metal webs to separate low voltage equipment as far as possible from instruments, and to obviate heating up of components. All instruments and equipment shall be securely mounted and internal wiring runs shall be so positioned as to ensure complete accessibility for servicing purposes.

I. Conductors between the busbars and the fuse switches shall be high conductivity copper rod, having a current rating of not less than that of the fuse switches to which they are connected. The conductors shall be insulated with black LS0H sheathing with suitable colour identification, coloured to B.S. colour code for phase identification.

J. All internal wiring shall be LS0H insulated neatly bunched and run on supporting cleats or insulated and shall be coloured and adequately labelled or sleeved for identification. All wiring shall be extended to terminate on easily accessible terminal boards or strips to which external connections can be easily made. All terminals shall be labelled for identification. The cubicle shall include a common earthing bar.

K. All paint finishes shall be stove enamelled the appropriate number of undercoats shall be applied, each being built up and flattened separately. The final coat shall be of an approved colour with gloss finish and sufficient body shall be given to the paint films so that with the building up and flattening the final appearance of the finish is entirely free from blemishes or defects whatsoever.

L. Attention is specifically directed to the need for each of the items to be adequately packed and protected against damage in transit from the manufacturer's works to site. Similarly, on delivery to site, each cubicle shall be properly protected from damage until all work is completed.

59.13 CONTACTORS RELAYS AND INSTRUMENTS

A. Contactors shall be of the ratings indicated on the Drawings conforming to the Standards. Contactor coils shall be suitable for use on direct-current. Rectifiers shall be of the selenium type and terminals shall be provided for external control of the contactors on the A.C. side of the rectifier.

B. Relays shall be of the plug-in type and shall be housed in dust-tight enclosures.

C. Instruments shall be of the moving coil/iron pattern as appropriate complying with the Standards for industrial accuracy.

D. All instruments shall be of the 100mm dial square 240º scale flush pattern and be complete with appropriate selector switches.

59.14 FINISH

A. The diesel alternator set shall be finished to an industrial quality and to the specialist manufacturer's standard colour.

B. The control panel shall be finished to the specialist’s manufacturer's standard colour internally and externally.

C. Any damage to the paint finish which may be occasioned during transportation, off-loading or erection, shall be made good without extra charge.

D. The daily fuel tank finish shall match that of the diesel generator set.

59.15 ACCESSORIES

A. The diesel alternator set shall be provided with:

B. Kit of tools adequate for all normal maintenance operations in a wall/floor mounted cabinet.

C. Four pairs of ear Protectors (muffs).

D. Set of Instructions for starting/stopping correct operation and routine testing (wall chart famed).

E. In addition to the requirements for O&M Manuals for the complete contract:

1. 2 No. Paper Operating and Maintenance Manuals including:

- Instruction books for the alternator and diesel engine.
- Electrical schematic diagrams (encapsulated and wall mounted).
- Outline drawings of all equipment.
- Sound data including attenuation provided by ear muffs.
- Foundation drawing.
- 2 No. Illustrated spare parts list.
- Emergency and Safety charts (encapsulated and wall mounted).

F. The Operating and Maintenance Manual and the illustrated spare parts lists shall be clearly marked with the scheme title and the site identification and shall be forwarded within 2 weeks of the acceptance of the installation.

59.16 ROUTINE MAINTENANCE TOOLS & SPARES

The diesel alternator set manufacturer shall put forward his proposals at the time of tendering for the routine maintenance tools and spares in respect of the alternator and diesel alternator control panel and shall include the cost of such tools and spares accordingly.

59.17 NOISE SPECIFICATION

Noise transfer to the exterior of the building shall be limited to NR 40 or in accordance with local the acoustic regulations at the nearest significant listening position, or lower if required. All required silencers and/or sound alternators shall be provided to meet this requirement.

Provide notice that ear protectors should be worn (black symbol on yellow background).

59.18 PIPEWORK

A. All pipework shall be new and shall be colour banded to identify different grades.

B. Pipework shall be installed with correct falls to ensure adequate venting and draining.

C. Pipework installed in trenches, ducts, voids and inaccessible places shall have welded joints except where screwed or flanged joints are necessary for connecting to valves, etc. No pipe joints shall be permitted concealed within the thickness of walls or floors, etc.

D. Welding shall not be permitted on galvanised pipework under any circumstances whatsoever.

E. All pipework shall be free from burrs, rust and scale and shall be thoroughly cleaned before installation.

F. During the course of the Sub Contract all open ends shall be plugged or capped to prevent ingress of dirt, and on completion each system shall be thoroughly flushed out.

G. Pipework materials for the various services shall comply with the following tables:

Cooling water	Black mild steel to BS EN 10255
Oil (fuel and lubricating lines)	Black mild steel to BS EN 10255
Vents, drains and overflows	Seamless Light gauge copper tube to BS EN 1057

60 PART 3 TESTING AND COMMISSIONING

60.1 WORK TEST

A. All plant and equipment, cables and other items forming these works shall be tested by the manufacturers in accordance with the relevant British Standards Specification. The Sub-Contractor shall be responsible for supplying to the Employer's Representative on request Test Certificates by approved testing authorities.

B. A factory acceptance test shall be carried out at the supplier's factory prior to delivery to determine the proper function of the equipment in accordance with the specification.

C. The Employer's Representative and other members of the Design Team may wish to be present at works tests of the following:

1. Diesel generator sets & associated control panels.
2. Load management software simulation.

D. The manufacturer shall issue via the Sub-Contractor for comment a list of all the tests, which shall be witnessed where requested, by the Employer's Representative.

E. Before shipment the electrical equipment shall be subjected to pass all the required tests as per the British Standard.

F. The complete generator set assembly, including its control equipment and switchgear shall be tested as a composite unit at the generator set manufacturer's works. The works test shall comprise but not be limited to:

1. Check plant build against the specification.
2. Record reference and rating data.
3. Prepare generators set(s) for test with connections for exhaust, cooling system, lubricating oil, electrical power, control wiring etc.
4. Preliminary starting and running checks / adjustments.
5. Performance tests *.
6. Load acceptance tests *.
7. Governing and voltage regulation (cold condition) *.
8. Load duration test with detailed examination of set immediately following hot shutdown *.
9. Governing and voltage regulation (hot condition).
10. Transient switching tests.
11. Insulation tests.
12. Final re-run of set to observe correct performance.
13. Final check and clearance including drain down, disconnection and completion of test certificates.

G. Tests noted with * shall be conducted as separate individual tests as follows:

Performance Checks (as above).

1. Run up and apply rated kW load at power factors 1.0 and 0.8 lagging.
2. Adjust engine speed and generator voltage to rated values and lock at these values.
3. Check that all control, indicating and safety equipment meet the functional requirements of the specification.
4. Throw off rated load and check that frequency and voltage values remain within specified tolerances.

Load Acceptance Tests (as above)

1. From cold start and no-load condition, apply single step load of 60%.
2. Record this load condition as confirmation of satisfactory load acceptance.
3. Governing and Voltage Regulation Tests (as above).

These tests shall be carried out under both cold conditions and steady state hot conditions:

The load conditions shall range from no-load to 100% and unit power factor, by increments of 25% of rated kW load.

The tests shall also be carried out at a power factor of 0.8 lagging using an inductive load bank.

Load Duration Test (as above)

1. For plant rated at 100kW or more, run up generating plant and run at rated load at a power factor of 0.8 lagging for a minimum period of four hours to ensure that thermal equilibrium has been achieved.
2. For plant rated at less than 100kW, run up generating plant and run at rated load at a power factor of 0.8 lagging for a minimum period of one hour.
3. Periodically record all instrument readings and plant air temperatures.
4. Check for leaks of fuel, oil or water during the tests.
5. On completion of tests, shut down plant and examine all components for excessive temperatures.
6. Tests to be carried out with cooling air at the site ambient temperature using air heaters if necessary.

60.2 SITE TESTING

A. The Sub-Contractor shall be responsible for the complete testing of the systems within the building to the standards laid out in this specification.

B. Prior notice of all site tests shall be given to the Employer's Representative giving him the opportunity to attend.

C. The Sub-Contractor shall provide all instruments necessary for carrying out the specified testing.

D. Tests shall be carried out as the Work proceeds but a final test on the whole installation shall be carried out on completion. Where tests are failed, works shall be rectified and tests repeated until a pass is achieved.

E. During the progress of the Works, the Sub-Contractor shall carry out tests on conduit runs to ensure low resistance and shall submit test sheets immediately any section of the conduit is completed and tested.

F. The testing schedule shall include but not be limited to the following:

1. Continuity of final ring circuit conductors.
2. Continuity of protective conductors including main and supplementary equipotential bonding.
3. Earth electrode resistance.
4. Insulation resistance.
5. Insulation of site-built assemblies.
6. Protection by electrical separation.
7. Protection by barriers or enclosures provided during erection.
8. Circuit impedance.
9. Polarity.
10. Earth fault loop impedance/fault level.
11. Prospective fault levels.
12. Operation of residual current devices.

G. Tests shall be carried out in the above sequence. Standard methods of testing shall be used as defined in the IEE Wiring Regulations for Electrical Installations.

H. On completion of tests the suitability of equipment installed shall be re-verified to ensure safety of operation. This particularly applies to disconnection times for fuses and circuit breakers.

I. When the testing is satisfactorily complete, the Sub-Contractor shall set to work and demonstrate the correct operation of the installations in accordance with the design intent.

60.3 LOW VOLTAGE SWITCHGEAR

A. The Sub-Contractor shall check the insulation resistance between phases, between each phase and earth and between the instrument wiring and earth.

B. The Sub-Contractor's attention is drawn to the need to short circuit all instrument and current transformer connections by bonding at the terminals, to open circuit all instruments and voltage coils by removing the potential fuses and disconnection of the current transformer earth connections.

C. The results of all these tests shall be recorded.

D. The Sub-Contractor shall ensure that on completion of the tests all bonding is removed and that the current transformer earth connections and potential fuses are replaced.

60.4 PRE-COMMISSIONING

A. On completion of the works and before systems are energised the Sub-Contractor shall visually inspect the installation to ensure that electrical equipment is in compliance with the Specification, correctly selected and erected and not visibly damaged so as to impair safety.

B. The Sub-Contractor shall ensure that all equipment included under this sub contract is thoroughly cleaned and checked for serviceability immediately before setting to work.

C. All automatic controls and safety devices shall be inspected and checked for serviceability before the working power is applied to the system.

D. The generator plant, including its associated fuel, cooling, exhaust, electrical and fire safety systems must be thoroughly checked for corrected operation in both manual and automatic modes during and upon completion of site installation. The initial checks shall consist largely of static checks to ensure that installation has been carried out correctly in readiness for full testing and commissioning.

E. The engine / alternator shaft alignment must be checked where the set is not skid-mounted or where the assembly has been dismantled for transportation to the site.

F. The generator output voltage, frequency and phase rotation should be checked before further tests are carried out and before final connection to the electrical distribution system.

60.5 COMMISSIONING AND TESTING RECORDS

A. The commissioning schedule shall include but not be limited to the following.

B. The Sub-Contractor shall be responsible for the manufacturers attending site to carry out all specialist commissioning of plant items and systems.

C. Setting, calibration and testing of all indication and alarm systems and safety devices.

D. Operation of all automatic and manual plant switching including interlocks and automatic changeovers.

E. Check instruments and gauges for scale range and accuracy of readings and set points.

F. Upon completion of commissioning and testing the Sub-Contractor shall assemble his commissioning and testing records into a bound manual. The manual shall be made available when the commissioned and tested installations are ready for demonstration to the Employer or Employer's Representative. The records shall be supplied in copies of the O&M manuals, the requirements for which are specified elsewhere.

60.6 SYSTEM PERFORMANCE PROVING

A. The Sub-Contractor shall be required to demonstrate to the Consulting Engineer the aspects of the generator system as described below.

B. A load test shall be carried out with the standby generator supplying its full output rating against a reactive load bank. The load bank shall be multi-stage and capable of offering loads at power factor 0.8 lagging.

C. The duration of the site full load test should be a minimum least four hours.

D. The test shall be carried out at varying loads up to the full load, with instrument readings recorded every 15 minutes. These reading should include jacket water temperature, exhaust temperature, lubricating oil level, temperature and pressure, output voltage and frequency. The room temperature should also be monitored.

E. Noise and vibration measurements shall be monitored and measured if the generator installation is likely to cause a disturbance to nearby occupants.

F. All local / remote controls, emergency stop and all protection devices / interlocks etc. shall be proved during on-site commissioning tests.

G. The time interval should be noted between initial start-up and load acceptance for the lead machine and, for multiple set installations, the time taken for the remaining sets to synchronise and accept load. Load sharing between sets shall also be checked.

H. Full operating and maintenance instructions, together with comprehensive record drawings and documentation, must be available on hand-over.

I. The Sub-Contractor shall be responsible and shall bear the costs for providing the necessary fuel to conduct the above tests.

J. Witnessing and Inspection by Statutory Bodies and Utilities

K. The Sub-Contractor shall allow for the witnessing of testing as required, any separate testing that may be required by Statutory Authorities and full-completed system inspection on the services installation by the following:

1. Local Fire Brigade.

2. Building Control Department.

3. Building Insurers.

L. The Sub-Contractor shall obtain in writing from the relevant authorities, written confirmation of their acceptance of the installations.

60.7 REGULAR TESTING AND MAINTENANCE

A. The complete electrical distribution system shall need to be regularly tested and maintained in accordance with BS7671, Requirements for Electrical Installations (IEE Wiring Regulations). The Sub-Contractor to ensure that the requirements for regular testing and maintenance are clearly stated in the Operation & Maintenance Manuals. A pro-forma for regular testing and maintenance shall be provided in the O & M manuals by the Sub-Contractor along with a log book.

B. Designers risk assessments have been carried out for the design; these risk assessments are not contained within this specification, but shall have been issued during tender with the tender documents.

C. Generating plant requires regular maintenance to keep it in good working condition, to ensure reliability and to achieve optimum performance and long life. Although the

alternator shall require occasional attention, in accordance with the manufacturer's recommendations, the engine system primarily requires routine maintenance.

D. The operation and maintenance manual should be consulted to ensure all aspects of maintenance are correctly carried out.

E. An ACB has been provided on the generator switchboard for connection of a temporary load bank. The Sub-Contractor shall advise the Employer on the frequency that the generator sets should run on the temporary load bank.

F. If during the testing on a load bank through the generator switchboard (isolated mode) and the mains supply was to fail, the shunt trip connected to the load bank ACB shall be tripped by the generator master control panel upon acceptance of load by the generator.

60.8 SUPPLEMENTARY EQUIPMENT

A. The following supplementary equipment shall be provided for each generator room:

1. Encapsulated wall mounted schematic diagrams for electrical and mechanical systems clearly indicating key points of isolation.

2. Electric shock resuscitation notice wall (encapsulated).

3. Rubber mats, minimum 900 wide in front of all switch and control panels.

4. Eye wash station.

5. Lockable cabinet with 4 sets ear defenders.

6. Portable twin spot emergency light with 3-hour battery and 50W lamps. Complete with support bracket, carry handle and arranged for non-auto operation on mains failure.

7. Portable fire extinguishing equipment as defined in the fire strategy report.

8. Bucket with dry sand and lid for oil spillage.

XXII. CENTRAL BATTERY EQUIPMENT

61 PART 1 - GENERAL

61.1 CODES AND STANDARDS

Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

Codes:	
BS EN 50272-1	Safety requirements for secondary batteries and battery installations. General safety information
BS EN 50272-2	Safety requirements for secondary batteries and battery installations. Stationary batteries
NFPA 101	National Fire Protection Association - Life Safety Code
UL 924	Emergency Lighting and Power Equipment
UL 1424	Standard for Cables for Power-Limited Fire-Alarm Circuits
UL 1425	Standard for Cables for Non-Power-Limited Fire-Alarm Circuits
UL 1598	Luminaries

62 PART 2 - PRODUCTS

62.1 STATIC INVERTER CENTRAL BATTERY SYSTEM CUBICLES

A. The cubicles of the Emergency Lighting Inverter System (ELI) shall have the following characteristics:

1. 1.6mm zinc coated steel panels with powder coat finish.

2. Plinth base feature to prevent build-up of moisture/corrosive materials and aid mechanical handling by fork or pallet truck.

3. Combined charger/inverter/battery housed in single cubicles or charger/inverter + separate battery cubicles configuration depending on size.

4. Electrical control gear segregated from battery compartments with lockable access door(s).

5. Battery compartments supplied with separate tiered sections, to enable ease of electrolyte level inspection.

6. Separate fixed facia panel for mounting control/display panel.

7. 75mm spacer fitted to back of cubicle to ensure ventilation grilles are not obstructed.

8. IP21 min. rating when installed within room.

B. The Contractor shall ensure that all batteries are installed to maintain the safety distance of the battery accordance with BS EN50272-2.

62.2 BATTERY CHARGER

A. Charger module shall be controlled by the microprocessor of the control module. There shall be automatic boost charge, cyclic charge and trickle charge facility for full battery capacity use and maximum battery life. The charger shall have built-in deep discharge protection for long battery life.

There shall be a DIP-switch for setting the maximum charging current, according to the battery capacity. Batteries shall have dedicated charger unit for each control panel.

B. The system shall have temperature sensor at the battery for automatic charging voltage adjustment. Fuse protection shall be provided. The charger shall be designed for 80% recharge of a fully discharged battery within 12 hours in accordance with BS EN 50171 and full recharge within 24 hours of a rated discharge.

C. Outputs shall have low AC ripple currents for maximum battery life and in compliance with EN50171.

D. Input protection by MCB to BS3871 Part 1 or BS4752 Part 1.

62.3 BATTERIES

A. The batteries shall be maintenance free sealed lead acid, gas recombination type with a minimum design life of 10 years, suitable for operating at ambient temperatures between 20 - 30°C.

B. A one year maintenance free warrantee shall be provided for the batteries by the Contractor, unless specified elsewhere within the Contract Documentation.

C. The batteries shall be extremely low gas generation, low self-discharge and have permanently sealed pressure release vents.

D. Care shall be taken to store/install these batteries within areas, which are free of prolonged extreme temperatures (i.e. temperature controlled room).

E. The batteries shall be sized to power the complete system for 3 hours following mains failure at 100% light output of all emergency luminaires.

F. The central battery system shall be installed with a temperature compensated charger and also protect the batteries from deep discharge.

62.4 FUSEGEAR

A. Removable industrial HRC fuses, complying with BS88.

62.5 INPUT CIRCUITS

A. Cable entry via removable gland plate on top of cubicle.

B. Single phase 230V ± 10% AC 50Hz supply.

C. Input terminals and MCBs DIN rail mounted and easily accessible

62.6 LOAD CIRCUITS

A. Substantial DIN rail mounted output terminals.

B. Integral distribution board (MCBs)

62.7 MONITORING CIRCUITS

A. Terminals provided for connection of remote monitors and controls.

62.8 CABLES

A. Compliant with BC6231

62.9 TRANSFORMER

A. Double wound with earth screen to BS171

62.10 RECTIFIER

A. Full wave controlled thyristor/diode bridge

62.11 CONTACTOR

A. Mains failure contactor to BS5424 Part 1

62.12 TEMPERATURE COMPENSATION

A. All lead acid cell systems supplied with transducer to monitor battery compartment temperature and gas monitoring

B. Chargers pre-set for optimum performance in 20°C ambient

C. Charging voltage automatically adjusted to optimise battery life

62.13 LOW BATTERY VOLTAGE DISCONNECT CIRCUIT

A. Automatically shuts down the inverter when battery voltage falls below pre-set level, during extended periods of mains supply failure

B. Helps prevent potential damage from deep discharge

C. Indicator remains lit until mains power restored and reset pressed

62.14 INVERTER

A. Extensively proven and reliable modular design, fully in compliance with EN50171

B. Modules shall be quickly and easily removable/replaceable to aid installation and maintenance

C. Output voltage: Pre-settable in the range 220-240V AC. Default setting is 230V AC. Voltage tolerance is 2% on loads of 0-100% of system rating

D. Frequency: 50 or 60Hz. ±0.01%. Standard setting 50Hz. Waveform: Sinusoidal

E. Voltage regulation: Static 2%, dynamic 6%

F. Isolation: 2kv rms between input and output terminals

G. Total harmonic distortion: Less than 3% into a linear load

H. Power factor: to supply loads in the 0.3 lag - 0.3 lead range

I. Overload: 200% for 10 seconds, 125% for 20 minutes without reduction in output voltage

J. Start-up time: Standard 30ms soft start, increasable up to 10 seconds if required

K. Noise level: Less than 55dBA at 1 metre

L. Efficiency: 85 - 89%

M. Protection: DC input and AC output MCB’s

N. DC input reverse polarity protection

O. Short circuit protection

P. Pre-charge protection fuse

Q. Reverse-fed mains proof

R. Low voltage shut down: Inverter module(s) automatically shut down when battery discharges to a pre-set level. Re-set is following a combination of the restoration of the mains supply and an increase in battery voltage above the disconnect threshold level. Residual current drain when the disconnect circuit has operated is less than 1mA per module

S. Inhibit: An inhibit switch to control the inverter is fitted on a user control pcb in the cubicle

T. Technology: Pulse width modulation with high frequency switching

62.15 TEST PUSH BUTTON

A. Simulates a mains failure.

62.16 METERING AND DISPLAY PANEL

A. Simple and easy to read status display

B. LCD meter indicating battery voltage, battery current or battery compartment temperature. Voltage is default, others displayed using push buttons. Display mode indicated by LED:

- Volts
- Amps
- Temperature - lead acid batteries only

C. Charger indication LED's

- Power on
- Maintained Lights (maintained systems only)
- Float Mode
- Current Limit
- Full Charge
- Boost mode of vented battery system

D. Alarm indication LEDs:

- Mains Fail
- Charge Fail
- Battery High Volts

- Battery Low Volts
- DC Earth Fault
- Deep Discharge Protection (protection circuit has operated)
- Inverter indication LEDs:
- Inverter Running
- Inverter Overload
- Inverter High Volts
- Inverter Low Volts

E. Audible alarm fitted internally, with mute button on display plus common volt free contacts for remote signalling of a fault condition to the Landlord BMS.

63 PART 3 - EXECUTION

63.1 COMMISSIONING

A. The whole system shall be tested by a person deemed competent by the installer and by the authority having jurisdiction or the Engineer.

B. A test certificate in accordance with the NFPA 101 and the local Civil Defence requirements shall be issued upon completion of the project for inclusion within the operating and maintenance documentation.

XXIII. POWER FILTERS AND CONDITIONERS

64 PART 1 - GENERAL

64.1 CODES AND STANDARDS

Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

Codes:

BS 5378	Low voltage switchgear and control gear assemblies Part 1 Colour and design Part 11 Particular requirements for fuse boards. Part 12 Particular requirements to type-tested miniature circuit breaker boards. Part 13 Specification for particular requirements of consumer units
BS 7671	Requirements for electrical installations IEE Wiring Regulations
BS EN 60044	Instrument transformers.
BS EN 60269	Low voltage fuses.
BS EN 60269-1	General requirements.
BS EN 60947-3	Switches, disconnectors, switch-disconnectors and fuse combination units.
BS EN 60947-4	Contactors and motor starters.
BS EN 60831-1	Shunt power capacitors of the self-healing type for A.C. systems having a rated voltage up to and including 1000 V.
BS EN 61921	Power capacitors – Low voltage power factor correction banks.
BS EN 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
BS EN 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
BS EN 60439	Low-voltage switchgear and control gear assemblies

65 PART 2 - PRODUCTS

65.1 POWER FACTOR CORRECTION CAPACITOR BANKS

A. The power factor correction capacitor banks shall be three phase, of modular design, shall be switched ON / OFF automatically in steps through the use of contactors designed for capacitor switching duty. The contactor shall be suitable for the type of electrical loads and shall incorporate series reactors to prevent amplification of system harmonics and resonance.

B. The normal rating of the Capacitor Banks shall be the maximum continuous rating under the worst temperature conditions encountered in Dubai. The capacitors banks, series reactors, power factor controllers, circuit breakers, contactors and other equipment called for in this specification shall preferably be from a single manufacturer and shall give continuous and trouble free service under the arduous temperature conditions in Dubai.

65.2 CAPACITOR UNITS

A. The capacitor units shall be dry, self-healing type with individual discharge resistors shall be protected against internal faults, over pressure, etc. and shall fully comply with and tested to the requirements of BS EN 60831.

B. The capacitor units shall be rated at 480V due to the voltage rise caused by connecting the detuned series reactors. The ambient temperature in the room shall be maintained at 40°C. If the ambient temperature of the room exceeds 40°C (due to failure of air conditioning systems) then the capacitor bank and its components shall be derated. The capacitor units shall then be de rated to 550V. The ambient temperature in the room shall not exceed 50°C.

C. The temperature category of the capacitor units shall be -5/D as per BS EN 60831.

D. The capacitors shall be completely leakage proof and of dry type construction without any filling of jelly, wax, etc. They shall be of the self-healing type utilizing low-loss metalized polypropylene film dielectrics.

E. The capacitor containers shall be of non-metallic design from high temperature withstanding material and shall not require an earth connection.

F. Each capacitor element shall have an internal HRC fuse combined with a secondary solid foil electrode to ensure safe disconnection from the circuit at the end of its normal working life.

G. A suitable device shall be provided to automatically disconnect the capacitor unit from supply if excessive pressure is generated inside the unit.

H. The capacitors shall have permanently connected built-in discharge resistors to ensure safe discharge of the capacitors to less than 50 volts in 1 minute after switch off.

I. The total losses including discharge resistors to be less than 0.5 Watt/KVAR.

J. The capacitors shall be rated for a minimum of 130% continuous current overload and 110% continuous voltage overload based on the Rated Voltage of the capacitors.

65.3 SERIES REACTORS TO PREVENT AMPLIFICATION OF SYSTEM HARMONICS

A. The three phase series reactors to be connected in series with each capacitor unit for harmonic current suppression and to prevent resonance shall be iron cored type with copper windings. The reactor shall comply with BS EN 60076-6.

B. The reactor insulation shall be Class "H" rated at 180°C to BS EN 60085-1. The maximum temperature of the reactor at maximum continuous RMS amperage shall be no higher than 145°C with a 45°C ambient. The maximum continuous RMS amperage of the reactor shall be sized to match the maximum continuous RMS amperage of the capacitors.

C. The capacitor and reactor combination represents a series resonant circuit. The circuit shall be tuned such that the series resonant frequency shall be below the lowest harmonics appearing in the system. The combination shall produce an inductive response to all frequencies above the series resonant frequency, thus avoiding resonances with system inductances.

D. The capacitors and the reactors combination shall be tuned below the lowest harmonic present in a particular distribution system.

E. For applications such as offices / shopping malls etc. with a sizable single-phase load generating third harmonics (150Hz), series reactors with a tuning order of 2.7 (135Hz) with a relative impedance 13.7 % shall be used.

F. For industrial applications with 6 pulse VFD's series reactors with a tuning order of 4.3 (215Hz) with a relative impedance 5.4 % shall be used.

65.4 ELECTROMAGNETIC CONTACTOR

A. The electromagnetic contactors shall be 660 Volts rated, of 3-pole type suitable for switching 'on' and switching 'off' operations of capacitor banks and shall comply with the requirements of BS EN 60947-1 & 4-1. The supplier shall choose a contactor of a suitable operational current rating taking into consideration the inrush current and the special considerations of capacitor switching duty. Incidence of higher inrush current in the case of successive switching of capacitor banks shall also be taken into account.

B. The supplier shall furnish data sheet of contactor in support of proper selection of the contactor rating including the making and breaking current ratings. The contactors shall isolate all three supply phases to the capacitor on switch off.

C. The rated voltage of control coil shall be 415V (phase-to-phase). This voltage is subject to a variation of (+) 20% and (-) 40%. The contactors shall work satisfactorily within this voltage range. The pickup voltage of coil shall be 60% and drop out voltage shall not be more than 50% of rated voltage.

D. The mechanical endurance of the contactors shall not be less than 3 million operating cycles at no load. The electrical endurance at normal utilization duty for capacitor shall not be less than 200,000 operations.

E. The contactors shall be subjected to routine and type tests as described in BS EN 60947.

65.5 THYRISTOR SWITCHED CONTACTOR

A. The thyristor switched contactor shall fully comply with and tested to the requirements of the relevant British Standard and shall be rated for 2200 PIV. They shall be fully suitable

for the extreme temperature and weather conditions prevailing in Dubai and guaranteed for fully satisfactory operation and running under such temperature and weather conditions.

B. The thyristor switched contactor shall be capable of handling the continuous current of 130% of the rated capacitor current at rated voltage of 415V. The blocking voltage of the thyristor switch during off condition shall be minimum 2200 Volt peak. Every thyristor switch shall be capable of handling the dv/dt of 2000 Volts/3S. This is to avoid spurious turn off while powering up as well as due to supply transients.

C. The thyristor switched contactor used shall turn on at zero differential voltage across it. These zero differential voltage tolerances shall not exceed 6 Volts peak value around zero.

D. The time delay between turn off and subsequent turn on shall be as minimum as possible and in the range of milliseconds. There shall not be any discharge devices across capacitor that can exceed the watt loss of more than 30 watt. The capacitors shall not be discharged to zero level before they are put back in the circuit. The differential zero voltage sensing shall even be able to capture the zero-voltage instance even when voltage across the capacitors is equal to the peak of the mains voltage waveform. (This is to avoid wastage of energy stored in capacitor while fast switching conditions.

E. The thyristor switched contactor shall be provided with adequate protections against any external transients that creates current and/or voltage spikes. Adequate arrangement like forced commutation and/or tuning reactors shall be provided with every thyristor switched unit block to prevent the thyristor from exceeding its i2t rating.

65.6 ACTIVE HARMONIC FILTERS FOR HARMONIC CURRENT FILTRATION

A. The Contractor shall make due allowance to engage the switchboard manufacturer to submit a harmonic distortion audit report to the Engineer to enable recommendation and implementation for any additional harmonic protection and filtering equipment that may be required.

B. The harmonic distortion audit should take the form of a written report with results obtained under real applied load conditions 3 months after building occupation. The report must conclude with a statement from the switchboard manufacturer recommending any harmonic protection and filtering systems that are required to attenuate the values of the harmonic distortion to within acceptable limits.

C. The Active Harmonic Filters shall work on the principle of measurement of harmonic currents and generate actively a harmonic spectrum in opposite phrase to the measured distorting harmonic current thereby cancelling the original harmonics.

D. The rating of the Active Harmonic Filters shall be selected such that the Total Harmonic Voltage Distortion (THD V) and Total Demand Distortion (TDD) limits at the point of common coupling is below the limits as specified in the relevant British Standard.

E. The Active Harmonic Filters shall be of parallel configuration.

F. The Active Harmonic Filters shall monitor all three phases of the low voltage line current in real time by means of a Digital Signal Processor (DSP).

G. The output of the DSP unit in combination with a micro-controller-based system shall generate a pulse width modulated (PWM) signal to control power modules based on IGBT (Insulated Gate Bipolar Transistor) technology which act as a current source.

H. The PWM signal shall be of fixed switching frequency.

I. The system shall be operated under closed loop control and shall have a maximum response time of not more than 40 milliseconds. The control system shall be such that the Active Filter cannot be overloaded.

J. Simultaneous filtering shall be provided for all harmonics up to the 50th one.

K. The filtering efficiency shall be typically of better than 97%.

L. The operating power factor of the Active Harmonic Filters shall be programmable over the range 0.7 capacitive. Both fixed and dynamic reactive power compensation shall be available for selection by the programmer.

M. The Active Harmonic Filters shall be protected against over current, short-circuit, thermal overload and IGBT bridge abnormal operation.

N. The design of the Active Harmonic Filters shall be such that the current rating of the filter system can be increased by the addition of extra power modules.

O. Optional graphic monitoring of the wave shape shall be provided.

P. Optional on-line harmonic analysis shall be provided.

Q. After the installation of the Active Harmonic Filters, harmonic measurements shall be carried out by the Contractor.

65.7 AUTOMATIC POWER FACTOR CONTROLLERS

A. The automatic power factor controller shall be microprocessor-based VAR Sensing type and shall comply with BS EN 61326. The controller shall be able to sense the reactive current requirement and switch on / off to the required stage of the capacitor bank.

B. The automatic power factor controller shall maintain a targeted power factor within 0.95 lagging and unity.

C. The controller shall be programmed to have different switching sequences in accordance with the latest DEWA requirements.

D. The controller shall sense current from a single phase and voltage from two phases to compute the average 3-phase power factor and accordingly compensate by switching in necessary capacitor stages.

E. The controller shall be suitable for 1A or 5 A current input. The voltage on the capacitor terminals may be particularly high at times of light load conditions. In such cases, some or all of the capacitors shall be switched out of circuit in order to prevent overstressing of the capacitors and undue voltage increase in the distribution system.

F. The controller shall be easily programmable from front panel itself.

G. The controller shall be able to recognize the connection of CT and Voltage and be able to automatically adjust itself to the phase angle difference.

H. The voltage input to the controller shall be through a VT and protected by a fuse.

I. There shall be a time delay of 120 seconds for Switching on a capacitor bank into circuit, from its last disconnection from the circuit.

J. The controller shall have LED / LCD Display. Parameter in display shall be cyclic with suitable time delay. The display unit shall be easily visible, preferably without opening the APFC Cabinet door/cover. The APF controller shall display the following parameters.

K. The Automatic Power Factor Controllers shall allow the following settings and readings.

1. Discharge time,
2. Disconnection pauses of relay stages,
3. Power station service,
4. Voltage transformer ratio,
5. Harmonic table,
6. Switching frequency of the stages,
7. Averaging time for reactive power,
8. Averaging time of the mean value cos (phi),
9. Fan control,
10. Over temperature disconnection,
11. Indication in manual mode,
12. Password,
13. Contrast,
14. Reset of programming,
15. Connection configuration,
16. Software release,
17. RS485 interface.

L. The Automatic Power Factor Controllers shall initiate alarms and warnings in the following events.

1. Insufficient capacitor output

2. Over current
3. Under voltage
4. Over voltage
5. Over temperature
6. Total voltage harmonic distortion

66 PART 3 - EXECUTION

66.1 CAPACITOR BANK ENCLOSURE SYSTEM

A. The capacitor bank comprising of capacitor units, power factor controller, series reactors, contactors, MCCB, MCB etc. shall be housed in a suitable metallic enclosure having a front door with a provision for locking arrangement.

B. The capacitor bank enclosure shall be fabricated from sheet steel of minimum thickness 2 mm and having Aluzinc coated steel having a coating thickness of minimum 25 microns shall be used for the enclosures.

C. The degree of protection of enclosures for indoor application shall not exceed IP 21 in accordance with BS EN 61921. The compartment door(s) shall be fitted by long robust weather-proof stainless-steel hinges and suitable locking devices.

66.2 RATING PLATE

A. Rating plates shall be provided on the capacitor bank unit giving full detailed information as follows:

1. Manufacturer.

2. Serial number and manufacturing year.

3. Rated total output in kVAR.

4. Rated voltage in volts (V).

5. Rated frequency in hertz (Hz).

66.3 INTERNAL WIRING

A. All wiring shall have a cross sectional area of not less than 2.5mm2 and shall be 600/1000V, insulated with Type 5 PVC Table I of BS 6746, stranded copper conductors. All small wiring shall be suitably terminated and fitted with identification ferrules and marked with circuit numbers.

B. The trip circuits shall have an additional ferrule coloured red and marked trip.

C. All terminal blocks shall be from an approved design and all exposed terminals shall be enclosed by detachable covers. The trip circuit cables shall be coloured black and the instrument transformer cables (C.Ts) coloured with their respective phase colours. Alternatively, all small wiring can be uniform colour (e.g., grey) but instrument transformer cables shall have additional coloured ferrules at both ends of each conductor run (in accordance with their phase colours). The wiring of the auxiliary circuits shall be segregated from the main circuit by heat resistant tubes made of insulating material covered by earthed metallic partitions. Terminal blocks, small wiring terminations, ferrules and wire numbering and colouring shall be subject to the approval of the Purchaser.

66.4 CAPACITOR BANK INSTALLATION

A. The installation of the capacitor bank shall be generally in accordance with manufacturer's recommendations. Clearance shall be provided around the capacitor bank as per the manufacturer's recommendations.

66.5 TESTS

A. GENERAL

The complete capacitor bank assembly shall be subject to routine tests including functional test of the control, protection and interlocking schemes. The routine tests shall be carried out at its place of manufacture.

66.6 SITE TESTS

A. The Contractor is responsible for submitting all contract works to site inspection by the Engineer, before site tests are commenced. Before commissioning, the Contractor shall depute an experienced and qualified testing Engineer from the manufacturer's works to carry out the following tests on the equipment and such other tests that may be considered necessary by the Purchaser.

B. The Site Acceptance Test (SAT) format for the capacitor bank shall be forwarded to the purchaser prior to the SAT.

C. The Contractor's test engineer shall complete all pre-commissioning tests, commission all plant and equipment supplied by him and hand over the entire contract works to the Purchaser in good shape.

D. The Contractor's testing engineer shall carry out all commissioning tests in co-operation with and to the satisfaction of the Purchaser's engineer who shall take part in all these tests.

E. The Contractor shall provide all test equipment required for different test purposes at site. The following test / inspections at site shall be carried out:

1. Mechanical Tests:

   a. Visual inspection to verify degree of protection creepage and clearance distances.

   b. All conductors and cables are checked for proper routing and all devices for proper mounting.

   c. Check effectiveness of all mechanical devices, e.g. handles, locks, interlocks, operating devices, etc.

   d. Check panel conformity to drawing and Engineer's requirements.

   e. Checking of all mounting plates/fasteners.

   f. Checking of dimensions and components as per drawings.

   g. Electrical circuits fasteners tightness/ surface area contacts.

   h. Crimping and ferrules as per drawing.

i. Labels / Identification/ Nameplate.

j. All doors checking, safety and accessibility.

k. APFC cabinet surface finish / smoothness.

2. Electrical Tests:

a. Insulation resistance test shall be carried out at all main circuits through to final terminals. Insulation resistance shall exceed 10 mega ohms. Record all measurements.

b. Power Frequency test all main circuit at 2.5 kV for one minute. Record leakage current.

c. Repeat Insulation resistance test to verify insulation resistance has not been affected by the dielectric test.

d. Function test of all circuit breakers switches, contacts, etc. and every circuit to verify correct operation.

e. Primary and secondary injection tests of all relays, CT's and indicating and metering instruments.

f. Insulation's resistance tests between phases and earth and between neutral and earth.

g. Operational test on components.

h. Switching ON / Off of capacitor bank on various KVAR requirement.

i. Checking of Display parameters.

j. Switching on / Off logic verification.

k. Data communication through Serial / optical port

l. HHU(MRI) & dumping of data in computer.

m. Verification of data/reports/functions in base computer software.

F. Prior to energizing the capacitor bank the following checks shall be carried out at site:

1. Operate the equipment through all design functions, including remote operation, actuation of alarm and indicating devices, mechanical and electrical tripping and closing and operation of the protective devices.

2. Insulation resistance measurements on the buses, phase to phase and phase to ground, with all breakers in the fully connected position and contacts open.

3. Control circuit insulation resistance to ground.

4. Inspect all relays and protective devices, and verify settings in accordance with the manufacturer's instructions.

5. Inspect current transformers and relays for correct polarity of connections and the installation of jumpers on unused current transformer circuits.

6. Simulate the operations and check the logic of interlocks.

7. Manually close and trip each breaker checking and adjusting the main contact alignment and wiring action in accordance with the manufacturer's instructions.

8. Check the phasing on each side tie breaker, before closing.

9. Test protective relay operation for incomer air circuit breakers.

XXIV. TRANSFER SWITCHES

67 PART 1 - GENERAL

67.1 1.1 CODES AND STANDARDS

Materials, equipment and associated works shall be carried out in strict accordance with the following latest standards and regulations as applicable:

International Codes:

BS EN 61439	Low-voltage switchgear and control gear assemblies
BS EN 60529	Specification for degrees of protection provided by enclosures (IP code)
BS 7671	Requirements for electrical installations IEE Wiring Regulations
BS EN 60947	Low-voltage switchgear and control gear
NFPA 70	National Electrical Code
NFPA 110	Emergency and Standby Power Systems
UL 1008	Standard for Transfer Switch Equipment
NEMA	Standard ICS10-1993- AC Automatic Transfer Switches
IEC 60947-6-1	Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment

68 PART 2 - PRODUCTS

68.1 AUTOMATIC TRANSFER SWITCH (ATS)

A. General

1. The Contractor shall supply, install and commission automatic transfer & bypass-isolation switch (ATS/BPS) system(s) with number of poles, amperage, voltage, withstand and close-on ratings as shown on the drawings and as herein specified. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All automatic transfer & bypass-isolation switches and controllers shall be the products of the same manufacturer.

2. Approval shall be obtained from the Engineer for the constructional details, power and control schematic diagram and installation details prior to manufacturing.

3. The Automatic Transfer Switch (ATS) shall be provided to transfer the electric load from the normal source of electric power to the standby source of electric power automatically in case of failure of normal source of electric power. The transfer switch shall automatically transfer the electrical load circuits upon an interruption or a decrease in the voltage of the normal source of power. The ATS shall also retransfer the load back to normal source on normal power restoration.

B. Automatic Transfer Switch Assembly

1. The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, single-solenoid mechanism. The switch shall be mechanically interlocked to ensure only two possible positions, normal or emergency is initiated at any one time, as per the drawings.

2. A two-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from all source and load power conductors. All main contacts shall be manually driven.

3. Separate bypass and isolation handles shall be utilized to provide clear distinction between the functions. Handles shall be permanently affixed and operable without opening the enclosure door.

4. A sustained voltage decrease at the transfer switch, in one or more phases of the normal power source to less than 80% (+ / - 20% adjustable) of normal sensed by a microprocessor controller shall operate the ATS from normal source under a delayed transition, and shall provide the signal to start the generator set after a time delay of 0.1 seconds to 30 seconds (Site adjustable). once the generator is started and power is available, the microprocessor controller ensure that the standby power source transfer occurs at, at least 90% of the rated value. The time for transfer of the load to the standby source is to be field adjustable from 0.1 to 30 seconds.

5. The Automatic Transfer switch shall re-transfer to the normal source upon restoration of the normal supply in all phases to 80% or more of normal voltage after a time delay site adjustable from 1 to 30 seconds. Further operation of the ATS to the normal source is delayed by a site adjustable delay timer, site adjustable timer from 0.1 to 30 seconds.

6. Voltage and frequency on both the normal and emergency sources shall be continuously monitored, with pickup, dropout and trip setting capabilities. Voltage and frequency settings shall be field adjustable either locally or remotely via serial communications port access.

7. A three position momentary-type key test switch shall be provided for the test / automatic / manual modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.

8. When the selector switch selected to Test on No Load position, it shall simulate the normal power source failure without disturbing / disconnecting the supply to the external loads, and shall start the generator. The generator shall be switched off automatically when the selector switch is switched to off position.

9. When the selector switch selected to Test on Load position, it shall simulate the normal power source failure and shall transfer the external loads from the normal power source to the generator power source. The transfer shall be automatic and shall be as explained above under auto mode of operation, provided the auto / manual selector is selected to auto position. When selected to off position, the load shall be restored back to the normal power and the generator shall be switched off automatically.

10. Whilst the test is being carried out and the normal supply fails, the transfer switch shall function normally irrespective of the position of the test switch.

11. LED type Indicating lamps shall be provided for indicating the status of following:

    a. Normal power available.

    b. Emergency power available.

    c. Normal & Standby Source Circuit breaker close / open status.

    d. Phase indications on generator incoming & mains incoming supply

    e. Phase indications for outgoing supply (where applicable).

12. Ammeters, Voltmeters and other meters as required shall be provided as shown in the drawings. If ATS is not provided as part of LV Panel / MDB, Voltmeters shall be provided for indicating the mains incoming voltage and generator incoming voltage.

68.2 MANUAL TRANSFER SWITCH (MTS)

A. General

1. The Contractor shall supply, install and commission the Manual Transfer Switch (MTS) as shown on the drawings and as herein specified.

2. The manual transfer switch is provided to transfer the electric load from the normal source of electric power to a standby source of electric power manually in case of failure of normal source of electric power. Manual transfer switch shall be used only up to a rating of 200 Amps.

3. For ratings above 200Amps an ATS shall be used unless otherwise indicated on the drawings.

4. Approval shall be obtained from the Engineer for the constructional details, power and control schematic diagrams and installation details prior to manufacturing.

B. MANUAL TRANSFER SWITCH ASSEMBLY

1. The MTS shall be factory-built type in compliance with the BS EN 61439 o construction of type tested assemblies (TTA). They shall also comply with BS EN 60529 as regards the degree of protection of the enclosures.

2. The protection index shall be IP54 as defined in accordance with the BS EN 60529 standard.

3. The rated operational voltage of the MTS shall be up to 690V AC.

4. The rated insulation voltage of the MTS shall be up to 1000V AC / 750V DC.

5. The MTS shall comprise of suitably sized wall mounting metallic enclosure equipped with 1No. of 4 pole 3position disconnect before make change over switch unit for Normal power - Off - Standby power change over. Both the line side of the switch shall be protected by suitably rated triple pole MCCB with separate neutral busbars for normal power cable and standby power cable).

6. The MTS shall be wall mounting, front access type, monobloc sheet steel enclosure with lockable hinged front door and bottom gland plate. The thickness of the sheet steel enclosure shall be minimum 1.5mm. The enclosure shall be suitably sized to accommodate all the MCCBs, changeover switch, busbars, relays, indication, cables etc.

7. The enclosure shall be protected by a thermo polymerised polyester epoxy powder coating to an approved colour after pre-treatment of the sheet metal.

8. The MCCBs,, changeover switch, relays, bus bars etc. shall be mounted on a suitable mounting plate fixed securely inside the enclosure.

9. The MCCBs and changeover switch shall be located in systematic manner and shall be interconnected by suitably rated busbars. Interconnection between the MCCB and the changeover switch shall be rigid busbar only; interconnection by cables is subject to local electricity authority and Engineer approval.

10. The busbar system shall consist of one or more tinned copper conductors fastened to the structure by means of appropriate insulating supports.

11. The busbar system shall be completely shrouded with special polycarbonate sheets or with metallic shrouds as applicable.

12. All busbars used within the panel shall be of high grade electrolytic tinned copper of 99.9% conductivity. The busbars shall be colour sleeved throughout the length for phase identification.

13. The size of the neutral busbar shall be the same as the phase busbar. The neutral busbars shall be colour sleeved throughout the length for phase identification.

14. The size of the earth busbar shall be half the size of the phase busbar. The earth busbar shall be identified with green / yellow-green tape at intermediate intervals.

15. The busbars shall be suitably extended and provided with bolts and nuts for ease of cable termination.

16. Voltmeters shall be provided for indicating the normal power incoming voltage and standby power incoming voltage.

17. LED type Indicating lamps shall be provided for indicating the status of following:

    a. Phase indications on normal power incoming supply

    b. Phase indications on standby power incoming supply

    c. Phase indications for outgoing supply (where applicable).

18. Each MTS shall be provided with a sounder and sounder reset push button to indicate that is normal power restored after a power failure.

19. Provision for remote indication of availability / loss of normal power shall be provided.

20. The changeover switch shall be 4-pole suitable for on-Load Transfer of power from either source and shall be of break before connect type with extended operating handle (external to the enclosure). The changeover switch shall be of AC23 duty and as per the ratings indicated on the drawings. The changeover switch shall be provided with a door interlocked operating handle and engraved label (Normal power - Off - Standby power) at front of the panel for ease of operation.

21. The changeover switch shall be mounted on the mounting plate inside the enclosure and external operating handle shall be provided external to the door. Mounting of the switch directly on the door will not be permitted.

22. Wherever required, the MCCBs shall also be provided with a door handle, however they shall not be interlocked to the door.

23. Warning labels shall be provided as required. All warning labels shall be of anodised aluminium or special PVC material, front engraved type with white / black text on red / yellow back ground.

24. Labelling of the panels, circuit / feeder description, components etc. shall be done in an approved and systematic manner. All such labels shall be either of anodised aluminium or special PVC material, front engraved with black text on white background.

APPENDIX – STORAGE BATTERY DATASHEET

	DATASHEET NO:	**MAT-EP-100**
	MATERIAL TYPE	**ENERGY STORAGE BATTERY**
SN	**PERFORMANCE SPECIFICATIONS**	
1	AC Voltage (Nominal)	230/240V
2	Frequency	60 HZ / 50 HZ
3	Total Energy	14 kWh
4	Useable Energy	13.5 kWh
5	Real Power, max continuous	5kW (charge and discharge)
6	Real Power, peak (10 s, off-grid/backup)	7kW (charge and discharge)
7	Apparent Power, max continuous	5.8kVA (charge and discharge)
8	Apparent Power, peak (10s, off-	7.2kVA (charge and discharge)
9	Maximum Continuous Current	24 A
10	Maximum Output Fault Current	32 A
11	Load Start Capability	88 LRA
12	Warranty	10 Years or 10,000 cycle system warranty – includes inverter, battery modules, cabinet and components
13	Battery Type	Lithium-Ion
13	Cell Discharge	90% DoD
14	Inverter Efficiency	97.30%
15	Round Trip Efficiency	90%
	COMPLIANCE CERTIFICATION	
16	Certifications	System certified – UL9540; Battery modules – UL1973, UL9540A; Inverter – UL1741, UL1741/SA
17	Grid Connections	IEEE 1547, IEEE 2030.5, Rule 21
18	Emissions	FCC Part 15 Class B (inverter)
19	Transient Protection	IEEE C62.41 Class B
	ENVIRONMENTAL SPECIFICATION	
20	Operating Temperature	-20 deg C to 50 deg C
22	Operating Humidity	Up to 100% condensing
23	Environment	Indoor and Outdoor Rated
24	Ingress Rating	IP67 (Battery & Power Electronics), IP56 (Wiring Compartment)
25	Noise Level @ 1m	< 40 dBA at 30 deg C
	APPLICATIONS	
26	Peak Shaving, Time of Use, Back-Up Power	
	REQUIRED	
27	Capacity Required	1 MWh Capacity
	PREFERRED MAKES	
	Sonnen	
	Tesla	