बृहन्मुंबई महानगरपालिका
Municipal Corporation of Greater Mumbai




Mithi River Water Quality Improvement Project

Package 3: Dry Weather Flow Interception at Tidal Outfalls (including Gate Pumps), Transfer Sewer, Training of River (Retaining wall and Service Road), Beautification including Promenades and Allied Works from Prem Nagar outfall, Kurla to Mahim Causeway.

Design Build Operate Contract

Volume 2C - General Electrical Specification

Employer:
Municipal Corporation of Greater Mumbai
Municipal Head Office Building, Mahapalika Marg,
Fort, Mumbai - 400 001.

Consultant:
Frischmann Prabhu (India) Pvt. Ltd.
315, Balgovind Wadi, New Prabhadevi Road,
Prabhadevi, Mumbai - 400 025

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India

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1 INTRODUCTION

1.1 Standards and Specifications

Where available, the appropriate Indian Standard (IS) shall take precedence over International (IEC) or British standard (BS EN).

1.2 Regulations

The Contractor shall ensure that the Works comply in all respects with the relevant statutory and regulatory instruments of India.

Where the requirements detailed thereon are less stringent than the relevant British or International instrument then the latter shall rule.

The relevant Indian statutory and regulatory instruments for electrical installations are as follows:

- The Factories Acts, 1948
- Workmen's Compensation Act, 1923
- Electricity Act, 2003
- Maharashtra Fire Prevention and Life Safety Act, 2006
- Energy Conservation Building Code

Electrical installations covered by the scope of the Indian Electricity Rule 1956, and designed, installed and tested in accordance with these regulations shall generally satisfy the requirements of the above-mentioned statutory regulations.

The Contractor shall be responsible for complying with all local byelaws, supply authority and local authority requirements. It shall be the Contractor's responsibility to determine the existence of these requirements and for compliance with them.

In view of sizing an electrical installation and the required equipment, as well as determining the means required for the protection of life and property, short-circuit currents must be calculated for every point in the network in accordance with IEC 60909, which is intended for radial and meshed low-voltage (LV) and high-voltage networks.

1.3 Abbreviations

Wherever the following abbreviations are used they shall have the meanings below:

A	Ampere
A.C./ a.c.	Alternating Current
ACB	Air Circuit Breaker
APFC	Automatic Power Factor Correction
ASTM	American Society for Testing and Material
BS	British Standard
CPU	Central Processing Unit
CRCA	Cold Rolled Closed Annealed
D.C. / d. c.	Direct Current
DOL	Direct On Line

ECBC	Energy Conservation Building Code
ELCB	Earth Leakage Circuit Breaker
EMC	Electro Magnetic Compatibility
EPABX	Electronic Private Automatic Branch Exchange
FAT	Factory Acceptance Test
FSD	Full Scale Deflection
GSM	Global System for Mobile Communication
GUI	Graphical User Interface
HMI	Human Machine Interface
HRC	High Rupturing Capacity
HV	High Voltage
ICA	Instrumentation Control and Automation
IEC	International Electro technical Commission
IEEE	Institute of Electrical and Electronic Engineers
I/O	Input /Output
IP	Ingress Protection
IS	Indian Standard
kA	kilo Ampere
kVA	Kilo Volt Ampere
kVAr	Kilo Volt Ampere reactive
kW	Kilo Watt
kWH	Kilo Watt Hour
LCD	Liquid Crystal Display
LDB	Lighting Distribution Board
LED	Light Emitting Diode
LPU	Lightning Protection Unit
LV	Low Voltage
mA	milli Ampere
MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MCCB	Moulded Case Circuit Breaker
MPCB	Motor Protection Circuit Breaker
NC	Normally Close
NO	Normally Open
PCC	Power Control Centre
P&ID	Process and Instrumentation Diagram
PLC	Programmable Logic Controller

PSTN	Public Switched Telephone Network
PT	Potential Transformer
RCBO	Residual Current Breaker with Overload Protection
RCD	Residual Current Device
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SF6	Sulphur Hexafluoride
SPD	Surge Protection Device
TCP/IP	Transmission Control Protocol/Internet Protocol
UPS	Uninterrupted Power Supply
VCB	Vacuum Circuit Breaker
VFD	Variable Frequency Drive

1.4 Design Development

Key engineering decisions shall be documented and the calculations and justifications on which they are founded shall be recorded and presented to the Employer's Representative for approval prior to detailed design.

1.5 Documentation and Calculations

All necessary documentation, drawings and schedules required to describe the design shall be developed and maintained during the course of the Works and be available for inspection by the Employer's Representative as requested.

Prior to key phases of design: detailed design and construction - these design documents shall be presented to the Employer's Representative as a base-line descriptions of the Works for review and approval.

From the following documents, schedules and drawings, the Contractor shall agree with the Client, those required to describe the Works at each base-line. The full breadth, depth and scope of that documentation as well as the programme for their delivery shall be agreed with the Employer's Representative prior to commencement of the Works:

a) Documents

- Specifications
- Control philosophies
- Works phasing plans
- Electrical changeover / construction schemes and plans
- Functional description specifications

b) Drawings

- Single line diagrams (power and ICA)
- Site, building and room equipment layouts
- Cable routing layouts
- Earthing and lightning protection system arrangements
- Control system architectures
- Electrical panel arrangements
- Panel wiring schematics

- Lighting arrangements
- Hazardous area zoning layouts
- PLC loop diagrams
- P & ID
- Starters wiring diagram

c) Schedules

- Protective conductor calculation schedule
- Cable schedule
- Lighting calculations
- Lightning protection calculations
- Instrument schedule
- PLC I/O schedule
- Drive schedule
- Load schedule
- Distribution board schedule

1.6 Testing

Appropriate testing shall be performed and witnessed by the Employer's Representative for key plant, equipment and systems prior to handover of the completed installation to the Client.

The programme of testing and witnessing shall be agreed and developed with the Employer's Representative following the tender submission base-line and as orders are placed for individual components.

These tests shall include:

1. Factory test.
2. Client and consultants witnessed factory tests.
3. Site acceptance testing.
4. All the succeeding tests shall be completed prior to energisation of the system:

    - Earth continuity
    - Insulation resistance
    - Earth fault loop impedance
    - Polarity
    - Functional testing

2 ELECTRICAL WORKS DESIGN

2.1 General

2.1.1 Scope

This section describes the electrical plant and services to be provided by the Contractor and specifies the particular requirements for the Works not covered elsewhere in the Contract.

The electrical plant and services to be provided shall comprise all the necessary Works for the completion of all main and ancillary installations and shall include but not be limited to:

- The power supply to the Site to cater for the Works installation, testing, commissioning, operation and maintenance
- The power distribution equipment, including power transformer, distribution boards, electrical protection, metering, earthing, cabling and cable support systems for the Works
- The electric motors and actuators to operate the mechanical equipment being installed.
- The electrical starting equipment, isolating equipment, electrical protection, controls and interlocks for each Plant item.
- The indoor, outdoor and emergency lighting including all poles, brackets, fixings etc.
- The Site electrical services including sockets, space heating, ventilation etc.
- The uninterruptible power systems
- The fire detection and alarm systems
- The gas detection and alarm systems
- The telecommunications systems (EPABX and PA systems)
- The security systems including CCTV system
- The lightning protection
- The construction phase electrical services
- The materials and accessories to provide a complete electrical installation
- The field instrumentation, PLC systems
- The equipment and control systems to interface with the power supply utility's incoming supply and the power generated through bio-gas generation

External power supply source at LV shall be made available by the Employer/ Electric Supply Company at POS near the plant boundary. The necessary liaison for obtaining approvals including Load Sanction / Load Release from Electric Supply Company, NOC from statutory authorities like CEIG / Electrical Inspector, Factory Inspector & relevant authorities as applicable is included in the Contractor's scope. However, the necessary fees (if any) deposited in respect of above work shall be reimbursed by the Employer on actual basis / receipt of payment produced by Contractor.

The Contractor shall be responsible for liaison for HT / LT supply connection required for the plant.

2.1.2 Emergency Stop Equipment and Local Isolation

Local Control Stations

The Contractor shall provide each item of electrically powered rotating machinery with local start and emergency stop pushbuttons. Where the drives have the capability to run

in forward and reverse, separate “Start Forward” and “Start Reverse” buttons shall be provided. The pushbuttons shall be housed in the same enclosure, clearly labelled, adjacent to the relevant access point or machinery.

Where applicable e.g. screen drive motors, the local control enclosure shall include pushbuttons for “inch forward” and “inch reverse” control.

“Emergency Stop” buttons shall be of the “Stay Put” type, twist or pull to release, in accordance with IEC 60947.

Material of construction for enclosure of Local Control stations shall be SS316.

Local Isolation

The Contractor shall provide each item of electrically operated machinery with a local isolator. Isolators shall be mounted in accessible locations adjacent to the motor or for submersible pumps, adjacent to the entrance to the sump.

Local isolators shall have auxiliary contacts to trip and lock out the contactor when the isolator is open.

Local isolators shall be provided in all cases for valve or penstock actuators.

All local isolators shall be suitable for padlocking in both the “on” and “off” positions and shall not be provided for use as an emergency stop facility.

Material of construction for enclosure of Local Isolators shall be SS316.

2.1.3 Emergency Power Supply

The facility shall be capable of safe shut down of non-essential services and of safe start up upon restoration of normal power. The Contractor shall develop a procedure and demonstrate how this would be carried out in safe manner.

2.1.4 Electrical Power Supply Design

The Contractor shall be responsible for the supply of power to the site from an appropriate power supply utility. At the earliest opportunity, the Contractor shall discuss with the utility, the provision of permanent power supply to the Site so that supplies are in place prior to commissioning of the Works. The Contractor shall consult with the supply authority in advance of each connection, shall make the necessary application for a new connection and shall meet all charges in relation to each connection.

The Contractor shall establish the maximum demand for the Site and in discussion with the power supply utility, the best method for provision of secure supply. In addition he shall provide a supply which is capable of running a facility with a demand 15% greater than that required for the design horizon.

The Contractor shall include for all necessary capital, running and maintenance costs associated with the provision of the power supply and fully liaise with the power supply utility with respect to sub-station provisions, switching, cable routes, metering requirements, maximum import capacities (MICs), tariffs, connections, protection/co-ordination, maximum demand, motor starting constraints, programming etc.

The Contractor shall establish the size and nature of the power supply requirements for the testing, commissioning and operation of the facility. The Contractor shall provide a detailed schedule of all electrical loads together with the rated current, power factor, efficiency and diversity factor of each load sector.

From the above load schedule, the Contractor shall establish the Works loading in kilowatt hours consumption per annum and the peak demand of the facility. Using the proposed electrical load, the Contractor shall submit detailed applications to the power

supply utility for the supply of these loads, noting the requirements of Section 5.11 of Volume 2.

The Contractor shall establish the nature of the power supply and shall ensure it is reliable and adequate for the operation of the plant without constraints.

The Contractor shall ensure that the necessary cable ducts are provided for the power supply utility and that power supply cables are properly designed and installed up to the location of the Contractor's main switchgear.

- Incoming Supply Conditions - Voltage and variations: 415V ± 10%
- Frequency and variations - 50Hz ± 3% combined variation : ± 10%
- Fault level at LV - 50kA (Max.) for 1 sec (this shall be confirmed with electric supply Co.)
- System ground - effective

2.1.5 Power System Studies and Selective Coordination

The Contractor shall prepare and submit a schedule of the electrical loads for the Works. This schedule shall show the total connected load in each category, together with the calculated diversity factor, the probable load and the maximum demand likely to be experienced.

This information shall be submitted to the Employer's Representative for review. The Contractor shall design the electrical power system to suit the ratings and duty cycles of the Plant items and auxiliary systems which are to be installed.

The power distribution shall be designed to suit the voltages at which power is supplied by the electricity supplier.

The Contractor shall select the necessary voltage and current transformers together with suitable protection relays to protect the electrical distribution system. This protection shall include thermal overload, short circuit, ground fault and single phasing as a minimum.

The electrical protection shall be graded so that indiscriminate tripping is prevented under fault or surge conditions.

The Contractor shall co-ordinate the electrical protection at the Site with the power supply utility system protection and shall submit a tabulation to demonstrate the protection settings to be employed and the appropriate discrimination curves for the power system to the Employer's Representative during the design.

2.1.6 Power Factor Correction

The Contractor shall design the power system to operate at a minimum power factor of 0.996 lagging at the point of supply of the power supply utility.

Automatic power factor correction systems shall be provided at all MCCs that feed the blowers. In addition an APFC system shall be installed at the PCC to meet the desired power factor.

Care shall be taken to ensure that harmonic distortions are limited and the Contractor shall consult the power supply utility concerning the impedance of their supply network at the frequencies most liable to cause resonance.

2.1.7 Switchgear

High Voltage (HV) switchgear (Not Used)

LV Switchgear and Power Control Centre and Motor Control Centre

LV switchgear power control centre and motor control centre assembly shall be of the totally enclosed metal clad pattern. PCC and MCC shall be of conventional type. All single/double front PCC and MCC shall be Totally Type Tested (TTA) according to IS 8623, IEC 439 and also internal arc tested (IAC) as per IEC 61641. Seismic withstand capacity of the MCC and PCC panels shall be at least for Seismic Zone 3. Type of internal separation for PCC/MCC panel shall be as per Form 3B. Lighting board or small distribution board separation shall be either as per Form 1 or Form 2.

Each incoming feeder of MCC shall be equipped with a Multifunctional Energy Meter incorporating the functions of a voltmeter, an ammeter, a kilowatt hour meter, a power factor meter and a frequency meter. The parameters monitored by the energy meter shall be available for monitoring and recording on the SCADA system.

The Contractor shall select the starter appropriate to each drive motor and shall ensure that starting sequences are programmed to minimise disruption of the power supply and maximise Works availability.

When designing the low voltage distribution assemblies, the Contractor shall ensure that they are dimensionally suitable for delivery and installation on Site.

The Contractor shall ensure that provision is included in the low voltage switchgear to interface with the necessary on-site generators and this provision shall include all the necessary control gear, protection and interlocking between generator and supply authority to enable the 'on-site' generators to synchronise.

The necessary volt free contacts and analogue signals shall be provided by the Contractor on each panel.

2.2 Measurement of Electricity Usage

The Contractor shall be responsible for the provision of electricity meters to permit assessment of compliance with the Energy Generation requirements and to assess whether Performance Damages are due.

As a minimum, electricity meters shall be installed to measure the electricity provided by the electricity utility service provider for the Works (this meter can be the service meter used by the electricity utility service provider for billing purposes provided access can be gained to the meter to take daily readings) and the energy generated by the Energy Generation System.

Each of the above meters shall be read by the Contractor every day at the same approximate time. The Contractor shall record and maintain these readings for the purposes of calculating whether the performance requirements relating to energy generation have been met and if applicable, calculating the Performance Damages.

2.3 Cabling and Earthing

2.3.1 General Cabling

This section covers the supply and installation of the necessary cabling and earthing systems not covered elsewhere in the Employer's Requirements.

HV cables forming part of a dual supply to the facility shall be from underground duct and separated both outside and within the Site by at least 2.5 m to reduce the possibility of

physical damage causing a complete power failure to the Works.

For the consideration of the Employer's Representative, the Contractor shall provide detailed schematic and block diagrams, together with schedules of all cables he proposes to install for power, control and instrumentation systems. The schedules shall include the following information:

a) Type of cable.
b) Size of conductors (including circuit protective conductor).
c) Number of cores.
d) Voltage grade.
e) Cable gland.
f) Cable identification reference number.
g) Cable source.
h) Cable destination.
i) Cable length.
j) Installation method.
k) Terminal references.

2.3.2 Types of Cables

Cables shall have a "Fire Retardant and Low Smoke" (FRLS) outer sheath as per IS 10810, and ASTM D 2863 to restrict release of toxic fumes from the cable in the event of a fire. XLPE cable shall be as per IS 7098 whereas PVC cables shall be as per IS 1554.

The following types of cables shall be provided:

a) HV power circuits
   AL/XLPE/PVC/F/FRLS, 3.3 kV – 22 kV (E) grade.
b) LV power circuits
   For conductor sizes above 2.5 mm^2 AL/XLPE/PVC/W/FRLS, 650/1100V grade.
   For conductor sizes 2.5 mm^2 or less, CU/XLPE/PVC/FRLS, 650/1100V grade, unarmoured.
c) Auxiliary control and protection circuits
   CU/XLPE/PVC/FRLS, 650/1100V grade, unarmoured, stranded.
d) Control and instrument circuits
   All control monitoring and instrumentation shall have individually twisted and screened pairs, a collective screen, CU/PVC/FRLS, 650/1100Vgrade, unarmoured, stranded.
e) Data highway
   Optical fibre cables shall be used throughout the data highway interconnecting each PLC with the SCADA system master-stations.
f) Telecommunications cables
   Cables for telephone and data outlets shall be Category 6A Unshielded Twisted Pair (UTP) type with FRLS sheath.

2.3.3 Cable Sizes

The short time fault current ratings of all power cables shall match the maximum fault ratings of the associated switchgear plant and protection systems.

The Contractor shall determine by site investigation the values of:

- Soil temperatures
- Soil thermal resistivity

With the exception of special cables for analogue signal and measuring circuits, the minimum core size for auxiliary power and control cables shall be 1.5 mm^2.

All multicore cables provided for the Works protection, control and monitoring systems shall incorporate 20% spare cores. All spare cores shall be terminated and identified.

2.3.4 Cabling within Buildings

Cable installations within buildings shall be run in ducts or trenches or run in cable containment installed on or suspended from structural walls or ceilings. Cables in general building areas shall be installed on heavy duty aluminium tray.

In all locations of the Works affected by chemicals creating a chemically corrosive condition, cable tray systems shall be of stainless steel, of approved type and manufacture.

For fixing cable trays in trenches, cable galleries etc., galvanised steel channel inserts shall be embedded into the concrete, spaced at centres not exceeding 1,500 mm. Civil structures utilised to support cable tray systems shall be designed to withstand the additional loading.

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

2.3.5 External Cabling

External cables shall be contained within underground cable ducts unless specifically agreed with the Employer's Representative in advance.

2.3.6 Earthing

The Contractor shall provide and install a complete earthing system in accordance with the requirements of IS 3043 rules.

The Contractor shall design the system to meet the following requirements:

a) Under normal and abnormal operating conditions, there shall be no danger to persons in any place to which they have access.
b) The maximum current from any point of fault shall be conducted back to the electricity system neutral without giving rise to dangerous potential gradients either in the ground or between pieces of apparatus and a person who could be in simultaneous contact.
c) The passage of fault current shall not result in any thermal or mechanical damage to the system.
d) Earthing systems for Electrical, Instrumentation Control and Automation (ICA) and lightning systems shall be laid separately. The Contractor shall be responsible for interconnection of these grids.

The Contractor shall satisfy the power supply utility that the earthing arrangements on the electrical installation are compatible with their system requirements.

Earth tape and conductors installed in areas subject to chemical corrosion shall be sheathed with green/yellow FRLS insulation.

2.3.7 Lightning Protection

The Contractor shall provide and install a lightning protection system where required, in accordance with IEC 62305: Protection against Lightning. Early streamer emitter type lightning protection shall not be used.

Selection, installation and maintenance of surge protection devices for protection from indirect lightning surges and switching surges shall be as per IEC 61643.

Earthing for lightning protection system shall be as per IS 3043 or IEC 62561.

The Contractor shall provide the anaerobic digestion complex with lightning protection including the CHP exhaust stack(s) and the waste gas burner stack(s). **(NOT USED).**

2.4 Building and Site Services

2.4.1 Power Supply

This section describes the building and site services required and specifies particular requirements not covered elsewhere in the Contract.

The Contractor shall provide the power supply for all building and site services from the building services switchboards or otherwise derived from distribution boards which, as far as practicable, shall form an integral part of the main LV distribution and plant control switchboards. The contractor shall maximise use of solar power through a centralised solar power system to provide the power supply for all building and site services with a provision of auto switch over to normal electric supply in case of emergency / any problem with the solar system.

Sub-distribution boards not forming part of LV switchboards shall be complete with outgoing miniature circuit breakers for connection to the services and other equipment. Distribution board providing power for lighting shall have provision of earth leakage circuit breaker (ELCB).

At least 3 spare ways for each type and size of circuit breaker in the distribution boards shall be included.

At least 2 No. 240 V single phase 5/15A outlets shall be provided in each room and in any case shall be within 15 m of any internal part of a building.

At least 1 No. 415 V three phase socket/ power receptacle shall be provided in each Plant area for maintenance purposes.

The Contractor shall provide for cooling and ventilation to maintain a temperature of $25^{O}C$ in PLC-SCADA control rooms and offices.

2.4.2 Lighting Design

The building internal lighting design shall take into consideration:

a) Operating environment.
b) Energy efficiency.
c) Activities to be performed in the areas concerned.
d) Type and style of architectural finish.
e) Access for maintenance.
f) Operating life.
g) Sustainability.

Lighting circuits shall be supplied from the small power and lighting distribution boards incorporating manually reset miniature circuit breakers. For large areas or buildings,

separate distribution boards may be located to serve discrete areas.

Switching shall be convenient to doors and entrances, two-way switching being provided where areas have more than one entrance.

For large areas, lighting shall be contactor controlled. Where practical, Contactors shall be incorporated within the respective distribution boards.

The lamps provided shall be of minimum three star rating as designated by Bureau of Energy efficiency.

In areas housing rotating machinery, lighting shall be arranged on multi-phase circuits to prevent stroboscopic effects.

The arrangement of circuits shall be such as to provide balanced loading of the phases.

The Contractor shall prepare detailed layout and installation drawings to show the location of the distribution boards, conduit routes, lighting and other fittings etc. for consideration by the Employer's Representative, together with illumination level design calculations to support and confirm the proposals.

Except in any building where ceiling or wall finishes permit conduits to be concealed, the installation shall be carried out in surface run galvanised conduit. All lighting switches, socket outlets, etc. shall be metal-clad surface mounting type.

2.4.3 Emergency Lighting

The Contractor shall provide emergency lighting for all control rooms, buildings and exit and escape routes to facilitate the safe evacuation of personnel from all buildings and structures in the event of power failure and shall be in accordance with BSEN 50172.

The Contractor shall also provide emergency lighting in any area where work may be required during a power failure.

The emergency exit lighting luminaries shall be bulkhead fluorescent, maintained and non-maintained types, incorporating self-contained battery/charger/inverter modules with a minimum battery life of two hours.

The emergency luminaries shall be directly connected to the respective area main lighting circuits, to cover both total power and sub-circuit failures.

Emergency lighting circuits shall incorporate central test unit switches to simulate failure of the normal supply. These test switches shall be situated in a position within the area covered by the lighting system to be tested and shall be suitably identified. Switches situated in positions accessible to unauthorised persons shall be of the tamper-proof, key operated type. All such switches shall be operated by a common key and the Contractor shall supply two keys for each switch installed.

2.4.4 Street Lighting (Not Used)

2.4.5 LED Lighting System (Not Used)

2.4.6 Site Area Lighting

Site area lighting installations shall provide an overall minimum service luminance as per IS 1944 over the whole of the Site.

Area floodlighting shall be fed from service distribution boards incorporated in the respective plant or ancillary switchgear buildings. Area lighting shall be capable of manual control from each respective building and the security control room and shall be capable of being switched on by a security intruder signal.

2.4.7 Low Voltage (LV) Portable Equipment

For each building, the Contractor shall provide one set of low voltage equipment comprising the following:

240 V, 50 Hz weather proof, portable, heavy duty floodlight and plug for 240 V centre tapped earth socket outlet complying with IEC 209 and colour coded.

2.4.8 Fire Detection and Alarm (Not Used)

2.4.9 Gas Detection System (Not Used)

2.4.10 Telecommunications and Data Systems (Not Used)

2.4.11 Security System

The Contractor shall provide a suitable security system for the facility.

In addition to the general site security system, high risk plant or materials shall be protected by lockable cabinets, intruder alarms or other devices. Alarm signals shall be fed to the centralised security control room which shall be located in or adjacent to the guardhouse.

The general Site security system shall be by Internet Protocol (IP) based colour Closed Circuit Television (CCTV) systems to detect intruders and raise alarms.

Sufficient cameras shall be deployed to ensure full site coverage. Output from all cameras shall be fed to a centralised security control room located in or adjacent to the main guard house which shall include multiple screens to permit live viewing of camera output. The system shall record the output from all cameras on Network Video Recorders (NVRs) and save the recordings for a minimum of 60 days on a First In/First Out (FIFO) basis.

The cameras shall include night vision capability. Principal cameras shall have a Pan/Tilt/Zoom (PTZ) capability with the facility to be controlled from the centralised security control room.

All the CCTV products i.e. fixed cameras, PTZ cameras, NVR etc. must be UL approved or equivalent.

2.4.12 Uninterruptible Power Supply (UPS)

The Contractor shall supply and install the necessary online, double conversion uninterruptible power supply (UPS) units CCTV system etc. to ensure continuity of supply for a minimum of 120 minutes duration during mains power failure or “brown out” situations. The UPS shall be either “parallel redundant” type or “hot standby” type. The Contractor shall provide a minimum of 2 No. 100% battery charger configurations of appropriate rating with a single set 100% battery bank. The UPS shall be suitable under normal conditions to operate continuously at the specified ratings for 24 hours a day and 365 days a year. Each system shall be sized for not less than 1.25 times the maximum current demand that might occur, taking into account in-rush currents and the like and shall support 1.25 times the maximum continuous load that might occur during a period of 120 minutes. The continuous load shall include all loads that might occur and de-rating for diversity shall not be taken.

The UPS shall incorporate a static switch to bypass the UPS seamlessly and effect a connection to the mains supply in the event of a UPS failure.

The load supplied by the UPS system shall be supplied from an isolation transformer on

the UPS output. Each load circuit shall be separately protected against over-current, with sufficient discrimination so that a fault on any circuit will not trip the UPS output supply. Fault trip times shall be based on a “mains failed” situation, when the internal impedance of the UPS will be apparent. The UPS shall have overload capacity of 110% for one minute.

Start, stop and reset procedures shall be clearly displayed for an operator. The system shall have features to assist in fault finding. Clear instructions, labelling, shrouding etc., shall be provided so that a technician may undertake maintenance and first line repair as a minimum.

The degree of protection shall be IP 42 or better.

Tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following:

a) Changeover from full load with mains present to full load on battery supply.

b) Carry out a discharge test on the system at full load and for the specified duty bridging time period.

c) Carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.

The UPS shall be supplied from an auxiliary switchboard. In the event of failure of the UPS or if it is taken out for servicing, then an alternative supply of power shall be provided from an associated motor control centre.

2.4.13 Miscellaneous Materials and Accessories

The Contractor shall be responsible for the supply and installation of all miscellaneous materials and accessories necessary to provide a complete electrical installation to conform to the Employer’s Requirements.

2.4.14 EPABX and PA (Public Address) Systems (Not Used)

2.4.15 Surveillance System

The work involves supply, installation and commissioning of fixed/PTZ IP cameras for an effective surveillance system in the specified areas.

The broad guidelines for CCTV surveillance are as follows:

- Installed CCTV cameras shall provide optimum coverage of entrances, sitting areas, vandal prone areas and the complete extent / perimeter;
- CCTV cameras shall be Open Network Video Interface Forum (ONVIF) compliant which is a global open standard for the interface of IP-based physical security products, such as communication between video management systems and devices (i.e. cameras and encoders). Installed equipment shall be capable of being integrated with the long term surveillance system.

2.5 Testing and Commissioning

Equipment shall not be delivered to Site unless an inspection has been carried out or waived in writing by the Employer’s Representative. Tests shall be organised to represent the installed condition as closely as possible and shall include the following:

a) Factory Acceptance Tests (FATs)

These tests shall provide documented evidence that the system under test meets the functional and performance requirements of the Employer's Requirements and Functional Design Specification (FDS).

b) Site Acceptance Tests (SATs)

These tests shall encompass the normal modes of operation and failure events and demonstrate correct functionality of the system in accordance with the Employer's Requirements. The tests shall be fully documented.

c) Commissioning

Commissioning shall be carried out on the complete Works where every item of equipment shall be individually tested and then collectively to form an integrated system.

3 LV SWITCHGEAR CONTROL GEAR AND ASSEMBLIES

3.1 General

The clauses in this section shall only be applied to low voltage (LV) switchgear and control assemblies.

The switchgear shall be designed and manufactured in accordance with IS 13947, IEC 60947 (Part I & II) and British Standard BS EN 60439-1.

3.2 Power Control Centre (PCC) / Motor Control Centre (MCC)

The MCC shall contain, as a minimum, the following items:

1. 3 Phase, 4 wire, 50 Hz, with appropriate short circuit rating and bus bracing. The short circuit rating will be as per design calculations.
2. Main Incomer(s)
3. Surge protection device
4. Feeders including 20% spare feeders.
5. Plant equipment starters
6. Unless specified otherwise and/or subject to specific site conditions, the MCC shall generally have bottom cable entry with front access.
7. The MCC Main Incomer protective device shall be rated to ensure discrimination with all upstream and downstream protective devices.
8. The MCC shall be provided with a full-length earth bar and shall form the main earth terminal for the installation.
9. The MCC shall be fitted with thermostatically controlled anti-condensation heaters where required.
10. ICA Section shall house any specified panel-mounted instruments controllers / transmitters, relays, power packs, Uninterruptible Power Supplies, Surge Protection Devices, fieldbus hubs and junction boxes, communications interfaces, terminators, and PLCs (if specified), I/O Racks etc.
11. Incomer / feeder status monitoring shall be provided where a PLC is specified:
    - on each incomer
    - on feeders supplying power to essential loads
    - on feeders and motor starters supplying power to process critical loads
12. MCC incomers shall utilise MCCBs for ratings up to 800 A. For ratings above 800 A, ACBs shall be provided.

The MCC shall be use the most appropriate type (i.e. wall-mounted or floor standing) and form of internal separation for the intended application.

1. Utilise lower form panels unless the requirement demands otherwise.
2. Where plant and equipment operate in duty / standby or duty / assist / standby types of configurations utilise higher form panels to allow maintenance of non-duty functional units safely; without exposure to un-shielded conductors or potentially live parts.

MCC internal separation Forms are defined as follows:

1. Form 1 – No separation.
2. Form 2a – Separation of the busbars from functional units. The terminals for external conductors not separate from the busbars.
3. Form 2b – As 2a but the terminals for external conductors are separate from the busbars.
4. Form 3a – Separation of the busbars from functional units and all functional units are separated from each other. The terminals for external conductors are separated from functional units but not from each other or the busbars.
5. Form 3b – As 3a but the terminals for external conductors are separate from the busbars.
6. Form 4a – Separation of busbars from functional units and separation of all functional units from one another, including the terminals for external conductors which are integral parts of the functional unit. The terminals for external parts are in the same compartment as the associated functional unit.
7. Form 4b – As 4a but the terminals for external conductors are not in the same compartment as the associated functional unit. Terminals for external conductors are in individual, separate, enclosed protected spaces or compartments.

   Suitable surge protection devices (SPD) shall be provided for the main incoming power supply of each MCC and PCC, PLC and field/outstation power supplies.

   Lightning protection units (LPU) shall be installed for cabling exiting a building/kiosk for SCADA purposes (e.g. cable to GSM antenna, PSTN cable, private wire systems, all field instruments etc.)

Unless otherwise specified, every 415 V PCC/MCC shall be single/ double front, conventional type floor standing multi-compartment complying with form 3b or better and shall meet IS 13947 and IEC 60947.

The short circuit rating of the MCC shall be assessed following a short circuit current calculation.

A floor standing MCC shall not exceed 2400mm in height including bottom plinth and top busbar chamber.

The top level of the plinth shall be located above the maximum 1:100 year flood level. A wall-mounted MCC shall have a maximum height of 1600mm (including cableway).

MCCs shall be located within dedicated electrical control rooms and have rated ingress protection according to the follow criteria:

1. Indoor, ventilated devices shall be housed in IP31 enclosures
2. Indoor non-ventilated equipment shall be housed in IP52 enclosures.
3. In areas that are wet or subject to spray: IP54 enclosures.
4. Higher rated MCCs shall be procured where avoidance of the detrimental conditions is not possible. Filters shall be provided, and the specific IP rating maintained, should force ventilation be required.

   Except for any withdrawable circuit breaker, busbar and cabling alley, a hinged door shall be provided for each compartment of the MCC. The door shall be interlocked with any switch- fuse or MCCB/MPCB fitted in the compartment and intended as a means of isolation for the circuits inside the compartment so that the door can only be opened when the switch-fuse or MCCB/MPCB is in the ‘Off’ position.

Every motor starter and other functional unit shall be installed in a dedicated compartment.

Except for withdrawable air circuit breakers, every motor starter and other functional unit shall be of the 'fixed' or 'swing-out' type, where:

1. 'Fixed' means that, except for those components which must be mounted on the compartment door, the starter or other functional unit is fixed within the compartment
2. 'Swing out' means that, except for those components which must be mounted on the compartment door and any components fixed within the compartment, the starter or other functional unit is mounted on a hinged panel which can swing out when the compartment door is open. A swing out panel is a back panel equipment mounted hinge plate. Swing-out units will only be acceptable for starters, rated equal to or less than 7.5 kW.

Except for the compartment doors, all removable covers, the removal of which gives access to live electrical circuits shall be fixed by means of bolts.

Switches and indicating meters such as ammeters, voltmeters, etc. shall not be positioned above 1800 mm or below 300 mm. Devices for isolation and switching shall be accessible within the zone 300 mm to 1800 mm above floor level.

Every fuse in the power circuit shall be of the HRC type unless otherwise stated.

Wiring inside the MCC shall incorporate copper conductors, the minimum acceptable cross-sectional area being 2.5 mm^2 for power circuits and 1.5 mm^2 for control and monitoring circuits. The cross sectional area for current transformer shall be minimum 2.5 mm^2 flexible copper wire.

Wiring for power circuits shall be phase colour identified throughout in accordance with IS 732. Alphanumeric identification ferrules shall be fitted to each end of each wire forming part of a control and monitoring circuit. Each ferrule shall completely encircle the wire. The identification of each wire shall be unique and shall correspond to that shown on the manufacturer's schematic and wiring diagrams.

3.3 Construction

3.3.1 The PCC shall be of the type specified by the Client as follows:

1. Cubicle/multi-cubicle construction
2. Shall consist of a single cubicle or a combination of mechanically joined cubicles, of the floor standing type, where each cubicle may comprise several sections, sub-sections or compartments as is appropriate for the intended purpose
3. Box/multi-box construction

   Shall consist of a single box or a combination of mechanically joined boxes, intended to be mounted on a vertical plane (i.e. wall-mount), with or without a common supporting frame and the electrical connections passing between two adjacent boxes via openings in the adjoining faces
4. Steel assemblies shall be suitably braced to produce a rigid structure. This shall include doors and covers. The following conditions shall apply:
   - Minimum frame thickness of 2.5 mm
   - Minimum side plate thickness of 1.6 mm
   - Minimum door thickness of 2.0 mm
   - Minimum gland plate and component mounting plate thickness of 3 mm

Unless agreed otherwise, floor standing panels shall be mounted on a rigid channel plinth of 100 mm in height.

Captive bolt type fasteners shall be used to secure covers.

Covers exceeding an 0.75 m^2 that require removal for maintenance purposes shall incorporate supporting lips, lift-off hinges and locating dowels or handles to facilitate removal and/or replacement.

PCC construction, including the determination of shipping unit size, shall take into account any special limitations on size or weight that may affect unit transportation to the installation site or subsequent movement on site to its final location.

Lifting eye-bolts shall be removed and the associated holes plugged after installation of the PCC at site.

Control-gear, terminals, labels and wiring within a compartment shall be arranged such that each component may be identified, inspected, maintained, removed and replaced without the need to enter any other compartment and without moving or dismantling any other component or wiring. If a special tool is required to remove a component, the tool shall be supplied with the PCC.

Fixings for internal components and component mounting plates shall not penetrate the boundary of an adjacent compartment. If self-tapping screws are used for component fixing, they shall be of the thread-forming or thread-rolling type.

The PCC shall be powder coated, RAL 7032 OR RAL 7035 as per the Client's requirements. Plinths shall either be finished black, semi-gloss or be the same colour as the PCC exterior.

3.3.2 The MCC shall be of the type specified by the Client as follows:

1. Cubicle/multi-cubicle construction
2. Shall consist of a single cubicle or a combination of mechanically joined cubicles, of the floor standing type, where each cubicle may comprise several sections, sub-sections or compartments as is appropriate for the intended purpose
3. Box/multi-box construction

   Shall consist of a single box or a combination of mechanically joined boxes, intended to be mounted on a vertical plane (i.e. wall-mount), with or without a common supporting frame and the electrical connections passing between two adjacent boxes via openings in the adjoining faces
4. Steel assemblies shall be suitably braced to produce a rigid structure. This shall include doors and covers. The following conditions shall apply:

   - Minimum frame thickness of 2 mm
   - Minimum side plate thickness of 1.6 mm
   - Minimum door thickness of 1.6 mm
   - Minimum gland plate and component mounting plate thickness of 3 mm

Unless agreed otherwise, floor standing panels shall be mounted on a rigid channel plinth of 100 mm in height.

Captive bolt type fasteners shall be used to secure covers.

Covers exceeding an 0.75 m^2 that require removal for maintenance purposes shall incorporate supporting lips, lift-off hinges and locating dowels or handles to facilitate removal and/or replacement.

MCC construction, including the determination of shipping unit size, shall take into account any special limitations on size or weight that may affect unit transportation to the installation site or subsequent movement on site to its final location.

Lifting eye-bolts shall be removed and the associated holes plugged after installation of the MCC at site.

Control-gear, terminals, labels and wiring within a compartment shall be arranged such that each component may be identified, inspected, maintained, removed and replaced without the need to enter any other compartment and without moving or dismantling any other component or wiring. If a special tool is required to remove a component, the tool shall be supplied with the MCC.

Fixings for internal components and component mounting plates shall not penetrate the boundary of an adjacent compartment. If self-tapping screws are used for component fixing, they shall be of the thread-forming or thread-rolling type.

The MCC shall be powder coated, RAL 7032 OR RAL 7035 as per the Client's requirements. Plinths shall either be finished black, semi-gloss or be the same colour as the MCC exterior.

3.4 Busbar System

The cable connections from the busbar to the functional units shall be kept as short as practicable and shall be sized, routed and supported to minimise the risk of a fault.

It shall be necessary to use tools to remove the covers from the busbar system compartment. Each removable cover shall bear a warning label engraved: 'DANGER BUSBARS'.

Where a motor control centre is installed as two separate units to suit the intended layout of the room in which it is located:

1. The busbars in the two units shall be interconnected by cable or bus-ducting or the same material used for the busbar in a steel enclosure.
2. The continuous current rating and fault withstand capability of the interconnecting bus- ducting or busbar or cables shall not be less than those for the horizontal busbar in the motor control centre itself.
3. The interconnecting bus-ducting or busbars or cables shall be installed not to impede access within the electrical control rooms.

Wherever a voltmeter, kW, kWh, kVA, kVAh or similar meter is fed directly from the busbar system or from the cable side of an air circuit breaker, it shall be protected by MCBs or fuses.

3.5 Internal Cabling

Cableways shall bear either 'CABLING COMPARTMENT' or 'CABLING RISER' warning labels.

Internal power cables shall have the appropriate cable colour in accordance with the latest IS wiring standards.

Lower voltage cables (e.g. 240 V ac, 110 V ac, 24 V ac, 24 V dc) shall have cable colours in accordance with the latest IS wiring standards and the Client's preferences.

3.6 Cable Pits

Floor standing, bottom entry MCCs shall require a cable pit beneath the unit to allow cables to enter and leave the MCC.

The cable pit shall be of sufficient depth to allow for the bending radii of the largest cable and to allow the Electrical Contractor to terminate and gland cabling at the MCC comfortably.

The cable pit shall be of sufficient width to allow SAFE access after the MCC has been installed.

The length of the cable pit shall be similar to the MCC to allow cables from each compartment to exit the MCC.

The cable pit shall have steel structural supports evenly spaced along the width of the cable pit. The spacing of the supports shall be of an appropriate length to allow the MCC to be braced and bolted to the supports.

Chequer plates shall be installed to cover the gap between the MCC and the edge of the cable pit for safe working access.

The chequer plates shall be of a suitable material for the environment and able to safely support the weight of the operator but light enough that they can be safely removed without the use of specialised lifting equipment.

3.7 Distribution Board

The Contractor shall provide proper protective device to avoid tripping of all phases due to over current, short circuit, earth fault etc. and isolate only the faulty phase in each lighting distribution board (LDB)

Each outgoing feeder of LDB shall be provided with a MCB. Power distribution board shall be provided to cater for window/split/cassette type air-conditioning load, auxiliary load (e.g. welding, drill machine, grinder, EPABX etc.).

3.8 Spare Compartments

Minimum 20% of spare feeders shall be provided in each MCC panel.

3.9 Earthing and Circuit Protective Conductors

All earthing systems shall be designed in accordance with IS 3043.

A suitably sized tinned copper earth-bar shall be provided in an accessible location inside and along the length of the motor control centre. If the MCC is to suit bottom-entry cables, the earth-bar shall be at the bottom of the MCC. If the MCC is to suit top-entry cables, the earth-bar shall be at the top of the MCC.

A separate ‘clean earth bar’, known as a functional earth, shall be provided for instrumentation, telemetry and intrinsically safe system.

The functional earth shall comprise of a dedicated earth network connected to a dedicated earth bar with a single connection to the main earth terminal at the source. There shall not be other interconnections between the main earth terminal and functional earthing systems.

3.10 Insulating Mat

Insulating mats shall conform to IS 15652. The Supplier shall provide rubber insulating mats, made of good quality synthetic raw natural rubber, raw synthetic rubber or a mixture of both with other suitable compounding ingredients, for floor covering in front of the HV and LV switchgear along its length. Mats shall be free from fabric insertions and fibrous material.

Mats shall be solid and not perforated.

The upper surface may be plain or have a fluted, ribbed or other suitable pattern. The lower surface may be finished in cloth imprint.

Plain mats shall have a minimum thickness of 6.5 mm. Patterned mats shall have a minimum thickness of 6.5 mm at the root of the pattern.

Mats of both types shall have a minimum width of 900 mm.

Mats shall be satisfactorily vulcanised, free from blisters, pin-holes, cracks, embedded foreign matter and other physical defects.

4 LV (415V) CIRCUIT BREAKERS

4.1 Air Circuit Breakers

Air circuit breakers shall be utilised for rated current greater than 800 ampere. Where air circuit breakers are specified, the operating mechanism of each air circuit breaker shall have mechanical 'ON' and 'OFF' indicators and a manual trip device fitted with means for locking. Hand charged and motor charged spring mechanisms shall have mechanical indicators to show 'SPRINGS CHARGED' and 'SPRINGS DISCHARGED'.

Operating mechanisms of the hand charged and motor charged spring types shall be arranged so that release of the springs to close the circuit breaker can only be achieved by a deliberate action.

1. It shall not be possible for vibration or mechanical shocks to release the charged springs.
2. 'Motor charged spring mechanisms' shall be arranged so that charging is initiated automatically following a discharge, and the necessary limit stops and switches for the automatic control of the charge once initiated, shall form an integral part of the mechanism.
3. It shall be possible to hand charge a 'motor charged spring mechanism' in an emergency.

Spring operated mechanisms shall be provided with volt-free contacts to give indication that the springs are charged.

The closing solenoids of dc solenoid operated mechanisms shall be suitable for operation at a minimum of 80% of the nominal supply voltage and shall not malfunction or cause excessive vibration when energised at 120% of the nominal supply voltage.

To facilitate maintenance and adjustment of contacts, it shall be possible to 'slow-close' the circuit breaker. This operation shall only be possible in the fully withdrawn position. Any necessary operating handle, lever or tube shall be supplied.

Each circuit breaker shall be 'trip free' and be provided with the following mechanical interlocks:

It shall not be possible to withdraw or to replace the circuit breaker from the 'service' position unless the breaker is open.

It shall not be possible to attempt to close the breaker unless the closing springs are fully charged.

It shall not be possible to remove the circuit breaker from its fixed cassette without manually overriding a catch.

Each circuit breaker shall be versatile enough to accommodate rating plug.

Each circuit breaker shall have mechanical indicator to display the deterioration status of the contacts.

4.2 Moulded Case Circuit Breakers

Moulded Case Circuit Breakers shall be used for rated current up to 800 ampere.

Design Conditions:

1. Moulded Case Circuit Breaker (MCCB) shall be a circuit breaking device which can make, withstand and break current whose intensity is at most equal to its nominal

current and protection device which can automatically break over current which may occurs as a result of fault in the system.

2. The terminals and connections between all current carrying parts shall be designed to assure permanently low resistance connections.
3. MCCB shall have rated operational voltage of 415V, 50Hz power supply system.
4. MCCB shall have minimum fixed symmetrical interrupting capacity i.e. ICS = 100% ICU and variable overload capacity.
5. MCCB shall have auxiliary contacts as required.
6. MCCB shall conform to the latest application of Indian Standard IS 13947-2.
7. MCCB shall have minimum power loss as defined by the standard IS 13947.
8. MCCB shall be current limiting type with let through energy limit as specified in IS/IEC 60947.
9. MCCB housing shall be heat resistant and having high impact strength.
10. Deleted.
11. All MCCB, fixed as incomer, shall be microprocessor based with adjustable overload (40% to 100%), short circuit (2 to 10 In) and earth fault protection (10 to 50%) and shall have RS 485 communication compatibility. All MCCB at incomer shall be provided with rotary handle and shall have under voltage release feature. All other MCCBs will be thermal magnetic type with earth fault protection.
12. MCCB terminals shall be protected against finger contact to IP 2X degree of Ingress Protection to provide total safety to the operating personnel.
13. Considering MCC panels, where specified :
    a) '3Pole + Neutral' MCCBs shall be used on mains incomers,
    b) 3Pole MCCBs shall be used on the outgoing ways for each motor load.
    c) '3Pole + Neutral' MCCB/MCB will be used as incomers for lighting distribution boards.
14. MCCB Operating mechanism shall be quick- make, quick-break and trip-free type. The 'ON', 'OFF' and 'TRIP' positions of the MCCB shall be clearly indicated and visible to the operator when mounted as in service.
15. MCCBs shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relays settings of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 20 milliseconds.
16. MCCB terminals shall be suitable for accepting spreader links to receive cable lugs for cable sizes relevant to circuit ratings. Phase barriers shall be provided for isolation of the poles.
17. Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be spring-loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

4.3 Miniature Circuit Breakers (MCBs):

MCBs selected for the scheme shall:

1. Be single, double, or three pole with or without a neutral as required.
2. Incorporate, if specified, residual earth current detection in combination with the over current protection.
    a) The 'current limiting' MCB (RCBO) shall be either of the 30 mA or 100 mA tripping variety.

The rated voltage for single pole and three pole (with or without neutral) shall be 240 V & 415 V, 50 Hz frequency respectively.

All single pole and three poles (with or without neutral) MCBs shall be suitable for 6 or 10 kA (M6 or M10) as per IS: 8828. The procedure for conducting the Short Circuit test and the test circuit etc. shall be in accordance with the IS: 8828.

4.4 Operating Conditions

The Time Vs Current characteristic of MCBs shall be fixed and non-adjustable.

1. The tripping curves shall be prepared in accordance with IS:8828 and the manufacturer shall submit to the Employer's Representative copies of these curves for record keeping and approval.

The tripping time of MCBs shall be as per IS:8828. The Reference Calibration Temperature for this purpose shall be 45 degree Celsius.

MCBs shall be capable of carrying out a given number of operation cycles as per IS:8828.

The measured temperature rise of the circuit-breakers' sub-components under test conditions, as specified in IS 8828, shall not exceed the RCT.

Under voltage release and shunt-trip release coil are not required.

Overload release and Short Circuit release shall be provided.

4.5 Design & Constructions of MCBs

Materials

1. Shall be suitable for the particular application and capable of passing the appropriate tests.
2. Metallic portions of the mechanisms shall be either inherently resistant to, or so treated as to make them resistant to atmospheric corrosion.
3. The terminal screws used shall be of brass or non-magnetic stainless steel.
4. The case shall be of insulating material and shall be designed to withstand reasonably rough usage without fracture or permanent distortion.

Conformity

1. Each MCB supplied in accordance with this specification shall conform to and bear markings as per IS:8828.

Tripping and release

1. MCBs shall have trip free operating mechanism.

2. MCB shall be fitted with an automatic release which shall at all times function independently of the means used to close the circuit breaker.
3. MCBs shall be arranged for manual closing and opening and for automatic tripping on over current / short circuit.
4. The MCBs' internal mechanisms shall be effectively sealed by the manufacturer to prevent access to the mechanism.

Ventilation

1. Outlets from circuit breakers shall be so situated that a discharge of gases or hot air from arc chambers, when provided in air circuit breaker, will not cause electrical breakdown and shall be directed away from any place where an operator may have to be in the course of his ordinary duties.
2. The construction shall be such that gas cannot collect at any point where ignition can be caused during or after operation by sparks arising from normal operation of a circuit-breaker or its ancillary equipment.

Terminals

1. The MCB shall be with stirrup type terminals as per IS 8828 and shall be such that live parts are not accessible. Live part cannot be touched by the test finger of design shown in IS 8828.
2. The terminals shall be of substantial mechanical construction and shall provide adequate electrical contact for conductors up to a maximum of 16 mm^2. size of aluminium / copper cable to be used.
3. Terminals shall be such that they cannot turn or be displaced when the connecting screws are tightened and such that the conductor cannot become displaced/loose.
4. Terminal connectors shall be such that the conductors may be connected to ensure that the necessary contact pressure is maintained permanently on connected cable.
5. Terminals shall be so mounted that the appropriate wire or cable may be connected without impairing the normal performance of the unit. No contact pressure shall be transmitted through insulating material and the gripping of the conductor shall take place between metal faces.
6. The terminals shall be clearly and indelibly marked for those circuit breakers which require distinction between the supply side and the load side and/or between phases and neutral.

5 LV BUS SECTIONS, RESILIENCE AND POWER TRANSFER SCHEMES

5.1 General

Bus ducts shall be three phase, four wire aluminium conductor Air Insulated type with earthing arrangement in enclosure.

Multiple transformers shall operate in a multiple redundant fashion, each energised and supplying a proportion of the total simultaneous load.

1. An engineering decision shall be made in consultation with the Employer's Representative, on the basis of a risk versus value assessment, of what degree of resilience shall be designed into each load centre. In practice this shall determine:
   a) which loads are critical to the process and must be maintained in the event of a loss of power
   b) which loads are essential to health and safety and returning the site to full operation following restoration of normal operation
   c) the number of busbars (NB) required in each MCC to effect points a) and b)
   d) the requirements for stand-by generation, either: permanently installed or facilities for connection of mobile generating sets
   e) requirements for Uninterruptible Power Supplies and Battery Back-ups.
   f) automatic / manual bus-transfer schemes.
2. Each transformer incomer and bus-section shall be rated to carry the total simultaneous load of the installation.
3. The electrical design shall ensure only momentary paralleling of multiple transformers.
4. During normal operation, all bus-coupling devices are in the 'OPEN' position and the transformers shall operate at approximately 1/ NB of the total simultaneous load.

The electrical system shall be designed to avoid out-of-synchronisation events. This shall be implemented either via:

1. Mechanical interlocks to prevent parallel operation of different power sources
2. Electrical interlocks with synchronisation relays to allow parallel operation

6 LV ELECTRICAL PROTECTION AND POWER QUALITY

6.1 General

Over-current & short circuit protection:

1. All electrical plant and materials shall be provided with over-current and short circuit protection. This shall be arranged, as far as is practicable, so that a fault on any item of electrical plant is automatically interrupted without interrupting the operation of any other healthy plant.

Residual Current (Earth fault) Protection:

1. Residual current protection (sensitivity 100 mA) shall be provided for all socket outlets except those for hand lamps.
2. Residual current protection (sensitivity 300 mA)
   a) Primary winding of every power transformer fed by a circuit breaker (instantaneous operation)
   b) Every motor rated at 22 kW and over. The residual current protection shall operate within five seconds of the fault being detected.
   c) Instantaneous restricted earth-fault protection shall be provided for:
   d) Secondary winding of every power transformer rated at 1500 kVA or more.
3. Operation of the protective relay shall trip the circuit breaker feeding the transformer and the associated circuit breaker on the secondary side of the transformer.

The requirements for drive protection are defined in 6 LV MOTOR STARTERS. Due care shall be taken by the Contractor to ensure that discrimination is achieved between electrical and drive protection devices.

6.2 Co-ordination of Disconnecting Devices

Where different devices provide protection against overload and short-circuit conditions neither device shall be called upon to interrupt a fault in excess of its maximum breaking capacity.

All disconnecting devices shall meet the requirements for Type ‘2’ co-ordination in accordance with IEC 60947.

6.3 Components

Components for use in low voltage assemblies shall be in accordance with IEC 60947

6.4 Fuses and Links

Fuses used for the protection of power circuits shall be of the high rupturing capacity, HRC type. Semiconductor fuses shall be utilised to protect soft starters.

Fuses shall comply with IEC 60947.

Fuse carriers and bases shall be black. The carrier and base for each neutral link shall be white.

Fuses and links shall be positioned to enable easy removal of the carrier without risk of contact with live parts.

6.5 Switches, Switch Disconnectors and Switch-Fuses

Every switch, switch disconnector and switch-fuse for use in a power distribution or motor power circuit at up to 1 kV AC shall comply with IEC 61439 and IEC 60947. Utilisation category shall be appropriate for the application, and shall be suitable for padlocking in the 'Off' position only.

6.6 Contactors for use at below 1 kV

Utilisation category for each contactor for use at below 1 kV shall comply with IEC 60947. It shall be maintenance free and where possible, allow replacement of the coil without disturbance to the wiring.

6.7 Indicator Lamp Circuits

Every indicator lamp circuit shall be fused separately from any functional circuit so that an indicator lamp failure will not result in the failure of any functional circuit.

A 'lamp test' facility shall be provided for each logical group of indicator lamps, as follows:

Common 'lamp test' button shall be provided on the front facia of the switchboard or motor control centre for which indicator lamps are provided

Holding the 'lamp test' button shall cause all the related indicator lamps to be illuminated. On releasing the button, the lamps shall return to their normal state.

Indicator lamps shall be based on LED semiconductor technology.

6.8 Motor Protection

See 9.3 - Motor Protection

6.9 Harmonics

The arrangement of the electrical system shall be such that any harmonics generated by the electrical system do not:

1. Exceed the limits permitted at the point of common coupling with the electricity supply company's electricity distribution system
2. Cause malfunction of any electrical plant or of any electrical system
3. Lead to overheating of any electrical plant, materials or of any electrical system.

To limit the harmonics generated by electrical plant, every rectifier rated in excess of 3 kVA shall be of the 6, 12, 18 or 24 pulse type as required.

When designing a system utilising variable frequency drives (VFDs), provision shall be made to minimise the introduction of additional harmonics into the power grid as per standard IEEE 519.

6.10 Electromagnetic Compatibility

The electrical system shall be arranged so that no part of it:

1. Gives rise to overheating of any metallic parts as a result of magnetic coupling. This situation can arise when single core power cables are used.

2. Gives rise to electromagnetic fields which can lead to the malfunction of other electrical plant and equipment. When the doors of switchboards, motor control centres and control panels are closed, the satisfactory use of laptop computers, mobile phones etc. in every room shall be possible.
3. Will malfunction when the doors of switchboards, motor control centres and control panels are closed and portable or transportable items such as laptop computers, mobiles phones etc. are used in close proximity to electrical plant.

   Plant and materials shall comply with the Indian Standard EMC directive IS 14700 or IEC 1000-4-9.

7 LV MOTOR STARTERS

7.1 General

Each motor starter shall incorporate the following features in addition to complying with the requirements specified elsewhere in the specification.

1. A suitably rated 3-phase switch-fuse or MCCB, see 3.2 Moulded Case Circuit Breakers or Motor Protection Circuit Breaker (MPCB) as a means of isolating the starter from the busbars and to provide short-circuit and overload protection. A facility shall be provided to enable the switch-fuse or MCCB or MPCB to be padlocked in the 'Off' position only.
2. Where any control or monitoring circuit inside the starter compartment operates at a voltage in excess of 24 V d.c. and is energised from outside the starter compartment, both poles of the circuit shall enter the starter compartment via miniature circuit breaker (MCB) so that the circuit inside the starter is isolated when the MCB is open.
3. An isolating transformer shall be provided to feed the control and monitoring circuit. The primary of the transformer shall be fed from one phase and the neutral; the phase connection shall be protected by fuse. The output from the secondary shall be 110V/ 240 V. One pole of the transformer secondary shall be earthed and a fuse shall be fitted in the other pole. An earthed metallic screen shall be provided between the transformer primary and secondary windings.
4. A 'test' switch to enable the control and monitoring circuit for tests while the main circuit feeding the motor is isolated. The 'test' switch shall only be accessible when the starter compartment door is open. The switch shall take the form of a pushbutton which has to be pulled out to select the 'test' position and pressed in to select the 'normal' position. The 'test' button shall be located in the compartment so that the starter cannot remain in the 'test' mode when the compartment door is shut.
5. An ammeter with a transformer shall be provided to measure the line current drawn by motors with a rating in excess of 5 kW.
6. The ammeter shall be connected on the compartment door with help of ammeter selector switch. The ammeter shall have an extended range to suit the motor locked rotor current and an adjustable red pointer which can be used to indicate the motor full load current.
7. The following relays and protective devices shall be provided as a minimum:
    - A 'Run' relay, the coil of which shall be rated and energised from the relevant control and instrumentation compartment
    - An 'Available' relay
    - An 'Inhibit' relay, where appropriate
    - One or more 'Trip' relays, where appropriate
    - Control relays (including terminals and controls)
    - A 'local switch-disconnector closed' relay, where appropriate. This relay shall only be energised when the switch-disconnector local to the pump is closed.
    - Overload and single phasing protective device
    - Earth leakage fault protection for motors rated at or above 22 kW
    - Thermistor or thermal switch motor protection for motors rated at or above 22 kW
    - Contactor(s)

- Other drive protection relays, as appropriate

8. The following control devices mounted on the starter door for conventional MCCs:
   - Start push button
   - Stop push button
   - Lamp Test button
9. The following indicator lamps shall be mounted on the starter door for conventional MCCs:
   - Pump Stopped
   - Pump Running
   - Auto Available
   - Fault
10. The colour of push buttons and starter door indicator lamps shall be selected to meet the standard specifications and preferences.

7.2 Motor Starting

In selecting the appropriate type of fixed speed starter for a motor, account shall be taken of the following factors:

1. The torque/speed curves of the driven equipment and of the motor
2. The calculated frequency of starting each motor and the starts/hour for which the motor is suitable
3. Voltage regulation

The motor starter shall be one of the following types:

1. Direct-on-line/Star Delta
   - DOL /Star Delta starters shall be provided wherever the voltage regulation which results is within the specified limits.
   - DOL/Star Delta starter shall be used for the motor rating up to 7.5kW
2. Soft starter
   - Where soft-start units are proposed, the appropriate characteristics (e.g. ‘voltage ramp’, ‘pump start’ and possibly ‘soft stop’) shall be determined.
3. Variable frequency drive

7.3 Variable Frequency Drives (VFDs)

VFDs shall be used where speed variation is essential to maintaining a process variable at a particular set-point or matching a given performance profile.

Wherever possible the selected drive shall utilise the minimum number of pulses required to perform the desired task whilst complying with national and international guidelines on harmonic emissions.

Each VFD shall employ Insulated Gate Bipolar Transistors (IGBTs) on both the rectifier and frequency convertor.

VFDs shall employ closed loop, flux vector control or direct torque control methodologies.

The selected drive shall be designed to run at full load for the full range of climatic conditions it shall experience.

The drive's characteristics shall as a minimum achieve the following:

1. Over-all power-factor (including total harmonic distortion) at rated load: 0.97 pu
2. Efficiency at rated load: 0.98 pu
3. Output voltage: 0 – rated voltage
4. Output frequency 0 – 240 Hz, adjustable
5. Frequency resolution: 0.1 Hz
6. Over-load, constant torque: 150 % of rated current for 1 minutes
7. Over-load, variable torque: 110 % of rated current for 1 minutes
8. Speed control resolution: +/- 0.5 % of rated speed.
9. Degree of protection: IP21 minimum

Each VFD shall be equipped with:

10. A user interface to allow manual setting of the speed reference.
11. At least 1 nr. analogue input (4-20 mA) of configurable use
12. At least 1 nr. analogue output (4-20 mA) of configurable use
13. At least 6 nr digital inputs of configurable use
14. At least 2 nr. digital outputs of configurable use
15. At least 1 nr. positive temperature coefficient device
16. where the drive is installed as part of an intelligent installation, it shall be equipped with appropriate communications interfaces

Data sheets detailing the climatic conditions the drive will experience, its minimum functional requirements and the operating limits it shall sustain in those conditions (load torques, starts per hour, harmonic emissions and speed range) shall be provided to the drive's vendor and a performance guarantee obtained from them prior to procurement.

The selected VFD shall employ internal optimisation algorithms to minimise energy usage, especially when not operating at rated speeds and torques.

The selected VFD shall have a configurable, proportional, integral and derivative controller. The selected drive shall incorporate motor protection features, including:

1. Earth Fault Detection
2. Motor Overload Prevention.

Controlled, active, rectifiers with harmonic mitigation algorithms shall be employed where harmonic emissions will fall out with national guidelines.

8 HV SWITCHGEAR AND ASSEMBLIES (NOT USED)

9 ELECTRIC MOTORS

9.1 General

Matching to Driven Equipment

1. The kW rating of each electric motor shall greater than 10% of the power absorbed by the drive at the duty point. For motors to be operated by variable frequency inverter drives (VFD), the kW rating to be used in this computation shall be the nominal kW rating of the motor derated by an additional 10% (on top of the 10% drive power absorption), to allow for diminished cooling and increased losses. The torque/speed characteristic of each motor shall be adequate to accelerate the drive to the required operating speed in an acceptable time.

Frequency of Starting

1. The Contractor shall calculate the maximum number of starts per hour which could occur for each drive under automatic control. Each motor shall be suitable for the calculated maximum number of hot/cold starts per hour (up to a maximum of 12 starts/hour).

'Energy efficient' motors

1. All motors shall comply with Indian Standard, IS 325.
2. All motor shall be of IE2 efficiency class as per IS 12615.
3. Motors to be installed in hazardous classified areas shall conform to the requirements of IS 5571.

Motors for Use in Variable Frequency Drive Systems

1. Every motor which is to be fed from a frequency converter (variable frequency inverter drive) shall be suitable for continuous maximum operation at any speed within the specified speed range and with harmonic Filters for the harmonics generated by the frequency converter. Enhanced cooling and design of the motor windings shall be provided where necessary to meet this requirement.
2. Variable frequency inverter drives (for motors above 75 kW) may cause induced voltages within the motor shaft and hence damaging currents within motor circuits, therefore insulated non-drive end bearings, insulated motor end shield arrangement, and/or shaft grounding/ earthing shall be required.

9.2 Motor Protection

Over-Temperature Protection

1. The protective over-temperature devices shall be in close thermal contact with each phase of the stator windings and the upper and lower bearings. These shall be provided for every motor which satisfies any of the following criteria:
   a) It is operated as a variable speed drive.
   b) It is subject to onerous operating conditions such as a high maximum number of starts per hour or a long run-up time.
   c) It is installed in a potentially hazardous area.
   d) It has a motor rating equal to or greater than 22kW.
2. For submersible pump motors, thermostatic devices will be an acceptable type of over-temperature sensor. Otherwise, each over-temperature sensor shall be a

thermistor. All thermistors shall be connected together to provide a single electrical circuit for connection to an external relay which will be capable of tripping the motor.

3. Other over temperature protective devices may be of the P100 (positive temperature resistance) type and some are commonly known under the 'Klixon' and 'Minicas' brand names.

Overload Protection

1. Electric motors having a rating equal to or greater than 0.37 kW shall be provided with control equipment incorporating overload protection of the motor.
2. Wherever 'low power' or 'low current' protection is provided, the motor starter circuit shall be arranged so that the 'low power' and/or 'low current protection' is overridden:
   a) For a suitable time after starting the motor to prevent spurious tripping of the drive before it has achieved its steady state operating condition
   b) Whenever the 'Test' mode has been selected at the motor starter

Motor rated fuses shall be used where fuses are to be utilized for motor overload protection.

In the starter for each drive, an over-torque protection relay, type tested by the manufacturer of the protection relay shall be provided to prevent damage to the equipment.

Additional Protection

1. Where specified, recommended by the driven equipment manufacturer or where otherwise appropriate, other forms of drive protection such as 'low power', 'low current' or 'over- torque' based on the measurement of electrical parameters shall be provided. Each type of such protection device shall be of a type tested by the equipment manufacturer.
2. In addition to the over temperature and overload protection described above, the following shall be provided for motors:
   a) Short Circuit Protection
   b) Under voltage protection
   c) Earth Fault Protection
   d) Phase Unbalance/ Failure Protection
   e) Locked Rotor/ Stall Protection
   f) Warning Before Fault Occurrence
   g) Thermistor Protection (if applicable)
3. Seal leak protection (e.g. Foxtam, Minicas, Chromalok etc.) shall be provided for submersible pump sets. Pump sets located in hazardous or explosive zoned areas shall stop automatically upon detection of a seal leak.

9.3 Cable Termination Boxes

Submersible pump sets shall be supplied complete with factory-fitted cables and IP 68 terminal box. These cables shall be long enough to permit termination in a conveniently located junction box and shall, in any event, be not less than 15 metres long.

For every other motor, cable termination boxes shall be provided and be suitable for air termination of cables. They shall be sealed with a neoprene gasket to provide dust and weather protection. Each box for the termination of power cables shall be the largest

'standard' box which the motor manufacturer can offer for the motor frame size concerned.

Cable termination boxes for phase-to-phase voltages in excess of 1000 V shall be treated with anti-tracking varnish.

Motors cable boxes shall be earthed to the motor main frame and provided with an external earth terminal

Heat shrinkable LV termination kits shall be provided for critical applications.

When connecting to a pump in a zoned area, sealed cable transit blocks shall be utilized to prevent explosive gases from travelling into the junction box via the cable ducts.

Appropriate ATEX rated junction boxes shall be used if they are to be installed within a hazardous zoned area.

9.4 Other Requirements

Every electric motor rated at 0.37 kW or more shall be three phase squirrel cage induction type or specific as per process requirement. The type of duty shall conform to IS 4722. Any motor rated under 0.37 kW shall be of the same type or shall be a single-phase motor if this is more appropriate. All motors excluding motors for submersible application shall be Totally Enclosed Fan Cooled (TEFC) type.

Motor bearings shall be provided with facilities to add additional lubricant. For grease-lubricated bearings, grease nipples shall be provided and a grease relief feature incorporated. Oil lubricated bearings shall be provided with sight glasses which provide an accurate indication of bearing oil level when the motor is in use.

Unless otherwise specified, motors shall be provided with class 'F' insulation, the permissible temperature rise above the specified ambient temperature shall be limited to that specified in the applicable Indian standards for class 'B' insulation.

Motors shall conform to IS 12065 for limits of noise levels and shall conform to IS 12075 for vibration severity limits.

Vibration monitors shall be installed for motors above 90kW:

Motors, unless otherwise stated, shall generally have an output speed kept to a maximum 1500rpm, at 50Hz.

Motors shall be selected for the environment in which installed related to;

Ingress Protection (IP Rating); Generally, IP55 for surface installed types, and IP68 for submersible pumpsets.

Operating temperatures and humidity; For India Tropical Environment (greater than +40 deg. C, RH > 95%).

EMC Class (A – Industrial, B – Residential, Commercial and light industrial).

10 REACTIVE POWER COMPENSATION

10.1 Capacitor Bank

Capacitor banks shall comprise of three identical single phase capacitors kept inside an aluminium enclosure. The capacitors shall be cylindrical/ box type in design.

The individual capacitor units shall be connected in a delta configuration. The capacitor technology shall have double side metalised paper + polypropylene film as core component. The unit shall be impregnated in the vacuum environment with non-PCB (poly chlorinated biphenol) oil as the impregnate.

For safety purposes, capacitor units shall be factory fitted with discharge resistors, with a standard discharge time to 50 volts or less in 60 seconds. The capacitor units shall have a self-healing feature. For external protection, they shall be provided with pressure sensitive disconnectors as per IS 12672.

The capacitor shall have bushing terminals designed for large cable terminations and direct bus bar mounting for banking.

The capacitors shall be provided with fuses. It shall be possible to identify the blown fuse from outside. The tolerance and degree of unbalances shall be as per the relevant Indian or international standard.

The capacitors shall be designed for (industrial application providing, high performance, high longevity, loss power loss, good harmonic capabilities technology. The technology shall be capable of giving the longest life, highest over load limits and the highest operating ambient temperature. It shall be suitable to use in a moderately high harmonic environment, up to 20% non-linear content. Appropriate rating detuned capacitors with reactors are to be considered.

The capacitor shall comply with Acceptance test, Type test and Routine test classified under IS 13585.

10.2 Performance

Permissible Overload:

1. The unit shall be able to withstand the overcurrent up to 2.5 x Is. The maximum permissible overloads with regard to voltage, current and reactive output shall conform to relevant IS.

Transient Free Switching:

1. Capacitors installed shall be switched in a transient free manner so as to ensure reliable performance of the installation.

Resonance:

1. To avoid the risk of resonance a safe combination of capacitor + filter reactor shall be selected for high voltage application to ensure reliable power factor improvement.

10.3 Automatic Power Factor Correction (APFC) Panel

General

1. Group power factor correction shall comprise individually switched power factor correction capacitors contained within a metal-clad enclosure.
2. The capacitors shall be switched individually in stages to maintain a set point power factor value.

Control

1. Each stage shall be provided with a control mode switch which shall provide the following control modes:
   a) Automatic mode: in this mode the stage shall be controlled by the dictates of the power factor control relay
   b) Manual mode: in this mode the stage shall be switched on permanently.
2. In automatic mode a capacitor control relay shall switch the various capacitor stages in order to maintain a set point power factor value. The set point shall be adjustable within the range 0.9 to 1.0.
3. The relay shall accept a voltage and current transformer input from the circuit to be corrected.

Capacitor Control Relays

1. Capacitor control relays shall be used for the step control of low voltage capacitors.
2. The power factor relay shall comprise a single phase electronic measuring circuit sensitive to reactive load and shall be used to control power factor capacitors in discrete stages.
3. The relay shall be fitted with a no volt release resetting feature such that the switching sequence resets itself to an all contacts open position following a failure of supply.
4. Capacitor stages shall be capable of manual or automatic selection.
5. The relay shall be provided with an HMI to indicate:
   a) the number of stages in operation;
   b) the kVAr presently employed;
   c) the required system power factor;
   d) the actual system power factor; and
   e) to allow the setting of the target system power factor.
6. A sensitivity feature shall be provided to prevent ‘hunting’ of the relay.
7. The warranty period for capacitors shall be not less than three years from the time of installation.

Construction

1. The panel shall be dead front, totally enclosed type with rear cable alley for capacitor mounting. It shall be of a free-standing type, suitable for indoor applications.
2. The panel shall be extendable to both sides.
3. The degree of protection for enclosure shall be IP 42.
4. Separate segregated compartments shall be provided for circuit breakers, busbars, cable box, voltage transformers, wire ways, relays and instrument and control devices.
5. Panel cubicles shall be provided with hinged doors in front and back with facility for padlocking doors. All doors, panels, removable covers shall be provided with non deterioratingnon-deteriorating (neoprene) gaskets all around the perimeter.
6. Adequately sized cable alleys shall be provided for easy clamping of all incoming and outgoing cables irrespective of their mode of entry.

7. The switchgear cubicles shall be rigid and robust in design and construction fabricated out of cold rolled close annealed, sheet steel. Corrosion proof coating shall be provided to avoid rusting due to a saline and / or sewage gaseous atmosphere. Total height of panel shall not exceed 2200mm. Cubicles shall be made from rigid welded structural frames made of structural steel sections or of pressed / formed sheet steel of not less than 3mm thickness.
8. The frames shall be enclosed by sheet steel of at least 2 mm thickness, smoothly finished, levelled and free from flaws. Stiffeners shall be provided wherever necessary.
9. After fabrication of the Panels, the entire structure shall undergo a 7 tank treatment for removing dust, grease, rust etc. The Panels then shall be powder coated to an approved shade.
10. A name-plate shall be fixed prominently on top of the switch board describing the panel designation. These labels shall be of non-corrosive material and clearly legible. The panel's rating, kVAr steps, date of construction and capacitor types shall be recorded on the plate.

Busbar / connection

1. The main bus bar system shall be horizontal, 3 phases and 4 wire.
2. All bus bars shall be made from copper. Rated short circuit withstand times for main and vertical bus bars shall be 50 kA for 1 second unless otherwise stated.

Wiring and Terminations

1. Power and auxiliary circuits shall be provided with 1100V grade XLPE insulated flexible, copper stranded conductors, colour in accordance with Client's specifications / requirements.
2. Coloured sleeves shall be provided on the termination for identification purpose.
3. Crimping type copper lugs shall be used as termination.
4. CT circuits shall be provided with 2.5 mm^2 wires whereas PT / Control / annunciation /auxiliary circuits shall be provided with 1.5 mm^2 wires.
5. Power terminals shall be bus bar type.
6. Fixed terminals of control circuit shall be of polyamide.
7. The material of control terminals shall have excellent resistance to deformations, optimum dimensional stability and strong resistance to surface discharge.
8. Normal clip-on type fixed terminals shall be provided for current transformer shorting.
9. Power and control cable entry shall be from the bottom of the panel.

Anti condensationAnti-condensation heaters

1. Anti-condensation heaters shall be supplied to maintain the interior of the APFC enclosure. Heaters shall be sized and located to prevent condensation of moisture during shutdown periods. The heaters shall permanently remain ON when the APFC is not in service and as such shall not cause damage to the components.
2. Heaters shall be unaffected by the accumulation of moisture and shall have terminals adequately protected against moisture under severe weather conditions. Heaters shall be mounted on non-combustible material and shall operate without thermal damage to the components or themselves. Heaters shall be rated single- phase 230 volts AC.
3. Heaters shall be controlled and protected through 2 pole MCB and thermostat.

Auxiliary Supply

1. The auxiliary supply for capacitor feeder shall be 230V AC received from control transformer installed in each APFC.
2. 5 ampere sockets shall be provided for lamps; receiving power from external power distribution boards and operated through 2 pole MCB.

10.4 Grounding

Unless otherwise stated, rated short circuit current withstand time for earth bus bar shall be 50 kA for 1 second at 415 V. The earth bus shall be tinned copper.

The earth bus bar shall be extendable to either side of the switchboard.

All panel doors shall be earthed.

All meters and relays mounted on panel doors shall be connected to door through mounting screw.

10.5 Name Plates

Each APFC and capacitor bank shall have a corrosive-resistant nameplate containing information in accordance with relevant IS.

Additional information as stipulated in applicable standards shall be included in the nameplate for APFC and capacitor banks meant for use in hazardous atmospheres.

The lettering shall be white on black background put up on panel surface by the use of adhesive material.

10.6 Cooling System

All APFC panels and capacitor banks shall be provided with proper ventilation as per requirement. For panels operating in hazardous area, the fans shall be of an anti-static non-sparking material.

10.7 Lifting Hook

All APFCs shall be provided with lifting hooks of adequate capacity.

11 STAND-BY AND STABILISED POWER SUPPLIES

11.1 Uninterruptible Power Supply (UPS)

The UPS shall be floor mounted, self-contained and metal clad and shall be suitable for supplying a nonlinear load.

It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply. The UPS shall also have an inbuilt isolating transformer to provide galvanic isolation to load.

The UPS shall incorporate a dc under voltage trip circuit to electronically trip the UPS output in order to protect the batteries.

The noise level of the unit shall not exceed 60 dB(A) at 1 m from the UPS cabinet.

The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% nonlinear load. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

The unit shall have a dynamic response such that a 100% step load causes an output voltage transient of less than ± 4% with a recovery time of less than 4 ms.

For three phase output units, the output voltage shall not vary by more than ± 1% for an unbalance of 10%.

The load crest factor shall not be less than 3 : 1.

The efficiency at full load and 0.8 power factor shall be greater than 88%.

The unit shall incorporate a monitoring and diagnostics system to provide an audible alarm to provide warnings and fault indication.

The following parameters shall be monitored:

1. Inverter output voltage
2. Battery voltage
3. Static bypass voltage
4. Output current
5. Inverter output frequency
6. Available battery bridging time at rated load
7. Available battery bridging time depending on actual load.
8. Indicators to indicate
9. UPS status
10. UPS alarm conditions.

It shall be possible for operations and maintenance personnel to determine the cause of UPS failure by viewing a fault annunciation display or by interrogation of a ‘user friendly’ integral key pad and display unit.

The UPS shall have an emergency power off facility. This shall be operable both locally and remotely. A 24 V dc emergency shutdown relay shall be provided to accept the remote shut down signal.

The UPS shall be manually reset after operation of the emergency shutdown. The UPS shall provide a volt free contact output to indicate:

1. Warning, i.e. low battery capacity
2. Fault
3. Static bypass in use.

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

Back up time provided by the UPS shall not be less than 2 hours.

The EMC emission level shall be equal to or better than suppression degree as defined in IEC 62041. The battery supply to the UPS shall be via a fused load break switch disconnector.

The battery recharge time to 90% of full charge shall be approximately ten times the discharge time at full load.

The Contractor shall give due consideration in his design to the location of the batteries and the ventilation that they will require. The Contractor shall submit to the Engineer sufficient calculations to demonstrate that the required number of air changes per hour is achieved. In the event of the room requiring forced air ventilation, the supply and installation of all fans and ancillary equipment shall be deemed to be within the Contractor's scope of work.

11.2 Battery Power Supplies

Battery power supplies shall be suitable for operation with the battery system and voltage specified. The battery charger assembly shall be solid state constant potential incorporating a self-protecting current limiting feature for protection against low battery voltage short circuit or reverse polarity connection to the batteries.

The charger shall have controls for:

1. On/off
2. Float/boost charge

And indication of:

1. Automatic high rate charge
2. Rectifier failure
3. High dc voltage
4. Low dc voltage
5. Battery voltage
6. Output current.

Volt free contacts shall be provided for remote signaling of common alarm.

The charger shall incorporate an automatic high rate charge circuit to be initiated manually or by operation of the rectifier current limit. This shall automatically bring the battery system, over a site adjustable time period, to float charge level.

Batteries shall be lead acid (tubular) type in transparent SAN container designated, constructed and tested in accordance with DIN 40736.

Batteries shall be contained within translucent impact resistant flame retardant polypropylene cases. They shall be designed for low maintenance and shall have a life in service of at least 20 years.

The batteries shall be suitable for use on switchgear and circuit protection applications.

Batteries shall be housed within the battery charger enclosure or within a separate battery enclosure. The cells shall be arranged in tiers to enable a rapid visual check of electrolyte level and access for maintenance. Terminals shall be shrouded to prevent accidental contact. The battery enclosure shall be corrosion resistant and ventilated to prevent the build up of gases.

The battery installation shall be supplied complete with all tools necessary for the safe and efficient maintenance of the batteries.

Warning notices shall be provided for wall mounting to warn of the presence of charge gases.

11.3 AC Power Supplies

AC stabilised power supplies shall be based on the ferro-resonant, saturable reactor transformer principle. They shall provide a regulated and filtered voltage power supply.

They shall be maintenance free and have a short circuit current limit of 2 times rated current.

Output voltage regulation shall be better than ±1% for steady state and ±3% for transient input voltage variation of ±15%. Harmonic distortion shall not exceed 3%.

A change of supply frequency of 1% shall not produce a voltage change in excess of 1.5%.

12 CABLE CONDUCTORS

12.1 General

All cable conductors shall be of electrolyte grade high conductivity annealed copper as per IS 191, or electrolyte grade aluminium as per IS 8130 and shall have a cross-sectional area of not less than:

1. 1.5 mm^2 for cables in between feeder pillar/main lighting distribution board and street lighting poles junction boxes.
2. 2.5 mm^2 for power circuit cables, such as to supply power to motor windings.
3. 2.5 mm^2 for motor and valve actuators, and 1.5 mm^2 for auxiliary circuits such as for anti- condensation heaters, thermistors, pushbutton stations, etc.
4. 1.5 mm^2 for indoor lighting circuits.
5. 1.5 mm^2 for instrumentation circuits.
6. 1.0 mm^2 for control panel and motor control centre internal control wiring.
7. Sizing of phase conductors shall be performed in accordance with IEC 60909
8. Each neutral conductor shall be of the same cross-sectional area as the associated phase conductors.
9. Cables shall be laid and maintained in conformance with IS 1255.

12.2 LV Cable Usage

Armoured Cables:

1. Power cables shall be as per IS: 7098: Part 1, provided with XLPE insulation, FRLS type.
2. Cables which are laid external to the electrical panels shall be armoured as per IS 3975.

Un-armoured Cables

1. Un-armoured cables shall be used inside each electrical panel for wiring of control circuit.

Control and Instrument Circuits

1. All control, monitoring and instrumentation cables shall have twisted and screen pair.

Analogue Signals: 4 - 20 mA

1. Plain annealed multi-stranded copper conductors, solid polyethylene insulation with aluminium-mylar pair screening including drain wire,
2. Collective aluminium mylar screen including drain wire.
3. Solid polyethylene bedded steel wire armour with an outer sheath of flame retardant PVC.
4. PVC sheath to be blue for intrinsically safe circuits, black for ac and dc non-intrinsically safe circuits
5. 650/1100 V grade to IS 7098: Part 1, Type 2 (steel wire armour).

24 V dc Digital (On/Off) signals

1. Plain annealed multi-stranded copper conductors, solid polyethylene insulation
2. Collective aluminium mylar screen including drain wire,
3. Solid polyethylene bedded steel wire armour with an outer sheath of flame retardant PVC.
4. PVC sheath to be blue for intrinsically safe circuits, black for ac and dc non-intrinsically safe circuits.
5. 600/1100 V grade to IS 7098 : Part 1, Type 2. (steel wire armour).

13 CABLE CONTAINMENT

13.1 General

Every cable shall be installed in a single length without joints.

Double compression cable glands shall be used to terminate each end of every armoured cable conforming to IS 4218. Exterior cable glands shall be weatherproof IP66 three part EIW types (CMP), and ATEX rated for installations in explosive hazardous areas. The cable gland for every cable rated up to 1100 V shall be constructed from brass.

Every cable shall be identified at each end, in line with the cable schedule, and with a unique cable number and reference related to;

1. P – Power,
2. I – Instrumentation,
3. C – Control,
4. IS – Intrinsically Safe Circuit (outer sheath colour light blue),

Instrumentation and Control cables carrying analogue and digital signals shall be separated from LV power cables by at least 300 mm and HV power cables by at least 600 mm.

Telecommunication cables shall be segregated from all other cables by, at least 600 mm.

13.1.1 Cable laying shall be initiated only after approval of entire cable route

13.2 Cable Support Systems

1. Cable trays and supports shall be in accordance with IEC 61537.
2. Cable tray supports shall provide adequate strength with minimum rigid support to the fully laden cable tray along its entire length.
3. All cable trays inside the control room and out of the trench shall be enclosed with a cover or lid.
4. A maximum of two layers of cable shall be installed on any tray/ladder.

Trays for Power Cables:

1. Ladder type cable trays shall be used for power cables. Material of construction shall be of aluminium.
2. Minimum thickness of all ladder type cable trays shall be 2 mm for trays up to 300 mm width, thickness shall not be less than 2.5 mm for trays above 300 mm up to 600 mm. Minimum supports shall be provided to maintain minimum deflections of cable trays and ladders to manufacturer's recommendations.
3. Depth of all power cable trays shall not be less than 100 mm.

Trays for Control and Instrumentation Cables:

1. Perforated type cable trays shall be used for control and instrumentation cables. Material of construction shall be of aluminium.
2. Minimum thickness of all perforated cable trays shall be 1.6 mm for trays up to 150 mm width, not less than 2 mm for trays from 300 mm to 450 mm and above 450 mm width of cable trays, thickness shall be minimum 2.5 mm. Minimum supports shall be

provided to maintain minimum deflections of cable trays and ladders to manufacturers recommendations.

3. Minimum height of all perforated cable trays shall not be less than 50 mm.
4. All perforated type cable trays shall be closed with aluminium covers.

External Cable Containment

1. Cables external to buildings and structures shall be installed underground in ducts/trenches buried to a minimum of 700 mm or 1000mm under roadways or along the roadways respectively.
2. In ducted section of cable routes the specified segregation between power and control cables shall be maintained throughout the ducted section and within cable duct manholes and draw chambers provided by the Contractor for installing cables.
3. Duct systems shall incorporate suitably located draw-pits/inspection chambers/pull boxes wherever there is change in direction of route of the cable or straight length is more than 200 m.
4. A minimum 35% space inside ducts shall be kept for future expansion.
5. Conduits shall have a minimum space of 45%, trunking 40%, cable tray 50%, and trenches 35%.

Cable segregation

1. Power systems operating at different voltages and control, protection and instrument circuits for separate units of Plant shall be in separate cables or conduits and shall be in separate runs.
2. On internal cable installations adequate spacing shall be maintained between all power cables to minimise de-rating due to proximity.
3. Instrumentation and Control cables carrying analogue and digital signals shall be separated from LV power cables by at least 300 mm and HV power cables by at least 600 mm.
4. Analogue and dc control signals must not be run in the same cables. A minimum 300 mm spacing shall be maintained between both analogue and dc control cables and all other cable systems.

13.3 Cable Ducts

Rigid ducts shall consist of:

1. Un-plasticised PVC pipe work, complying with IS 4985 or other equivalent Indian Standard;
2. Corrugated plastic ducting (inside building and through slabs)

Underground cable runs shall be marked by cable covers or a suitable warning marker tape.

Rigid ducting shall have proprietary self-aligning, water-tight joints and a smooth internal bore.

Sufficient ducts shall be installed to provide a spare capacity of 20%. Under roadways carrying vehicular traffic, sufficient ducts shall be installed to provide a spare capacity of 50%, subject to a minimum of 2 ducts.

All joints in the duct system shall be achieved using proprietary accessories of the same material as the duct. All changes in direction in the duct system shall be achieved using draw pits.

The maximum length of a straight duct run (between draw-pits) shall be 100 m.

Ducts shall be installed perpendicular (90°) to roadways carrying vehicular traffic and haunched in concrete to prevent damage. The duct shall be extended beyond kerbs by a minimum of 750 mm.

Ducts shall be laid on and surrounded by a backfill material that will not cause damage to the ducts.

Ducts passing through floors shall terminate approximately 75 mm above the floor surface. Upon completion, all duct runs shall have a swab drawn through to clear any obstructions.

Ducts shall be left with an excess 1 m length of 8 mm diameter nylon draw-cord in place and anchored at each end.

13.4 Draw-Pits

The minimum draw-pit size shall be at least 750 mm^2.

Mechanical lifting equipment shall be provided if draw-pit covers cannot be safely removed by one person.

Draw-pits shall be provided with suitable drainage.

Draw-pit sizing shall facilitate cable installation and maintain cable segregations while allowing for the minimum cable bending radii.

Draw-pits installed under roadways carrying vehicular traffic shall be fit for purpose.

13.5 Installation of Cables in Ducts

If draw cords are used to pull cable through ducts, a replacement draw cords shall be drawn through with the cable.

Proprietary pulling socks shall be used to attach a draw line to larger cables. Care shall be taken to ensure that cable tensions are maintained below the cable manufacturer's specifications.

Where practicable, cables shall be pulled directly off the drum (which shall be free to rotate) into the duct system. Cables shall not contain any kinks or twists resulting from manual handling.

Where a cable exits a duct, it shall be supported between the duct exit and the start of the fixed wiring support system or entry into another duct.

13.6 Conduits

Metallic Conduit:

1. Internal non-wet area's may utilise black stove enamel steel conduits, all exterior or wet area conduits shall be of rigid galvanized steel, unless otherwise specified. The galvanization process shall have three stages: Surface Preparation, Galvanization and Inspection. All metallic conduits shall be as per IS 9537 (Part II)

Non-Metallic Conduit:

1. All exposed, wet, or corrosive indoor conduits, underground, concealed or concrete embedded conduits shall be of high impact rigid uPVC unless specified otherwise. Conduits in classified areas shall be of uPVC material as per latest Indian Standard.

2. Conduits shall be circular with mechanical strengths as per area requirement i.e. low mechanical strength for indoor conduit installation and high mechanical strength for outdoor and buried application.
3. Conduit shall be durable and impact resistant as per IS 9537 and IS 14927.
4. Conduit shall be fire retardant and corrosion resistant as per IS 9537.
5. Conduit shall have negligible water absorption.

Corrugated Flexible Conduit:

1. uPVC covered metallic corrugated flexible conduits shall be manufactured as per IS 9537 ideally suited for electrical wiring and cable protection.
2. Liquid-tight, flexible, uPVC conduits for termination at junction boxes, local control stations termination to motors, field instrumentation and process equipment shall be used unless otherwise specified.

Conduit Fittings:

1. Fittings, as required, for use with the conduit specified, with coating and colour the same as conduit shall be provided.
2. All conduit fittings and covers shall be weatherproof and watertight as per Indian Standard 3419, unless otherwise noted.

Conduit Fastenings:

1. Use uPVC straps for uPVC conduits and steel straps for galvanized steel / galvanized iron conduits.
2. Channel type supports shall be provided for two or more conduits.
3. Conduit runs shall be designed to accommodate thermal expansion.

Expansion Fittings or Couplers:

1. Appropriate water-tight expansion sleeves with bonding where conduit crosses a structural expansion joint or to accommodate for thermal movement due to temperature change on surface installations, complete with grounding strap and clamps shall be provided.
2. Expansion couplers shall be installed with a short side coated with solvent cement and coupler pushed firmly over the conduit down the nib. The slip side coated with silicon grease receives the conduit to a midpoint to the nib. This will then permit for expansion or contraction providing the conduit is free to move in the saddle.

Outlet and Conduit Boxes:

1. Outlet boxes shall be sized in accordance with IS 3419.
2. Appropriate switch enclosures shall be provided where wiring devices such as switches, fan regulators etc. are grouped.
3. Blank cover plates shall be provided for boxes without wiring devices.
4. Where outlet boxes contain multiple circuits care shall be taken to ensure the isolation of each circuit from the others to prevent accidental exposure to live parts.
5. Outlet boxes made from uPVC or galvanized steel and shall be suitable for mounting/fixing on masonry and/or concrete construction and shall be flush mounted or surface mounted as per site requirement.
6. All underground fittings, boxes and covers, shall be weatherproof conforming to relevant IS unless otherwise noted.

7. Outlet boxes, conduit boxes and fittings for hazardous locations shall be as per IS 5571.

Hazardous Areas:

1. For hazardous areas, epoxy coated, rigid galvanized-steel conduit, conduit fittings, compounds etc., to conform to the code's requirements for the specific type of hazardous.
2. All boxes, fittings and joints shall be threaded for connection to conduit terminations and shall be explosion proof. Threaded joints shall be made up with at least five threads fully engaged.
3. For flexible connections at motor terminals, liquid tight flexible conduit and fittings approved for Zone 1 locations shall be provided.
4. Conduit, conduit fastener and conduit fittings shall be made of rigid, galvanized-steel and procured from manufacturers of good repute.

Markers:

1. 300 mm wide red polyethylene cable marker tape, with the following imprinted continuously over its entire length: 'DANGER-'sign of Skull & Bones' BURIED ELECTRIC CABLE BELOW' in both English and the principal language of the region.
2. Circular cable route marker posts made of stainless steel of diameter 100 mm and thickness not less than 4 mm. shall be used for cable route indication. The inscription shall indicate the presence of a cable below, the depth and voltage rating.

Sealing Compound:

1. Conduit fittings shall be installed in the system using solvent cement for restriction of water and silicon grease where installation is subject to frequent changes.
2. PVC solvent cement shall be used as a method of joining uPVC conduit into fittings couplings, adaptors, bends and boxes, especially formulated for watertight joint.

14 EARTHING SYSTEMS

14.1 General

The Earthing System shall be designed in accordance with IS 3043.

The resistance to earth of each earth electrode system on its own shall not exceed the value specified in the IS 3043.

The Contractor shall supply all calculations used in the design of the Earthing System to the Employer's Representative for approval and record keeping.

14.2 Earthing Arrangements

The main earth bar shall be:

1. sized appropriately for the rating of the transformer(s) and shall, in any event, be not less than 50 x 6 mm
2. constructed from tinned copper
3. located and mounted to facilitate regular testing.

The main earth bar shall be connected to the following:

1. The local network of earthing, lightning down conductors shall be earthen separately.
2. The neutral of the secondary winding of each transformer substation. This shall via bolted sections to allow for their isolation for testing
3. The earth bar in the power or motor control centre which is fed from the transformer(s)
4. The casings or enclosures of each transformer, motor and other electrical equipment.
5. Supplementary bonding of potentially conductive parts in the locality, such as: metal walkways, stairways, handrails and mechanical plant.

A separate 'clean' earth bar shall be provided for Instruments, Control and Automation.

Transformer Substation Earthing:

1. According to the classification of the installation: 'Hot' or 'Cold' the HV earth shall be connected as follows:
    1. 'Hot' installations – the neutral point of the secondary winding (DYn11) shall be isolated from the HV earth.
    2. 'Cold' installations – the neutral point of the secondary winding (DYn11) shall be connected to the HV earth.

Earth Electrode System:

1. Earthing pits shall comprise of MS pipe with copper coating of 250+ micron, filled with high conductive and corrosion resistance back fill compound around electrode. Installation of the electrodes, including separation, shall be as per IS 3043.
2. Marker posts and plates shall be provided to mark the route of buried electrodes. The markers shall be similar to those provided for cable routes.

Earthing of Power or Motor Control Centre, Distribution Boards:

1. Earth busbars shall be of Galvanized Iron and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second and be appropriately supported and reinforced within the enclosure.

2. Positive connection of all the frames of equipment mounted in the switchboard to the earth busbar shall be maintained through conductors of size equal to the ground busbar or the load current carrying conductor, whichever is smaller. Earthing of drawout equipment frames shall be achieved through a separate plug-in contact.
3. All instruments and metallic, relay cases shall be connected to earth busbar by means of 1100 V grade, PVC insulated, stranded, tinned copper, 2.5 mm^2 conductor, which shall be looped through the case earth terminals.
4. The earthing Galvanized Iron conductor located below ground level shall be coated with tar and every welded joint for earthing shall be coated with tar.

15 LIGHTNING PROTECTION

15.1 General

The lightning protection system (LPS) shall be designed in accordance with IEC 62305.

An assessment of the building lightning risk shall be conducted by the Contractor to determine the appropriate lightning protection level and suitable external and internal lightning protection systems shall be designed appropriate to the lightning protection level.

The LPS shall protect structures from damage and dangerous internal sparking due to lightning strikes.

Material for lightning protection shall be copper.

The LPS shall protect the structure by:

1. Intercepting a lightning flash to the structure by the mesh method on flat roofed areas.
2. Intercepting a lightning flash to the structure with an air termination system:
    a) An interception rod shall provide protection to objects on the roof such as solar panels, HVAC equipment, water tanks etc. against direct lightning strikes based on a protective angle or rolling sphere methodology.
3. Conducting the lightning current safely to earth (using a down conductor system)
4. Disperse the lightning current into earth

The LPS shall protect personnel from injury by:

1. Reducing the exposure to dangerous currents by insulating exposed conductors and/or increasing the surface soil conductivity;
2. Reducing the exposure to dangerous currents by physical restrictions; and
3. Erecting warning notices

15.2 Air Termination

A mesh air terminal shall be provided on flat roofs for intercepting direct lightning strikes. The size of the mesh shall be as per the selection of the lightning protection level and shall be based on IEC 62305.

Interception rods shall provide a protection area against direct lightning strikes, based on either the protective angle or the rolling sphere methodology. The calculation of the protection radius shall be based on the rolling sphere methodology as per IEC 62305 standards.

In order to reduce the probability of damage to electronic/electrical equipment, the down conductors shall be arranged in such a way that from the point of strike, several parallel current paths shall exist and the length of the current path shall be minimised. The distance between down conductor shall be as per IEC 62305.

At the connection of the earth terminal, a test joint shall be fitted on each down conductor to enable the earth resistance value to be measured.

15.3 Expansion of Metal

In order to accommodate the expansion and contraction of the conductor, expansion pieces with suitable connectors shall be provided to the mesh on the flat roofed areas.

15.4 Lightning Arrester and Accessories

Lightning arresters with all the associated accessories required for protection from direct lightning surges shall be made from corrosion proof material as per IEC 62561. Lightning components shall be protected from natural weathering and exposure to corrosion. Electrical tests with the lightning wave shape i.e. 10/350 µs with a test impulse as per selected lightning protection level and mechanical tests shall be carried out on the lightning protection system components. The test certificates shall be submitted to the Engineer.

Dissimilar metals shall be connected using bimetal connectors. Drilling or welding shall be avoided for installation of the vertical air termination.

15.5 Surge Protection Device

Surge protection devices (SPDs) shall be fitted as appropriate to protect the electrical and electronic plant from damage due to:

1. Indirect lightning strikes;
2. Switching surges on the incoming mains electricity supply;
3. Surges on the exterior/outdoor power, control and instrumentation cables entering a building or structure;
4. The rapid interruption of the current flowing through a transformer, motor winding or other inductive device which can occur, for example, when a vacuum contactor opens; and
5. Equipotential bonding between structural metal components, metal installations, internal systems and external conductive components and lines.

Switching surges and indirect lightning surges may cause damage to the LV distribution network. The SPDs shall provide protection against such over voltages. Type I protection shall be provided for indirect lightning surges, Type II protection shall be provided for switching surges and Type III protection shall be provided for instrumentation all fully co-ordinated to avoid the false operation of SPDs. SPDs shall be efficient and shall provide reliable protection for the low voltage network and equipment.

The operating condition of SPDs shall be able to be determined at any time and easy access shall be provided for maintenance and replacement as required.

SPD selection, installation, testing, commissioning and maintenance shall be as per IEC 61643 and IEC 62305.

15.6 Earthing System

The earthing system shall be as per IS 3043 or IEC 62561. The resistance of the earthing system shall not exceed 10 ohm as per IEC 62305. Independent earthing system including earth pits shall be provided for the lightning system.

16 ELECTRIC ACTUATORS

16.1 General Technical Requirement

Each electrical actuator shall be designed and selected in accordance with the requirements stated as per the IS: 9334 and relevant Indian and International Standards.

All electric actuators shall conform to the requirements of AWWA Standard. The actuator shall be suitable for installation in any position without lubricant leakage or operational difficulty.

Actuator shall be modular in construction having 'Plug-in' type connection between integral starter unit and basic actuator for easy repair maintenance

Actuators shall be suitable for the environment installed, i.e. tropicalised (India), or for example if for a hazardous area shall be with flame proof design and suitable for operation in atmosphere that may contain H_2S, CH_4, CO etc. which emits from the sewage.

The main gearbox of the actuator shall be special quality grease filled, suitable for outdoor purposes. Each actuator shall have a hand wheel for manual operation.

Clockwise operation of hand wheel shall cause clockwise movement of the output drive. The hand wheel shall be clearly marked with an arrow and the words OPEN / CLOSE.

Power drive shall have a preference over manual drive. The hand wheel shall automatically disengage when the power to the motor is restored.

Actuators shall have local position indicator to display and communicate the physical position (open, close and intermittent) of the valve or gate.

Actuator shall maintain and update position indication during hand wheel operation when external power to the actuator is isolated and shall update position indication when external power to the actuator is restored.

In order to minimize the inventory of spare parts, such as limit switches, torque switches, counter gear assembly, torque switch drive assembly, mechanical position indicator assembly etc. shall be interchangeable type, for the different models offered.

The actuator shall be painted with corrosion resistant Zn rich primer followed by epoxy resin paint. Paint shade shall be RAL 7032 or RAL 7035

In order to prevent condensation, a space heater shall be provided in the switch compartment, suitable for continuous operation.

16.2 Limit and Torque Switches

Independent torque and limit switches shall be provided in the actuator. A minimum of two position limit switches and two torque switches, one each for each direction of travel, having 2 NO + 2 NC potential free contacts shall be supplied. Also, two additional limit switches shall be provided for intermediate positions.

Torque switch dial shall be graduated directly in 'kg-m' for easy setting to desired value within the range specified. Separate dials shall be provided for CLOSE and OPEN torque switches. The rating of both torque and limit switches shall be 230 V ac and 5 amperes.

The switches shall individually be enclosed to a minimum of IP66 protection class.

Torque and limit switches shall have non-corrosive material like stainless steel flaps for protection against environmental conditions.

Limit switches shall be operated by gear driven cams, which are mechanically linked to the driving devices. The counter gear used for counting and tripping the limit switches shall be of metallic construction. No plastic gearing shall be allowed.

To guarantee proper function under high ambient temperatures, torque and limit switch sensing shall be of mechanical type.

16.3 Electric Drive Motors

Motors shall be specifically designed for valve actuator operation, which is characterized by high starting torque, low stall torque & low inertia. All motors shall be high starting torque type to facilitate 'unseating' of valves.

Motors shall be suitable for power supply of 415 V, 3 ph, 50 Hz, ac and be suitable specifically for local, outdoor, climatic conditions.

Motors shall be squirrel cage induction type and shall generally conform to IS 325.

Motors shall be suitable for ON-OFF/Inching duty having S2-15 Minutes rating (for ON-OFF - 60 starts/hour & for Inching - 150 starts/hr)

Motor shall have minimum class 'F' insulation with external temperature rise restricted to class 'B'.

Motors shall be of totally enclosed surface cooled type with IP-67 protection class after mounting on actuator.

Motor shall have three thermostats connected in series, one in each phase of stator winding, for protection against overheating.

Motors shall be suitable for operation under varying supply conditions:

1. Voltage variation of +/- 10%,
2. Frequency variation of +/- 5%
3. Combined voltage & frequency variation of 10% absolute.

Motors shall be suitable for direct on-line (DOL) starting.

It shall be possible to separate the motor from the lubricant filled gearing of the actuator allowing easy replacement of motor without losing any lubricant regardless of mounting position.

Fins shall be provided on the motor body to ensure heat dissipation.

An arrangement shall be incorporated to change the output RPM of the actuator, if required, at the site at a later date, without hampering the mounting arrangement and loss of any lubricant.

The motors shall be supplied with reversing contactor starter, capable of starting from any position of the valve. The contactor starter and a set of push buttons with the words clearly marked 'OPEN' 'STOP' & 'CLOSE' shall be supplied with the actuator's control panel.

The starter shall comprise of mechanically and electrically interlocked reversing contactor of appropriate rating to the motor size. The maximum control voltage shall be grounded so that the contactor shall drop out in the event of leakage to earth.

The thermal cutout device shall be provided to automatically disconnect the valve operating motor under overload conditions.

Actuator shall be provided with following protection features:

1. Stall - the motor shall be de-energized in the event of a 'stall' when attempting to unseat a jammed valve.
2. Over temperature - thermostat will cause tripping of the motor and shall auto-reset when normal temperature is attained.
3. Single phase protection with a potential free contact for the annunciation of power supply failure.
4. Thermal overload relay of appropriate capacity to trip the actuator in case of overload.
5. Automatic phase correction facility.
6. It shall possible to reverse the direction of travel instantaneously without giving a Stop command. The motor starter shall be protected from excessive current surges during rapid travel reversal.

16.4 Integral Starter with Controls

The starter unit shall be with electronic control logic. Entire unit along with basic actuator shall conform to IP 67 standard of enclosure.

The starter unit shall be with electric interlock system, so that when the valve is under manual control, the electric motor cannot operate.

Three push buttons i.e. OPEN-STOP-CLOSE shall be provided for local operation.

The starter unit shall have electro-mechanical reversing contactor, control transformer and fuses etc. The Contactor coils shall be suitable for 230 V, 1 ph, 50Hz, ac operation.

It shall be possible to reverse valve travel without the necessity of stopping the actuator. The motor starter shall be protected from excessive current surges during rapid travel reversal.

The internal circuits associated with the remote control and monitoring functions are to be designed to withstand simulated lightning impulses.

The starter unit shall posses the following safety features:

1. Anti-hammer protection
2. Instantaneous protection
3. Jammed valve protection/auto re-try.

Actuators shall have suitable sensing unit for remote position transmission in the form of 4 to 20 mA. Necessary power supply to position sensing unit will be derived internally. The accuracy of position shall be less than 1%. The transmitter shall have screws for span settings.

Isolated 24 V dc output shall be available from actuator for client's use and for electronic cards.

Actuators shall have microprocessor based control logic with integral terminal box to transmit hardwired control and status signal to the Instrument control panel.

Contacts shall be provided which can be selected to indicate any position of the valve, Provision shall be made for the selection of a normally closed or open contact form. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.

The contacts shall be rated at 5A, 250V AC, or 30V DC.

As an alternative to providing valve position any of the above contacts shall be selectable to signal one of the following:

1. Valve opening, closing or moving
2. Thermostat tripped, lost phase
3. Motor tripped on torque in mid travel, motor stalled
4. Remote selected
5. Actuator being operated by handwheel

Provision shall be made in the design for additional contacts having the same functionality.

Provision shall be made in the design for the addition of a contactless transmitter to give a 4-20mA analogue signal corresponding to valve travel for remote indication when required. The transmitter will auto range to the set limits

The following are the minimum Status/Alarm signals require to be available from actuators:

1. Actuator running in; OPEN direction.
2. Actuator running in; CLOSE direction.
3. Actuator – Full Open
4. Actuator – Full Close
5. Torque switch OPEN tripped.
6. Torque switch CLOSE tripped.
7. Thermal overload relay tripped,/Thermostat trip, phase lost, 24VDC supply lost, Local control failure
8. Selector switch position LOCAL-REMOTE-OFF.
9. Configuration error, Position sensor failure, Torque sensor failure
10. Single phasing / power supply failure.
11. Loss of main or auxiliary power supply
12. Battery Low (if standby battery power pack fitted)

All above signal shall be available on local display as well as on PLC-SCADA system

Wherever required, reversing contactor starter, control module, local push buttons, selector switch etc. of actuator including housing shall be suitable for wall mounting (away from basic actuator). Suitable connectors shall be provided within the actuator and wall mountable actuator control unit to have a proper connection between basic actuator and starter unit including electronic control unit. Connector shall be provided with proper mechanical protection.

Control facilities

1. The necessary control, wiring and terminals shall be provided in the actuator for the following functions:
2. ‘Open’ and ‘close’ external interlocks to inhibit ‘local’ and ‘remote’ valve opening and/or closing control. It shall be possible to configure the interlocks to be active in remote control only.
3. Remote controls fed from an internal supply to be suitable for any one or more of the following methods of control:

a) ‘Open’, ‘Close’ and ‘Stop’ control.

b) ‘push to run’ (inching) control.

c) Overriding Emergency Shut-down to ‘Close’ (or ‘Open’) valve

Integral data logger to record and store the following operational data:

1. Opening last /average torque against position
2. Closing last /average torque against position
3. Opening motor starts against position
4. Closing motor starts against position
5. Total open/closed operations
6. Maximum recorded opening and closing torque values
7. Event recorder logging operational conditions (valve, control and actuator)

The data logger shall record relevant time and date information for stored data.

16.5 Cable Terminals and Cable Glands

All control and power terminals meant for client connection shall be brought out to 'plug / socket' type connectors to facilitate quick disconnection without disturbing the existing wiring, in case of maintenance/repair and use of portable test equipment for pre-commissioning testing. The plug-in type connectors shall be suitable for termination of wires of size 2.5 mm^2 (max) for control and 4 mm^2 (max) for power connections.

Two earthing terminals shall be provided on either side of the motor.

Actuators shall be provided with a minimum of 3 no. double-compression, nickel-plated-brass cable- glands of the appropriate size.

Internal wiring shall be of a tropical grade PVC insulated, stranded cable of appropriate size for the control and 3-phase power circuit. Each wire shall be clearly identified at each end. The terminals shall be embedded in a terminal block of high tracking resistance compound. The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal.

16.6 Testing & Inspection

The following tests shall be conducted as a minimum requirement:

1. Routine tests on motors shall be as per IS 325.
2. Functional test on actuator and each accessory.
3. Insulation resistance and high voltage test.
4. Stall current and stall torque test.
5. Output shaft speed and actuator output torque and corresponding current tests.

16.7 Certification

For the following type tests carried on similar actuator frame size / models shall be furnished for reference / records:

1. Degree of protection tests for the enclosure.
2. Temperature rise test.
3. Type test for motor shall be as per IS-325.

17 INSTRUMENTATION

17.1 General

Instrumentation system shall be designed, manufactured, installed and tested to ensure high standards of operational reliability. Instrumentation shall be selected with performance parameters appropriate to the process, the process media and the location.

All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design. No custom made hybrid type integrated circuits shall be used.

All digital outputs from the instruments shall be volt free. Unless otherwise stated, overall accuracy of all measurement systems shall be ±1% of measured value, and repeatability shall be ±0.5%. Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range. Zero and span adjustments shall be provided for all instruments. The transmitters shall be provided with on-line test terminals.

The installation shall avoid any degradation of instrument performance due to spurious reflections, absorptions, sound velocity, variations, sensor detection area, temperature fluctuation, specific gravity changes and condensation. Facilities shall be provided for rejection of spurious reflection. The performance of all instruments shall be unaffected for the ±10% variation in supply voltage and ±5% variation in frequency simultaneously.

Wherever necessary access ladders/ platforms shall be provided for maintenance and operation of the instruments.

On return of power after an electrical power failure, all instrumentation and controls shall function automatically without any reset action required by personnel. The Contractor's attention is drawn to the requirements of installations which require being "FAIL SAFE". Instrumentation systems shall be designed such that failure of the system shall not result in damage to plant or result in the development of a hazardous situation.

The mode of operation of any device used for alarm signalling shall be such that on failure of the power supply, the devices shall de-energize and actuate the alarm even if no alarm condition exists.

All wetted parts of the sensors shall be made of non-corrosive material. The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

Unless otherwise stated, field mounted electrical and electronic instruments shall have minimum ingress protection as IP-65. All instruments of submersible type shall be protected to IP-68. Where a unit is fitted in a panel or other enclosure, it shall preserve the design IP rating of that enclosure. Cable connections to instrumentation systems shall not reduce the IP rating of the device..

The instruments shall be designed to work at the temperature, humidity, and chlorine contamination levels that may prevail at site. Materials which are exposed to the process fluid shall not corrode. In all cases materials shall be chosen that are compatible and that

no chemical or electrochemical actions are present other than those intended. Instrument enclosure shall have corrosion–resistant properties. Enclosures of all the field instruments shall have locking arrangement.

All field instruments, and cabinets/panel mounted instruments shall have stainless steel tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Client for approval before any labels are manufactured.

All coated parts of sensors shall be made out of non-corrosive material capable of working against chlorine content up to 5 ppm.

Instrumentation shall be selected and installed with due regard to application, security, reliability and the environment in which it is installed.

Instrumentation systems shall in general comprise a sensor and a converter unit. The sensor shall be sited in or above the fluid or medium being measured.

The converter shall be housed where practical within the associated control panel or motor control centre common control section.

Where this is not possible the transducer shall be mounted in the field or in a nearby enclosure where it shall be readily and safely available for maintenance and calibration purposes.

Converters shall not be located in a hazardous area.

Converter units shall provide facilities for configuring the instrumentation system and shall provide an LCD display of the measured parameter, programming facilities and fault annunciation.

Analogue instruments shall provide an isolated 4 to 20 mA output proportional over the range of the measured parameter.

17.2 Selection and Installation

Instrumentation shall be selected and installed in accordance with the manufacturer's instructions.

Wherever practical components of similar systems shall be interchangeable, i.e., open channel flume flow measuring systems and open sump or tank level measurement and pump control systems shall incorporate identical sensors and converter units.

17.3 Construction

Instrumentation systems shall be modular in construction with individual modules or circuit boards easily removable. Circuit boards shall be protected against the effects of moisture and shall comply with BS 6221 (IEC 60326).

17.4 Environment

Atmosphere

1. A sewage works atmosphere is generally damp and dirty, containing trace amounts of hydrogen sulphide. Instrumentation systems shall be resistant to corrosion for the life-time of the Works. Support systems and housings for field mounted instrumentation devices shall be non-metallic.

17.5 Level Instrumentation

Owing to the nature of sewage and sewage sludges, non-contact methods of level measurement are preferred. Where foaming problems are identified as a local concern, the level measurement by level transducer shall be considered. Float switches are reserved for emergency high level indicators and/or controls where they would not normally be in contact with the medium.

The sensor head shall be protected to IP 68.

Sensing heads shall be mounted on 316 stainless steel brackets and positioned to ensure an unhindered beam path and ease of access for maintenance.

The signal converter shall be supplied in an IP 65 polycarbonate enclosure and shall comprise a base unit and a programming device.

A converter four digit liquid crystal display shall be used to indicate key programming features, settings and output conditions.

Accuracy shall be better than 0.25% of the measured distance with a resolution of not less than 1% or 2 mm whichever is the greater.

The signal converter shall have the following programmable outputs:

1. 4 -20 mA proportional to level in user definable engineering units.
2. SPDT relay contact output closing upon failure of the signal converter or lost echo.
3. Three SPDT contact outputs with independently set trip points. These outputs shall be programmed to energise upon high/low level, rate of change or to allow a number of pump sequencing operations.

Non-volatile memory shall contain all set points and display data. It shall be possible to select fail safe modes as high, low or hold.

Temperature compensation shall be provided where necessary in order to ensure the required signal accuracy.

Float Switches

1. Level switches of the buoyancy type shall consist of a non-mercury switch with changeover action enclosed in a non-corrodible material. A balance weight shall also be incorporated in the switch to counteract the buoyancy effect of the specific gravity of the particular fluid. The connecting cable shall be factory sealed to the switch.
2. Level switches shall be installed with a minimum of 2 m of spare connecting cable neatly coiled at a supporting bracket. The connecting cable fixing shall facilitate any alteration in operating level within the limit of the spare cable.

Ultrasonic level sensor as sludge Level Detector

1. This device is used to detect a sludge blanket level.
2. The device shall operate on ultrasonic principles employing two sensors acting as transmitter and receiver. The absorption of the beam by the presence of a sludge or slurry shall initiate a switching action which may be used for control purposes.
3. The device shall be unaffected by vibration, temperature or viscosity of medium being detected.
4. The ultrasonic sensor frequency shall be selected with regard to the medium in which it is to be used.
5. For sludge blanket level detection the sensor shall be suspended/fixed in the tank concerned at the required level. The sensor shall be secured to a corrosion resistant

pipe in order to 'steady' the sensor. It shall be possible to adjust the level of the sensor and to remove it easily if required for checking and cleaning.

6. Pipe mounted sludge detectors shall be mounted on opposite sides of a pipe section with the sensor faces flush with the inner pipe surface, in order to promote self cleaning of the sensor faces by the flow of sludge. The pipe section shall be lined with an epoxy lining or other suitable chemical resistant lining material in order to prevent the build-up of grease in the region of the sensors.
7. The sensors shall operate in conjunction with a converter. The converter shall be provided with the following features:
   a) LED sensor status indicators
   b) DPCO relay output
   c) Internally selectable time delays (typically 0.5 to 30 seconds).
8. The converter shall be provided with sensitivity control typically providing a range of 1:20.

18 PROGRAMMABLE LOGIC CONTROLLERS

18.1 General

Programmable logic controller (PLC) selection shall performed according to the following criteria:

1. Select a micro PLC when:
   a) Number of I/O is LOW
   b) PLC shall be used to control small installations or single pieces of equipment
   c) The control functionality required is limited.
2. Select a standard PLC when:
   a) Number of I/O is AVERAGE
   b) PLC shall be used to control average installations or process areas
   c) The control functionality required is average.
3. Select a comprehensive PLC when:
   a) Number of I/O is HIGH
   b) PLC shall be used in high availability, mission / safety critical systems (IEC 61508); perhaps with redundant processors.
   c) The control functionality has high / intensive memory demands for precise, real-time control of multiple plant.

The PLC system shall be designed and installed in accordance with the manufacturers' instructions, guidance and recommendations, and shall also be suitable for the environment installed, i.e. tropical, industrial, hazardous etc.

The PLC shall be compliant with the latest versions of IEC 61131.

The PLC shall be fully compatible with the 'field-bus' and networking communications protocols to be deployed and shall be officially certified as such by the relevant communication protocol's industrial body.

The PLC system design shall comply with the Clients' preferences and standards.

A twin single-phase LV ac metal clad socket with suitable protection and 30 mA Residual Current Device (RCD) shall be installed in close proximity to the PLC for the purposes of powering a standard notebook / laptop computer.

A Type-3 (class-3), IEC 947-1, surge suppression device shall be installed on the PLC power supply. The PLC's control and instrumentation interfaces with plant devices may employ either or both of the following and shall be housed in one or more PLC module banks:

1. digital and / or analogue input/output (I/O) cards
2. 'field bus' or 'serial' communication cards

Network communication cables shall be directly connected to components using proprietary connectors appropriate to the network installation e.g. RJ45 for ethernet shielded twisted pair (STP)/unshielded twisted pair (UTP) cabling etc. Jointing or splitting the network by any other means shall not be permitted.

Isolation of analogue signals shall not be compromised by the earthing arrangements of the signal wiring.

Segregate differing voltage levels on separate I/O modules.

Where an output is being used to control inductive devices include an additional suppression device compliant with the manufacturers' recommendations and electro-magnetic compatibility (EMC) regulations and directives.

All interposing relays shall have interference suppression on the coils of all contactors and relays. Only one output device shall be directly connected to any one PLC output module terminal.

The PLC system shall be expandable, OPC (Open Productivity and Connectivity) Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC System (Panel) shall be housed in a dust free, air conditioned environment.

18.2 I/O Modules

General:

1. PLC I/O modules shall be rack mounted.
2. I/O cards shall be connected to field marshalling terminals using proprietary disconnect type I/O card connectors and multi-core cable harnesses.
3. The maximum number of discreet digital inputs and outputs per card shall be 32. The maximum number of analogue signals per card shall be 8. Status indication of each digital input and output shall be provided on I/O cards.
4. Each individual input and output to the PLC shall be optically isolated from the field to the PLC backplane (minimum 500 V dc peak to peak).
5. The maximum voltage on any I/O card shall be 24 V dc.

Digital Inputs (Non-pulsed)

1. Non-pulsed digital inputs shall be provided with volt-free contacts/solid state devices from field equipment and shall be 'fail safe'.
2. Interposing protective relays must be supplied and fitted into the MCC and appropriate electrical segregation/shrouding and barriers installed if 240 V ac field voltages are to be used.
3. Non-pulsed digital inputs shall be supplied with Opto-Isolators.

Digital Inputs (Pulsed)

1. Pulsed digital inputs for count or totalising purposes shall be provided with volt-free contacts/solid state devices from field equipment and shall provide contacts that close or switch true (1 input) on each count to be registered by the PLC.
2. Input circuits shall be powered from the PLC. Digital inputs/solid state devices shall be provided with a 24 V dc or 240 V ac supply from the MCC.

Digital Outputs

1. Interposing relays shall primarily be used for interfacing differing control voltages or high current applications.

2. Interposing relays for signal duplication may be used however it is preferable that this application is minimised and that duplication is provided by the signal's originating device.
3. Interposing relays may act as sacrificial components to surges where signals leave a building.
4. Relays shall be arranged to energise a normally open contact suitably rated for the intended switching duty.

Analogue Inputs

1. Analogue inputs shall be in the form of 4-20 mA dc current loops with the maximum loop impedance not exceeding 250 ohms.
2. Each analogue input loop shall be powered by its associated instrument where the instrument is device powered.
3. Critical loops shall be powered by individual power sources.
4. Use of loop-powered instruments are discouraged but shall be supplied with signal isolation where its use is required.

Analogue Outputs

1. Analogue outputs shall be of the 4-20 mA dc current loop type, with a 12-bit minimum conversion resolution and shall be capable of driving 0-500 ohm impedances.
2. Analogue outputs shall have a direct connection to the load.

PLC I/O Marshalling

1. All PLC I/O, whether allocated, unallocated or unused, shall be wired to knife disconnect marshalling terminals via interposing relays where such interposing relays are required. All marshalling terminals shall be mounted within the ICA section.
2. Note that pre-wired cabling systems to terminal blocks are preferred.
3. All hazardous area signal cabling shall be segregated within the MCC and cables routed to avoid causing any interference or induced signals.
4. Common terminals for signal 'wetting' as required by the PLC I/O modules shall be included.
5. Reserve terminal rail capacity, panel space and services shall be allocated to allow a future minimum expansion of 10%.
6. All unused analogue inputs shall be terminated as recommended by the PLC equipment manufacturer.
7. The Contractor shall test that all marshalling terminals are connected to the correct digital and analogue I/O and shall provide a dedicated drawing detailing the terminals, reference numbers and descriptions prior to commissioning.

HMI Interface

1. Plant control systems utilising a single PLC that require a Human Machine Interface (HMI) may have a direct connection between the HMI and the PLC's local interface port provided that there are no other process control PLCs which would be disturbed by such an arrangement.
2. For HMIs with multiple linked PLCs see section 19 COMMUNICATION NETWORK ARCHITECTURE

Network Connectivity

1. Communication interfaces shall be either integral to the PLC processor or by additional communication modules in the PLC module bank.
2. Note that sufficient communication interfaces shall be provided to allow a PLC programmer to connect to a single PLC or the entire network simultaneously with all network communications connected and functional.

18.3 Hardware Requirements

Central Processing Unit (CPU)

1. An appropriate CPU Module shall be selected that will achieve reliable control and communication functions while leaving adequate unused processor capacity for future expansion as detailed in 18.1 General.
2. If an existing Works is to be upgraded and an additional PLC is required, the PLC choice shall be compatible with existing PLCs and PLC networks.
3. The selected PLC processor module shall ensure that CPU cycle times do not exceed 500 milliseconds and maintain proper control functions for required plant functionality while reserving sufficient system resources for communications purposes.
4. The CPU shall have word length of 32 bits minimum and shall not be loaded to over 60% of their capacity even under worst data loading conditions.
5. The CPU RAM shall have 360 hours battery backup for continuous operations and periodic, automatic and self-diagnostics facility.
    1. The CPU shall be provided with ‘non-volatile’ memory modules sized to be at least equal to the amount of RAM fitted to the CPU.
    2. The non-volatile memory shall be capable of over 25000 read/write cycles without any impact on performance or reliability.
6. Diagnostics message shall be issued on fault detection.

Program Memory

1. The PLC shall store its configuration in a ‘non-volatile’ retentive memory, e.g. Electronically Erasable Programmable Read Only Memory (EEPROM), compact flash, etc.
2. An appropriate CPU memory capacity shall be selected by the Supplier to allow sufficient unused memory for system expansion.
3. The PLC shall reload its program from this ’non-volatile’ memory upon reset.

External PLC Watchdog

1. Each PLC shall have a ‘watchdog’ which shall perform the following functions:
    a) The main ‘program’ or module on the PLC shall give output pulse to reset a hardware watchdog timer.
    b) The watchdog timer shall provide a volt-free contact which shall close to indicate PLC program failure (i.e. the timer shall perform a ‘monostable’ function and is continually prevented from ‘timing out’ by reset pulses from the PLC).
    c) The PLC reset pulse shall be generated by a solid-state device
    d) The watchdog timer shall not exceed a value of 5 seconds unless otherwise specified or approved by the Client.

e) The watchdog power supply shall be provided from the same source as the PLC. When the PLC is running from mains power, the watchdog shall run from the mains. When the PLC is running from a standby supply, the watchdog shall run from the same standby.

2. The relay shall also be configured to operate a red indicator lamp on the ICA section panel door. The lamp shall illuminate continuously upon watchdog time out and shall only be extinguished when the condition has been cleared.
3. The watchdog relay shall cut the power supply to the PLC output cards on a time out.

I/O Module Arrangement

1. The Contractor shall include the additional expansion capacity define in section 18.2 I/O Modules.
2. Modules shall have adequate status and diagnostic indication on the front panel.
3. The Contractor shall logically group plant I/O signals based on plant functionality. Signals of the same type and associated with the same plant function or area shall be grouped together.
4. Plant I/O signals related to duty / standby equipment, controlled by the PLC shall have the duty and standby signals allocated to different modules and / or I/O cards to reduce the potential for total plant failure through a single module failure.
5. The Contractor shall provide 20% spare channels in each configured card/module and minimum 10% spare module for each type of I/O modules shall also to be provided. The spare channel shall be fully wired and terminated.
6. Failure or physical removal of any module connected on the system bus shall not lead to any loss of communication.

Signal Replication

1. Digital signals entering or generated within the MCC common controls section that are required to be input into more than one device shall be replicated by 24 V dc slave relays. Replicated signals shall be individually routed to the relevant device e.g. controlling PLC.
2. Interposing relays shall be independent of any PLC.
3. Analogue signals shall be replicated through the use of analogue signal loop isolators.
4. The analogue loop isolator shall be selected to preserve the integrity of the analogue loop. Replication shall not degrade the original signal accuracy to worse than 0.5% total.

18.4 Software Requirements

The Contractor shall only use approved programming software except where additional software programming is required to configure approved non-standard PLC system modules.

1. The Contractor shall supply any standard programming software, licensed for the Client's use and capable of running on the Client's standard corporate PC.
2. The Contractor shall submit details on any additional programming software to the Client for approval prior to use.

All software shall be well structured and fully annotated, exhibit a high degree of modularity and provide ease of understanding.

Software modules shall be functionally self-contained and independent of other software while having clear and well-defined interfaces with other modules.

Software modules shall comprise of the minimum number of lines of code to accomplish the modules' intended purpose while retaining legibility and single entry and exit points. The use of nested function blocks within modules is permitted.

Non-standard programming techniques shall be avoided. Numbers, parameters and other fixed data shall not be embedded in software but in a database.

Databases and decision tables shall be fully normalised and structured to maximise processing speed and efficiency.

Software shall be structured such that changes to one software module shall require minimal changes to other components.

PLC application software and operating data shall be stored in appropriate memory locations secured against power failure.

The Supplier shall structure and document PLC programs according to the standards defined in this specification and as per the Client's requirements.

18.5 Naming Conventions

The Supplier shall use the Client's standard I/O naming convention to identify I/O points within the PLC.

SCADA shall utilise this naming convention to maintain consistency from signal origin through all data acquisition equipment (e.g. SCADA, telemetry etc.).

18.6 System Diagnostics

The Supplier shall incorporate into the PLC program a code module to extract and format CPU diagnostic information for access by HMI and SCADA systems.

The Supplier shall incorporate into the PLC program a code module that shall utilise the PLC system fault and diagnostic registers to produce information on the current status of the PLC processor.

All standard PLC/SCADA/communications fault and diagnostic functions shall be enabled and configured for system fault monitoring, reporting and diagnostics.

A systems maintenance and diagnostics package shall be included for the PLC/SCADA/ communications systems to enable monitoring and reporting of hardware integrity, rapid identification of system, component and network system faults.

The Works SCADA/HMI shall have diagnostic screens to allow fault finding on PLC and/or communications systems. Diagnostics shall be standard diagnostics packages readily available from PLC and communications system vendors and not bespoke systems.

18.7 Set Point Configuration

Where SCADA or HMI are provided, process set points (including variable process timers) shall be input via password protected operator screens in engineering units. Where necessary, conversion of raw analogue values into engineering units shall take place in the PLC using a standard code library.

The system shall perform checks of input values, irrespective of source (i.e. SCADA, HMI etc.) to ensure that only valid set points are entered.

A SCADA alarm shall be raised if a process variable is not maintained within +/- 5% of the set point within an alarm delay period of 5 times of the process period. Alarm bounds shall be configurable at the SCADA from a range of +/- 2% and +/- 10% with the alarm delay period between 3 and 10 times the process period.

18.8 Alarm Generation

The PLC shall detect internal error or fault conditions and act upon them to place the system in a predefined safe state.

The PLC shall bring this condition to the operator's attention though visual on-site.

Each PLC that forms part of a distributed network control system shall have stand-alone operating capability to enable the continued monitoring and control of its associated plant in the event of network failure or disconnection. Any set points and parameters available prior to the network failure shall be used.

19 COMMUNICATION NETWORK ARCHITECTURE

19.1 General

Design and Support

1. The Supplier shall be responsible for configuring and integrating all hardware and communications.
2. The Supplier shall be responsible for all software installations and hardware configurations. This shall include memory and disk allocations to meet the system functional requirements.
3. The Contractor shall supply the User Requirements Specification to the Supplier, establishing the specific requirements of the Client.
4. The final communication system's topology; the selection of control technologies and protocols shall be determined by the Contractor in liaison with the Client to meet the needs of the scheme and deliver a robust yet cost effective solution.
5. Wherever possible Open Standards and licenses shall be employed throughout and every effort shall be taken to ensure the broadest range of third party suppliers are available to support the design into the future.
6. The architectures and protocols suggested within this document are not binding but are proposed as being suitable technical solutions with proven reliability, functionality, supplier support and representative of good, industrial practice in the water and wastewater sectors.

Technology

1. Transmission Control Protocol (TCP) / Internet Protocol (IP) shall be used for communications between Programmable Logic Controllers (PLCs), Human Machine Interfaces (HMIs) and Supervisory, Control and Data Acquisition (SCADA) systems.
2. For device level communications with items such as instrumentation and actuators either hardwired I/O, or an appropriate field-bus technology shall be used as per the criteria below:
    a) Where a system of Intelligent Assemblies (IAs) is selected, the preference shall be to use field-bus communications systems throughout.
3. The use of distributed / remote IO shall be chosen under the following circumstances:
    a) Where an required instrument cannot be supplied with the appropriate 'field-bus' communications protocol interface
    b) Where a conventional motor control centre is selected and cabling from remote areas can be rationalised.

19.2 Communications Protocols

All communications protocols shall confirm with the relevant International and Indian Standards.

The following technologies are proposed as good, industrial practice but are not binding and shall be subject to the Client's preference:

1. Enterprise and data reporting:
    a) Ethernet TCP/IP,

2. Remote access and deterministic control over Ethernet:
    a) ProfiNet – Industrial Ethernet TCP/IP
3. Device level communications
    a) Profibus DP (Decentralised Peripherals)
    b) Profibus PA (Process Automation) – particularly for Hazardous area
    c) Emergency stops and safety critical interlocks
    d) Hardwired directly to the appropriate starter

Industrial Ethernet TCP/IP shall be used for bulk data movement for SCADA purposes.

Control data shall use deterministic communications protocols (e.g. Profibus, Profinet, etc. as appropriate.

Profibus DP shall be used to provide 'distributed intelligence' for motor management systems, variable frequency drives, instrumentation, sensors and actuators via the PLC system. In order to utilise the application layer functions, various service levels of the DP protocol are defined as follows:

1. DP-V0 for the cyclic exchange of data and diagnosis
2. DP-V1 for acyclic and cyclic data exchange and alarm handling
3. DP-V2 for isochronous mode and data exchange broadcast (slave-to-slave communications)

The Profibus DP shall be selected to utilise the appropriate service level for master-slave communications.

Profibus PA shall be used for monitoring and measuring equipment and sensors from the PLC system.

Profibus PA is ideal for explosion-hazard areas (e.g. Zone 0 or Zone 1) and shall be installed to ensure intrinsically safe circuits to prevent explosive sparking in the event of malfunction when installed in a zoned area.

The Designer shall pay due consideration to the environment in which cables are to be installed and as to whether fibre optic Profibus DP is required.

Copper cables, when used, shall be segregated according to type (i.e. power, signal) and the appropriate separation between different cable types provided.

Redundant communication architectures shall be used where a communications failure would prevent plant and process control from the SCADA system.

Intelligent MCCs shall use redundant communications architecture.

All field networks shall be optically/galvanically isolated from the Motor Management system using Profibus approved isolation devices.

All fibre optic and copper cables used shall be fully approved by the Profibus association.

The disconnection of any Profibus slave device (e.g. instrument, actuator, etc.) shall not affect the integrity of the Profibus network. The disconnection of a slave device shall not disrupt communications to other devices.

Appropriate surge protection shall be provided.

Fibre optic cables shall be used for communications between buildings or equipotential zones.

19.3 Internet Protocol System Topology

The standard arrangement for a site employing multiple PLCs or a SCADA system is to deploy an Ethernet based star topology locally (process areas) and a ring across site.

1. Where a high level of redundancy and resilience is required, the contractor shall provide an up-rated solution appropriate to the needs of the project, nominally: dual redundancy at site level and a ring topology locally.

Where an existing communications network is already in place then:

1. Where it is practical and in accordance with the prior permission of the Client, the legacy system shall be replaced by the new, standard topology.
2. Where replacing the legacy system is impractical or the Client does not wish to pursue this course of action the new topology may be installed along side the existing infrastructure. In this case the two networks shall be interconnected through a dedicated primary, network gateway to provide inter-network communications. This shall provide for the gradual migration of the site's future plant and infrastructure on to the new system.

Within a site, different strategic functions: security, process and enterprise, for instance, shall not be operated on the same network hardware. Each function shall be provided with its own functional network. Each functional network shall be comprised of:

1. A single secondary network gateway,
2. Fibre optic (FO) ring
3. Various local, functional sub-networks, see below.

A local, functional sub-network shall serve specific requirements, typically unique, localised process streams and be comprised of a single tertiary network gateway, and various plant and equipment.

Where an up-rated, highly resilient system is absolutely necessary for a particular function: dual redundancy shall be incrementally employed to meet the immediate need:

1. Initially at the local, functional, sub-network level with dual-redundant tertiary gateways and sub-systems;
2. Then at the site-wide functional network level with dual redundant fibre optic rings
3. And finally with dual redundant secondary gateways.

Plant and equipment, including Programmable Logic Controllers, Human Machine Interfaces and distributed I/O, where provided, shall interface with each other via the local, functional sub-network's tertiary network gateway. Where necessary, this shall be via appropriate coupling devices that translate the employed field-bus protocol to TCP/ IP.

Where a site employs multiple functional networks but does not demand multiple functional sub- networks, perhaps due to its small geographical area; tertiary network gateways shall not be used. Local plant and equipment shall connect directly to the secondary gateway's internally facing layer 2 switch.

Where there is only one functional network required on site and there are no external TCP / IP interfaces, only tertiary network gateways shall be provided.

In order to provide a deterministic control solution, an open, Industrialised Ethernet protocol shall be superimposed upon the process control function's TCP / IP network. The selection of protocol shall be made in accordance with the Client's preference and compatibility with the PLCs selected.

1. Design of the deterministic control system shall be in accordance with the PLC supplier's requirements and instructions.

Ethernet switches shall be or the hardened type for use in industrial environments and selected with due attention paid to the climate it is being installed in and exposure to electrical noise it will suffer.

1. The individual ports shall be lockable to prevent unauthorised access.
2. The switches shall operate at a minimum of 1 Gb/s.
3. Switches in process areas shall be configured for optimal use of the Industrial Ethernet protocol selected.

19.4 Network Gateways

Primary, network gateways shall consist of a single layer 3 switch to which each secondary network gateway shall interface over fibre; along with site external networks.

1. If absolutely necessary, Virtual Local Area Networks can be utilised if the hardware available is not sufficient to provide total physical separation of each functional network.

Secondary Network Gateways shall consist of:

1. An externally facing layer 2 switch which shall connect to the primary network gateway and the functional network's Universal Threat Management (UTM) system.
2. An internally facing layer 2 switch that, via the fibre optic patch panel and ring, shall interface with other local, functional, sub-networks' tertiary network gateways. Where there is only one sub-network no additional fibre or patch panels is required.
3. A UTM gateway (firewall) shall stand between the externally facing layer 2 switch and the internally facing layer 2 switch

Tertiary Network Gateway are simply layer 2 switches that interface via the fibre optic ring and local patch panel with other functional sub-network gateways and the functional network's secondary network gateway. All local plant and equipment, where appropriate, shall connect to this tertiary gateway in a star topology.

19.5 Client/Server Architecture

It shall be possible to view each process area's mimics and alarms from any main control panel HMI for critical multi process areas and large works. Client/Server architecture shall be used whenever there is a need to provide such functionality.

Client/Server architecture shall not extend to package plant local control panels except for data, as specified in the plant Control Philosophy, required from the package plant for central SCADA monitoring.

Wherever possible, control functionality shall be devolved to local, vendor control packages.

The extent of integration for existing systems into the PLC / SCADA architecture shall be agreed with the Client and detailed in Particular Specification / Work Packages and Control Philosophies.

19.6 Non Internet Protocol Communications

Following the style of, low voltage assembly chosen: whether conventional or intelligent, selection of instrumentation shall follow accordingly;

1. Where an 'intelligent' approach is taken all new instrumentation, actuators and field devices shall employ, where possible an open, field-bus protocol. All such equipment shall be certified as being fully compliant, having been tested by the protocol's relevant authority.
2. Where a 'conventional' approach is adopted the use of remote / distributed I/O shall be employed in order to rationalise cabling. Where necessary the distributed I/O modules may interface with the functional, sub-network's tertiary gateway (local switch) via a field-bus intermediary.
3. A standard approach shall be taken in both of the above cases to determining which protocol to employ. In anyone of the three levels of control listed below only one protocol shall ever be employed.
    a) Intelligent Assembly
    b) Field device (including remote I/O)
    c) Hazardous areas

The design of the Non-IP network shall be performed in full consultation with the PLC manufacturer's recommendations, particularly with regard to network topology, number of nodes, cable lengths and configuration.

Where there are multiple process streams in anyone functional sub network (see IP Communications above) separate field-bus segments shall be provided for each process stream, i.e. wherever possible the introduction of single points of failure shall be avoided.

1. Where a particular process stream demands a higher level of resilience than normal a 'dual redundant' system shall be employed and both the architecture and components selected shall be appropriately up-rated.

The 'field-bus' network shall be appropriately designed and configured such that the removal or failure of any individual device: instrument, starter or actuator for instance shall not cause that particular 'field-bus' segment to fail, nor shall it be possible for the failure to propagate up the network.

Design and installation of the 'field-bus' system shall follow a logical course, such that associated components of a process stream shall not be grouped on the same segment as devices from other streams.

Field devices shall not interface to the process PLC via the same communications cards as the intelligent assembly's segment(s).

The data transfer rate employed across the network shall be chosen to maximise cable length.

There shall be a minimum cable length of 1 m between each node.

Normally 'field-bus' cables shall as a minimum be segregated from other cables by 100 mm, this shall be 200 mm if the voltage of nearby cables exceeds 415V.

A "piggyback" connector shall be fitted on each master socket of the PLC to allow Operations to access the network for programming and monitoring without disrupting it.

SCADA and HMI network overview screens shall be provided that illustrate the health of the system's nodes and where available system alarms.

19.7 Off-site Communications

Where an external interface is required the contractor shall identify the various technologies available for the application with an assessment of cost Vs reliability and

present these to the Client with a recommendation. It may be necessary to provide duty and 'fall-back' systems.

1. Selection of the technologies to be employed shall be made with the agreements of the Employer's Representative and the design modified to incorporate the selection(s).

Where two-way, control and monitoring is requested, communications shall occur via a TCP / IP interface and consequently go through the primary network gateway.

19.8 Ethernet cabling

Ethernet shall be distributed around site according to the following criteria:

1. Cat 5e / Cat 6 cabling shall be provided for internal, functional sub-network, cable runs
2. Armoured Cat 5e / Cat 6 cabling shall be provided for external functional sub-network, cable runs under 100 m.
3. Armoured fibre optic cabling shall be employed to interconnect the:
    - Functional network's tertiary gateways
    - Secondary gateways with the primary gateway
    - External functional, sub-network runs over 150 m.

Fibre optic rings shall be configured with 210 % of the fibres immediately required; to provide the ability to upgrade the systems' resiliencies and / or add further functional networks.

Fibre optic cabling shall preferably be installed in ducts, cable trays may be used where ducting is inappropriate.

Ducts and trays shall be separated to ensure simultaneous damage cannot easily occur.

There shall be no joints in the fibre.

Each individual cable run shall be no longer that 75 % of the maximum recommended distance at 1 Gb/s transmission speed.

Fibres shall be capable of transmissions of at least 10 Gb/s.

All fibre cables shall be terminated in patch panels.

Where the likely future expansion of the site can be identified prior to laying the cable, a loop of fibre shall be provided at that location for the future installation of a node there. The loop shall be left in a dedicated draw pit.

20 INSTRUMENTATION, CONTROL & AUTOMATION (ICA) DESIGN

20.1 Plant and Equipment to be provided

This section describes the ICA Plant to be provided by the Contractor and specifies the particular requirements for the Works not covered elsewhere in the Contract.

The Plant to be provided for the treatment work Site shall include, but not be limited to, the following:

(a) ICA panels complete with all accessories
(b) Flow monitoring equipment for all main process streams including wastewater inflow and treated wastewater outflow etc.
(c) Quality, sampling and monitoring equipment
(d) Level monitoring equipment
(e) Process control equipment
(f) Pressure measuring equipment.
(g) Measurement for sludge management system

In addition, the Contractor shall provide all other monitoring equipment required for the full functional and safe operation and maintenance of the Works.

All PLCs and four wire monitoring equipment shall operate at 240 V, 50 Hz. Two wire monitoring equipment shall operate at 24V DC. All monitoring equipment shall be supplied from a UPS such that monitoring of all facility conditions is maintained during a mains power supply failure.

PLCs used in the plant shall be from a single manufacturer.

All Plant equipment and products containing electronics must carry a CE mark.

20.2 Drawings and information to be provided

The Contractor shall provide drawings and information which shall include but not be limited to:

- Functional design specification
- Process and instrumentation diagram (P&ID)
- PLC system architecture
- Input/output (I/O) list/Alarm list
- Manufacturers' catalogues and data sheets.
- Operation and Maintenance Manual
- Cable and Junction box schedule
- Instrument hook up drawings
- Loop schematics and interconnection wiring diagram
- Instrument data sheet, Instrument test and calibration report
- Instrument operation and maintenance manual
- Complete project documentation with operation and control Philosophy
- Final documentation and manuals
- As built drawings.

20.3 Control Room ICA Panels

General

All instrument control panels shall be free-standing, floor-mounted cabinets of the cubicle, console or desk pattern located within the respective plant buildings or in kiosks housed in civil structural housings.

Each local plant MCC shall have an associated ICA panel. It shall include, but not be limited to, the following equipment and facilities:

a) Local PLC with redundancy to CPU unit;
b) Human Machine Interface (HMI) key-pad (minimum 300mm) and colour display unit
c) Online double conversion type UPS system
d) Relays as required to interpose PLC I/O with plant control equipment.
e) Alarm annunciator panel to give local indication of failures not indicated elsewhere on the ICA panel or corresponding MCC.
f) Pushbuttons, signal lamps, selector switches and indicating instruments and all other necessary equipment for the automatic or manual control of the Plant.
g) Monitoring instrumentation as required for the effective operation and maintenance of the plant.

For the pumps, blowers, valves and penstocks the controls, signal lamps, switches and indicators shall be mounted on the respective panel as a group for each item of Plant.

20.3.1 ICA Panels

ICA panels for the plant shall be located within control rooms as free standing panels or shall be incorporated into MCCs as an integral part of the panel suite. They shall comprise, but not be limited to, the following main items of equipment:

a) PLC system for the control and monitoring of pumps and associated rotating Plant and equipment. By means of an associated PLC keypad an operator shall have the facility to select a variety of mimics for presentation on the PLC display unit or HMI unit with the added facility of modifying control set points. These mimics shall include:
    i) Simplified displays of plant and auxiliary equipment, with status, set-point, flow and level indications displays of blowers, pumps and associated plant, with status, set-point and variable value indication.
    ii) A display of the duty for each pump or rotating plant item, with the facility, by use of the PLC keypad, to manually select duty; or to select auto-duty rotation such that the duty of each rotating Plant item is automatically changed after a preset time has elapsed.
b) Alarm annunciator shall include those failure indications not displayed at the local MCCs, these generally shall include high/low alarm for sump, forebay level, Motor/Pump winding/bearing temperature, pump pressure, failure of level instrument, pump trip alarm etc.

20.4 Surge Protection Devices for Electronic Equipment

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising from high energy static discharges and lightning strikes and protect the instruments to which they are connected. SPDs shall be passive and shall require negligible power for operation.

SPDs shall be provided to protect devices transmitting and receiving analogue and

digital signals from outdoor field devices.

The surge protection devices shall comply with IEC 61643.

Surge protection devices shall be provided for all field devices, data communication lines and buried signal cabling.

20.5 Plant Control System

Works to be included

The Works included in this section shall comprise the design, manufacture, supply, installation, of the Plant Control System.

This section details the main systems and Plant together with the proposed methods of control of the Plant installations, and shall be read in conjunction with the mechanical and electrical Plant and measuring equipment sections of the Contract.

In addition to the supply and installation of the Plant Control System, the Contractor shall also be responsible for testing and commissioning as detailed elsewhere in this Contract. As an integral part of the commissioning procedure the Contractor shall ensure, and demonstrate to the Employer's Representative, that all the monitoring, instrumentation and control systems are tuned, calibrated, regulated and adjusted to achieve optimum control of the treatment facility process and Plant operation and that all control systems are correctly interfaced and operating as a fully integrated system.

The Plant Control System and main items of Plant to be supplied shall include:

All power and control cabling associated with the above Plant shall comply with Clause 12.2 of this document.

20.5.1 Operating Philosophy

The Plant monitoring and control systems shall provide automatic operation of the Process Plant and their associated support and subsidiary Plant, with minimum operator intervention.

20.5.2 Operation and Control (Not Used)

20.6 Process Monitoring

In order that the performance of the Works may be effectively monitored, wastewater, sludge, and other process parameters are required to be analysed by on-site instrumentation.

20.7 Instrumentation

The Contractor shall provide instruments to measure all variables shown on the process and instrumentation diagrams for the Works. Instruments shall be of an approved & suitable for working in sewage treatment plant environment. They should be from a reputed manufacturer and be supplied with manufacturers calibration certificate.

20.8 Testing and Commissioning

Equipment shall not be delivered to Site unless an inspection has been carried out or waived in writing by the Employer's Representative. Tests shall be organised to represent the installed condition as closely as possible and shall include the following:

a) Factory Acceptance Tests (FATs)

These tests shall provide documented evidence that system under test meets the functional and performance requirements of the Employer's Requirements and functional design specification (FDS).

b) Site Acceptance Tests (SATs)

These tests shall encompass the normal modes of operation and failure events and demonstrate correct functionality of the system in accordance with the Employer's Requirements. The tests shall be fully documented.

c) Commissioning

Commissioning shall be carried out on complete Works where every item of equipment shall be individually tested and then collectively to form an integrated system.

20.9 Auto Dialer System

The Contractor shall provide an Auto Dialer system. From the Auto Dialer facility it shall be possible to send an SMS to the relevant operators/engineers whose mobile numbers are set in the system.

As a minimum a Short Message Service (SMS) shall be sent if the following events occur:

a) Failure of pump-motor set i.e. Motor stops during operation or fails to start after receiving START command;
b) Gas level of a particular area detected above the limit which is dangerous for personnel;
c) Failure of sensors or field instruments detected;
d) Emergency event i.e. unplanned overflow or bypass, fire detection, smoke detection.

21 INSTRUMENTATION & CONTROL

21.1 Instrumentation System

This section outlines the particular requirements for the instrumentation systems. Unless specified in this section to the contrary instrumentation Plant provided by the Contractor and workmanship shall comply with the General Chapters of these Requirements.

The scope of instrumentation, control and automation (ICA) works for Wastewater Treatment Plant under this contract shall comprise of the design, manufacture, programming and configuration, off site testing, delivery to site, installation and erection, testing, commissioning, setting to work and provision of documentation for a complete instrumentation, control and automation IC&A system including the interfaces required to provide monitoring and control for a safe and efficient operation of the PLANT. The scope shall also include

1. Deleted
2. Complete operational data of the plant to be transmitted to the SCADA Monitoring & Control Centre at PLANT.

The minimum scope of work for ICA at plant shall include but not limited to:

21.2 Field Instrumentation and Control

Each field instrument shall be operable in local mode and have display functions in SCADA. The Contractor shall be responsible for providing the appropriate signals at the locations required to provide the specified control and monitoring functions.

The Contractor shall ensure that field measuring systems shall respond quickly to any changes of the measured process variables.

All field instruments shall, as far as practicable, be mounted in a location that shall be free of vibration and shall be powered from the instrument control system.

24V dc power wiring for field instruments shall be individually fused and provided with a means of disconnecting the power without disturbing terminated wiring (e.g. knife-switch-type terminal blocks). Visual indication of a blown fuse condition shall be provided.

All field instrument components shall be of a proven and reliable design and shall have a high degree of uniformity and shall, wherever possible, be interchangeable. The design shall facilitate easy maintenance and repair, taking into account the availability of access routes through plant and structures generally.

Field Instruments shall perform sensing, indicating, transmitting and controlling. The materials of those parts of the field instruments, including piping material, which are exposed to the measured media shall be compatible with the conditions of the respective media and of the ambient fluid and atmospheric conditions.

All field instruments shall be mounted within enclosures that are corrosion proof and waterproof to provide a minimum protection specified in elsewhere in this Specification.

All field instruments, including the components, shall be tropicalised and designed for the ambient conditions detailed elsewhere in this Specification. Lighting protection barriers shall be used for protecting transmitters and receiving instruments from the surge voltage due to lighting strike. Lighting protection barriers shall be supplied at both receiving and sending ends for all signals from outside building and those installed between the building.

21.3 Instrumentation Design Criteria

The design criteria to be applied to instrumentation systems shall be as follows:

- All instruments shall be suitable for continuous operation;
- All transmitting instruments shall have a 4 - 20 mA linear output;
- All digital outputs shall be volt free;
- All instruments shall be designed for the ambient conditions of temperature and humidity;
- All wetted parts of instruments sensors shall be non-corrosive and suitable for use with sewage;
- All instrumentation systems for use out of doors shall be protected to IP 65;
- All analogue displays shall be of the digital type with no moving parts utilizing back lit liquid crystal diode LCD / LED technology;
- Instrumentation shall utilize solid state electronic technology and avoid the use where practical of any moving parts;
- Minimum maintenance requirement;
- Instrumentation shall resume operation automatically on the application of power following a power failure.
- All analytical instruments shall be single channel and have individual analyzer units.

Digital systems shall be provided as detailed in the Employer's Requirements and as necessary for the efficient and safe operation of the treatment plant

The Contractor shall provide Plant to measure any other parameter required for the efficient and safe operation of the treatment plant.

Instrumentation sensors shall be suitable for the environment in which they are expected to work. Sensor located in hazardous (flammable) or potentially hazardous atmospheres shall be certified for use in these areas. Sensors should be of self-cleaning type.

Instrumentation converter units shall where practical be located in the associated MCC common control panel well away from any injurious effects of the process.

21.4

21.4 Level Measuring System

(i) Conductivity Type Level Switches

Conductivity type level switches shall be provided in pump pits, IPS Wet wells, drain pit for complete auto control of pumps. The weather protection class for sensor and controller shall be IP-65 of IS 13947. Each level detector shall be of conductivity type and comprise of PVC insulated rigid stainless steel electrodes.

(a) Technical Particulars for Electrodes / Probes

(i) No. of electrodes	:	For Pump Pits, drain pits and Plant water Tanks, Medium screens (Inlet), IPS /EPS Wetwell etc. where ever applicable as per process requirements
(ii) Material of Electrodes	:	SS 316, Rigid with PVC/PTFE coating.
(iii) Mounting	:	Flanged; 150 LBS ANSI B.16.5

(iv) Length of electrodes	:	To be finalised during detailed engineering as per process requirement.
(v) Spacers between electrodes	:	Required
(vi) Stilling pipe	:	Required (SS 316)
(vii)Weather protection class for level probe	:	IP 65 of IS 13947

(b) Level Controller

(i) Type	:	Field Mounted
(ii) Switch Contact (for each setting)	:	2 NO + 2NC
(iii) Contact rating	:	240 V AC, 2A
(iv) Sensitivity control	:	Required
(v) Weather protection class	:	IP-65 of IS 13947
(vi) Cabinet for mounting level Controller	:	Required

Note:- Magnetic Type Float Level Switches shall be provided instead of Conductivity type switches for the following Sub systems of PLANT such as Chemical Storage Tanks, Alum Preparation Tanks and Polymer Tank Mixers etc. (Where medium of the fluid shall be chemical solution there Magnetic type float Switches are applicable)

(ii) Ultrasonic Level Meters

Technical Particulars		
(a) General		
(i) Service	:	Level Measurement at different sub systems of entire PLANT process (As Per Process Requirement)
(ii) Quantity	:	As per Process Requirement.
(iii) Range	:	As per process requirement.
(iv) Accuracy of measuring Loop	:	± 0.5% of full scale.
(b) Sensor and transmitter		
(i) Output	:	4-20mA
(ii) Mounting	:	Top Mounted, Flanged 150 lbs, B16.5, SS
(iii) Programming	:	Required facility with programmer
(iv) Weather Protection class	:	IP – 65 of IS – 13947
(v) Stilling pipe	:	Required
(vi) Power Supply	:	24 VDC or as per site condition
(c) Digital display unit		
(i) Type	:	Electronic micro processor based
(ii) Display	:	Digital, 3 ½ digit LCD
(iii) Engineering Units	:	Metres or As per Process Requirement
(iv)Accuracy	:	± 0.1% of full scale.
(v) Input	:	4-20mA from sensor/transmitter.

(vi)Alarm Contact	:	2NO+2NC, (adjustable).
(vii) Contact Rating	:	240V AC, 2A
(viii) Retransmission Analog output	:	Required.
(ix)Weather Protection class	:	IP – 52 of IS – 13947

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21.5 Process Plant Operation Philosophy

(a) General

The control system in addition to providing the facilities detailed in the preceding clauses shall provide the following process plant specific requirements.

In case of power failure, all equipment that was in operation immediately preceding the power failure, except for equipment not wired to run on standby power, shall automatically restart when the standby generator starts. When main power is restored, all equipment that was in operation immediately preceding the power failure, including equipment not wired to run on standby power, shall automatically restart. All restart sequences shall be implemented with delay timers set to prevent the simultaneous start up of all equipment. The restart sequence shall follow a general downstream-to-upstream direction with respect to treatment process flow, i.e., start downstream equipment first and then move upstream in steps.

21.6 Control Philosophy

21.6.1 General Control Philosophy

This section describes the general control philosophy that the Contractor shall follow for all DWF Interceptors at Tidal Outfalls, included in this contract. These requirements are specified for tender purposes only and the information provided is not intended for construction. The bidders/contractors shall submit more detailed and specific versions of the control philosophy and the functional design specifications in both the bidding and design stages.

Incoming raw sewage shall be screened by mechanical screens and flow by gravity into existing sewer network.

21.6.2 Dry Weather Interceptor

This section applies to DWF Interceptor Screening Plant included in this contract.

21.6.3 Screens

Gravity sewage flow shall enter the inlet channel of screens. The high level switch in this channel shall initiate a screen cleaning cycle, and both the high and high-high level switches shall generate an alarm.

Gates with manual hand wheel operators shall be installed both upstream and downstream of each screen so that each screen channel can be isolated for maintenance.

The Medium screens shall be operable manually from a local control panel located adjacent to the equipment. Operation shall be operator selectable as manual or auto. In auto mode, operation of the screen rake mechanism shall be controlled by level differential with a timer override. Level elements shall be installed both upstream and downstream of the screens. When the upstream minus downstream level differential reaches an operator specified maximum, a screen cleaning cycle shall be initiated. Alternatively, the operator may also specify a maximum interval between cleaning cycles. If this interval elapses without cleaning, a cleaning cycle shall be initiated regardless of level differential. The upstream and downstream levels shall be continuously monitored by ultrasonic type level sensors/transmitters.

Note- Automatic Jam Removal System shall be provided by the contractor for Screen.

21.7

21.7 System Completeness

This section of specifications defines the particular requirements of Instrumentation and Control system to be installed at PLANT and IPS. For selection of field instruments and control system or anything related to instrumentation, the Contractor shall follow the specifications contained herein.

Being a Turn Key contract, irrespective of the detailed specifications of the respective items detailed in the various chapters of the tender specification, the Contractor shall be required to provide all the equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic, interlocks, cabinets, panels etc. to achieve the functional requirements described in the Bid Document. The System completeness will be the Bidder's responsibility.

Note:- In FAT all the field instruments & Automation systems shall be tested 100% under category-'A'. The description about category -'A' (Mandatory).

21.8 Particular Requirements for (PLC) System General

This part covers the general & Particular requirements for the design, supply, installation, Inspection and testing of Programmable Logic Controllers (PLC) and associated plant and materials.

21.8.1 Volume 2 – Clause 23 Applicable Standards

All equipment shall comply with all applicable national and local laws regulations and standards, in addition to those listed below:

A. ISO 9000 and 09004	-	Quality Systems
B. IEEE 587	-	Power Supply Surge Protection
C. IEC 61131-3	-	Programming Languages for Programmable Controllers.
D. IEC 61158-2	-	Communication Protocols
E. ISO 9075 (BS 6964)	-	Structured Query Language (SQL)
F. BS 5515	-	Documentation of Computer Based Systems
G. BS 7165	-	Recommendation for Achievement of Quality in Software

H. BS EN 50081	-	Electromagnetic Compatibility
I. ISO 3511	-	Process measurement control functions instrumentation symbolic representation.
J. ISO-OSI	-	7 Layer Communication Model
K. IEEE 472-1974	-	Surge protection.
L. IEC 61850	-	PLC sub-station automation protocol.
M. IEC 8705101	-	Modbus protocol conversion\

21.8.2 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during the Bid submission, and FDS submission. Failure to do so will be treated as a non-responsive bid. Contractor should take note on the importance of this obligation.

21.8.3 Quality Assurance

A. The Manufacturers shall be operating under an accredited ISO 9001 or above Quality System.

B. Upgrades and improvements to the manufacturers standard system that are released before the expiration of the warranty period shall be supplied, installed and commissioned at no additional cost.

These shall include all hardware and software necessary to implement the upgrade.

21.8.4 Submittals

A. Functional Design Specification (FDS) :

The Functional Design Specification (FDS) shall be submitted to the Engineer within 3 months on the award of the contract and approved before manufacture and purchasing commences. FDS document for plant shall be separate and shall be submitted within the time period indicated above. The system vendor and/or Contractor shall include the following material as a minimum:

a. Project Overview, design concept, criteria and system architecture

b. Description of the design and design criteria.

c. Details of associated equipment.

d. Datasheets of the proposed equipment.

e. Electrical Design Specifications

f. Quality Plan.

g. Outline of acceptance test procedures (FAT & SAT).

h. Implementation program for manufacture, installation and commissioning.

i. Manufacturers literature for each item of equipment supplied/proposed.

j. Software architecture, etc.

Note: Contractor to note that no part approval of FDS will be accorded. FDS shall be submitted in full with all details as detailed above.

B. Drawings and Documentation:

All drawings of telemetry and instrumentation control and Automation (ICA) equipment shall be on A3 or A4 size sheets, with title blocks approved by the Engineer.

Signature of the Contractors authorized representative to indicate the drawings have been checked prior to submission.

The text of all drawings and documentation provided by the Contractor shall be in the English Language.

C. Contractor's Drawings:

The Contractor shall submit 3 (three) reproducible copies plus two photocopies of general and detailed dimensioned arrangement drawings, schematics and wiring diagrams of all major items of Plant, for the Engineer's approval Manufacture of an item of Plant shall not commence until the associated drawings have been approved in writing by the Engineer.

All modifications or revisions to drawings shall be clearly indicated and the revision reference changed.

Drawings affecting work by other disciplines shall be provided to the Engineer, within 6 weeks from the date of enterprise.

Drawings for electrical equipment shall include:

Manufacturer's general arrangement drawings for all items showing clearly the position of all cable glands and main components including, where appropriate, foundation plans, showing the position of all holes required for fixing bolts and cables etc.

Manufacturers' schematic diagrams and connection diagrams for all items showing all internal wiring and terminal connections, suitably referenced Connection diagrams shall include existing and proposed outgoing cable connections.

General layout of plant showing cable routing.

Block diagram showing all plant, cable runs and cable reference numbers.

Cable schedules giving full details of use, destinations, size and number of conductors, grade, class and length.

Layout of grounding facilities.

Proposed arrangements for cables laid below ground showing identification references, voltage, depth of laying, route and length, crossings with other services, location of any joints and position of ducts, with cross sectional arrangements.

The Contractor shall modify existing drawings to show the modifications. If suitable existing drawings are not available the Contractor shall provide drawings showing the modifications.

Record Drawings:

As part of the Works and before Taking Over, the Contractor shall provide and forward to the Engineer, a complete set of drawings comprising two original size permanent transparency and six paper prints, of all final drawings of the Works as installed, schematic wiring diagrams, panel wiring and connection diagrams, cable route diagrams and schedules and any other special drawings which have been prepared during the course of the Contract. The Contractor will also provide drawings on computer disk in AUTO CAD (Latest Version), for the modification and printing of

drawings. Also all drawings have to converted in to PDF files and stored in the Engineers workstation.

D. Training Plan and Manuals:

As part of the Works and before beginning training, the Contractor shall submit to the Engineer, 6 copies of complete operating and maintenance instructions for the system, referring specifically to the Plant. The documents will also be presented on computer disk in Microsoft Office 2003/2007 Word or latest version available for Windows software format. Each copy of the instructions shall be contained in a substantial binder. These manuals shall include but not be limited to the following information:

a. Detailed descriptions of the Plant operation and control scheme.

b. Manufacturer's original operation and maintenance procedures.

c. Complete parts list for all items of the Plant.

d. Recommended spare parts list.

e. Detailed maintenance instructions for all items as necessary to maintain the items in good working order, including all step-by-step procedures for troubleshooting and fault correction.

f. Configuration of data base, reports, logs and screen displays.

g. Data communication interface standards and protocols.

h. FBD and control loop flow diagrams.

i. Programme user instruction for all software

j. The system shall provide on line, complete user documentation, including examples of how to operate the various modules within the system. The documentation must be in electronic format, HTML based with the ability to search for topics by keyword or search for specific text.

21.8.5 Site Conditions

A. Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non-condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

B. EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

C. Generated Interference. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1or equivalent Indian Standard for noise emissions.

D. Coordination. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are

specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.

E. Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

21.8.6 Commissioning

A. The Contractor, the Engineer and any appropriate personnel of the Employer shall be present when the equipment or installation is tested & commissioned.

B. Commissioning shall include operating the equipment in a variety of modes and sequences to prove its satisfactory operation, prior to commencing the formal site inspection and testing.

21.9 Automation System Components

21.9.1 Programmable Logic Controllers

Screening Plant

Programmable Logic Controllers (PLC) shall be provided in a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules of the same series of the CPU and communication interface.

PLC shall have the following attributes as a Hot-Standby Controller.

- Carry out sequential logic implementation for operations of plant;
- Carry out computation and interfacing for data acquisition, data storage and retrieval;
- It shall accept downloaded program from a programmer;
- It shall have different functional modules to perform the desired functions;
- It shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible (OPC should be a built in feature of the software and hardware. No external software patch or hardware module is allowed) and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be ‘off’).

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions. Refer approved vendor list.

PLC System (Panel) should be housed in a dust free environment.

21.9.2 PLC Coding

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software.

The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. **FBD shall be used for coding of PLC's**.

The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

21.9.3 Functional design specification for PLC

The Contractor shall submit a complete functional design specification (FDS) for approval by the Engineer within 3 months of the award of the contract. Separate FDS shall be submitted for plant under this contract. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item.

The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Employer's Representative before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

21.9.4 Drawings and Schedules

The contractor has to submit the following set of drawings

(a) Process and instrumentation diagram

(b) General arrangement drawings of field-mounted instruments showing Installation details.

(c) General arrangement drawings of instrument and control panels, fully dimensioned In plan and elevation views, showing foundation and fixing Details, access doors, clearances, cable-entry positions, weight and lifting arrangement.

(d) Layout drawings of panel fascias showing instruments, controls and details of all labels.

(e) Layout drawings of panel interior showing equipment, terminal blocks and Cable ways.

(f) Annunciator arrangement and engraving details.

(g) Internal circuit and wiring diagrams for instrument and control panels.

(h) Schematic control diagrams.

(i) Instrument loop diagrams.

(j) Instrument wiring and piping diagrams.

(k) Interconnection wiring diagrams.

(l) Cable block diagrams, drawings and schedules.

(m) Instrument system and panel power distribution diagrams.

(n) Programmable-device functional design specifications which shall include Hardware details, logic flow charts, ladder diagrams and program listings.

(o) Schedules of inputs to and outputs from programmable controllers and Telemetry outstations.

(p) Labelling schedules.

(q) Comprehensive testing schedules for all off-site, on-site, pre-commissioning, Commissioning tests and take-over tests.

21.10 Quality Assurance/Quality Control (QA/QC)

QA/QVC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for PLC systems. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Insulation and High Potential Testing;
- Packaging and Shipping;
- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;
- All other documentation required by applicable codes and standards.

22 LIGHTING AND SURVEILLANCE SYSTEM

22.1 Lighting

The work involves supply, installation and commissioning of various types of LED lighting fixtures on poles, in floor or as specified complete with allied works to achieve optimum lighting throughout the pathways, walkways, connecting bridges, utility / service areas and specified adjoining areas. Refer to beautification drawings in Volume 5.

The Works include, but are not limited to:

- area lighting poles, lighting fixtures, cabling network, lighting control panels and allied works complete with earthing system;
- cabling network in HDPE pipes complete with inspection chambers and covers; and
- outdoor lighting, power distribution control panels and allied works.

The lighting system specified herein shall conform with the specifications, in addition to the description given in the respective items of the BOQ (if there is one), whether explicitly specified or not. In case of contradiction between specifications and the BOQ, the most stringent condition shall apply. The scope of work includes the supply, installation, testing and commissioning of the following LED luminaries complete with LED chip, housing, heat sink and electronic driver, all types of mounting arrangement, and all fixing accessories. The minimum lumen output of the LED light shall not be less than 80 Ln/W. The performance of the fixture shall be guaranteed for the life time of the fixture.

22.1.1 Lighting Pole Fixture:

Hot dip galvanised (100 x 100 mm Class C pole) with inbuilt IP67, 55W LED light fixture/s complete with reflector system encased in clear UV protected polycarbonate diffuser for distribution of light. The fixture shall be provided with a suitable driver and other required accessories. The pole shall have epoxy zinc rich penetrating primer finished with polyester powder coating of approved specification with an IP 54 integral control gear box complete with rust free zinc cast lock and key, sealed with a silicon rubber gasket, GI chain link, etc. provided to interlink the pole and control box cover. The control gear tray shall be prewired with MCB connector and loop in / loop out terminal block suitable for the cable selected. The pole shall be mounted on a surface mounting base plate with hot dip GI. foundation bolts and nuts. Base plate size and thickness shall be suitable for a minimum of wind speed of 55km/hr and pole load.

22.2 Surveillance Works

The surveillance works include but are not limited to, the following:

- IP CCTV and allied accessories;
- power and data cable network;
- network switches;
- monitoring and recording equipment for CCTV (network video recorder) and software;
- electrical and allied works;
- earthing;
- enclosures for equipment; and

- standby power with UPS & power distribution.

22.2.1 Details of Surveillance System and Allied Works

The Works include, but are not limited to:

- Design, supply, installation, testing and commissioning of CCTV cameras, surveillance system and allied works (refer to Contract Drawings in Volume 2D).
- The control room for the system shall be located at the WSP Site, and all civil works necessary for the control room shall be provided;
- The Contractor shall survey the Site to identify strategic locations to place appropriate CCTV cameras to achieve maximum coverage of the public circulation area and other locations which require monitoring;
- The cameras shall sense objects even in low illumination. These cameras shall be connected to the Network Video Recorder (NVR);
- The NVR unit shall direct recording of all cameras in real time. The resolution of the picture shall be as provided in the Specification. The operator shall have the facility to choose any given camera for viewing on the monitor. Each image recording shall be recorded with the camera number, title, time, date and recording speed visible on the screen at all times;
- Housing for outdoor cameras / lens shall be environmental, weather proof, IP66 rated, vandal proof and complete with sun shield;
- The cable for the CCTV shall be laid in the ground or in DWC pipe with the required excavation support, and the diameter of DWC type HDPE pipe shall be as specified;
- The Contractor shall provide comprehensive hands-on training to at least 4 personnel for the operation, preventive maintenance, recording and retrieval of CCTV recordings, and operating system of the installed CCTV surveillance system free of cost. The supplier shall provide a simplified description of operating systems, playback, downloading images to a local PC, etc., for the CCTV system as approved by the Employer's Representative;
- The Contractor shall resolve any complaints regarding the CCTV surveillance system within 24 hours;
- The Contractor shall take all precautions to prevent any damage caused by rain lightning, wind, storm, floods, tornado, earth quakes, or other natural calamities during execution of the work. The Contractor shall make good any such damages at his own cost;
- The Contractor shall ensure that the cameras, hardware and software systems will be suitable for all weather conditions;
- The cameras shall be robustly manufactured to withstand wind, rainfall, hailstorm and other inclement weather conditions;
- The Contractor shall remove any debris from the Site on the same day at his own cost and cleaning of the Site shall be undertaken on a daily basis. No assistance for cleaning work shall be provided by the Employer;
- The proposed CCTV surveillance system shall have a recorded data backup capacity for a minimum period of one month (31 days);
- In planning and execution, the Contractor shall take into account the electrification of the units considering 1.1KV grade stranded copper conductor PVC insulated FRLS wires/cables in concealed B grade GI conduit of the required size;

- Planning, design, supply, installation testing and commissioning of the electrification work including camera, switch, equipment power supply, and earthing as proposed for the pole and control room shall be as per the approved architectural and landscape plans;
- Cabling for the pole shall be through 1.1 KV grade XLPE insulated standard armoured cables laid in buried HDPE pipe;
- The colour and shape of the pole shall be as approved by the Employer's Representative;
- Planning and installation of control room ventilation shall be in accordance with NBC requirements; and
- Any other surveillance systems work required for successful and safe installation shall be as per the specification and approval from the Employer's Representative.

The Contractor's scope of work shall also include but not be limited to:

- Detailed design of the surveillance systems including any requirements that are not specified herein but are required for successful operation of the system;
- Supply & installation of the equipment, devices and components and all other accessories required for the complete functioning of the system/ installation;
- Testing, commissioning, verification and validation of the system;
- Selection of equipment to meet the specification and performance criteria with supporting calculations; and
- Co-ordination with all other services and contractors for any interface requirements.

22.3 Technical Specifications

The base technical specifications, in accordance with which the entire work described hereinafter, shall be constructed and completed by the Contractor, comprises the following. However, the Contractor is free to offer any system provided he can demonstrate a more enhanced specification as well as the advantages of the system within the quoted offer. The work shall be completed as per the approved specification from the Employer's Representative.

Part-II: Additional Technical Specifications

The technical specifications for the items which are not covered in the Employer's (MCGM) Schedule of Rates / Specification are separately provided as additional technical specifications under respective heads in the subsequent sections.

IP Indoor Fixed Dome Camera

1)	Pick-up device	:	1/3" CCD with integrated 3.5/3/ 2.1/6 mm lens for wide angle view format, interline transfer, CCD image sensor
2)	Horizontal resolution	:	470TVL
3)	Voltage range	:	12VDC / 24VAC
4)	Sensitivity	:	89.9% scene reflection and using an f/2 lens(50 IRE)
	• (Usable Picture)	:	4.5lx (0.45 fc)
	• (Full Picture)	:	22 lx (2.2fc)
5)	Power	:	2 Watts
6)	Signal to noise ratio	:	>48dB
7)	Video Output	:	1.0 Vpp, 75 ohm

8)	Synchronisation	:	Line lock, with phase adjust (0-330 degrees)
9)	Gain	:	20dB
10)	Aperture correction	:	Horizontal & Vertical
11)	Back Light Compensation	:	Internally selectable On/Off
12)	Lens	:	Fixed Iris Lens (2.1mm, 3mm, 6mm, f/2.0 integral lens)
13)	Electronic Shutter	:	(1/50) TO 1/100,000 sec
14)	Feature	:	
	• Sensitivity	:	• High
	• Resolution	:	• High
	• Technology	:	• Advanced digital signal process technology
	• Lens Type	:	• Auto detection of lens type with lens wizard
15)	Voltage	:	Accepts AC or DC voltages
16)	Line Lock Capability	:	The camera shall have line-lock capability when powered by AC that synchronizes the camera to the power line zero for roll-free vertical interval switching.
17)	Operating Temperature	:	10 °C to +45 °C
18)	Storage	:	-250 C to +700 C
19)	Humidity	:	0% to 93% relative, non-condensing
20)	EMC	:	CE immunity, CE emission Class B product Electrical Safety: UL.

Outdoor Fixed IP Camera

Camera Details

- Camera : 1.3MP IP, IR fixed bullet;
- Lens of camera : 4mm, M12;
- Image sensor : 1/3” progressive scan CMOS;
- Illumination min 0.01 Lux @F1.2, AGC ON, 0Lux with IR;
- Shutter time 1/25s (1/30s) ~ 1/100,000s;
- The angle of view of the camera shall be 69.4°;
- The camera shall have the property of IR cut filter with auto switch, digital WDR (Wide Dynamic Range), DNR (Digital Noise Reduction).

Compression Standards

- Video compression : H.264/M-JPEG;
- Bit rate : 32 Kbps ~ 16 Mbps;
- The camera shall be capable of providing dual streams.

Image

- Image resolution : 1280 × 960;
- The camera shall have configurable frame rate;
- The cameras shall have image settings like saturation, brightness, contrast, sharpness, exposure settings adjustable;
- The camera shall have the property of BLC (Backlight Compensation, zone configurable).

Network

- The camera shall generate alarm trigger on motion detection, trip wire, intrusion as well as video tamper;
- The camera shall be inter-operable with ONVIF, CGI, PSIA etc. protocols;

- The camera shall support TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP, SMTP, SNMP, 802.1X, QoS, IPv6 network protocols;
- The communication interface of the camera shall be 1 RJ45 10/100Mbps Ethernet.

General

- There shall be minimum 30 IR array LEDs in the camera;
- Camera range : Min.20-30m;
- Power : DC12V (+/-10%), max 10W;
- The camera shall have PoE support;
- The camera shall be IP66 proof, CE, FCC and RoHS certified.

Outdoor IP PTZ Camera

Camera Details

- Image sensor: 1/2.8'' progressive scan CMOS;
- TVL: 2 MP IR high speed dome camera;
- Minimum illumination of the camera: 0.05 Lux (F1.6, AGC ON), 0 Lux with IR; B/W: 0.01 Lux (F1.6, AGC ON), 0 Lux with IR;
- The camera shall have the property of auto white balance (auto / manual / ATW / indoor / outdoor / daylight lamp / sodium lamp);
- S/N ratio: >= 50dB;
- The camera shall have property of digital WDR, 3D DNR;
- Automatic electronic shutter speed:1 ~ 1/10,000s;
- The camera shall have IR cut filter;
- Optical zoom: 30×;
- The camera shall have the property of backlight compensation and highlight compensation;
- The camera shall have 2 privacy masks programmable;
- Focus mode of camera shall be auto / semi-auto / manual;
- The camera shall support G.711u/G.711a/G.726/MP2L2 audio compression.

Lens

- Lens size:4.3 ~ 129mm;
- Zoom speed: max 3s (optical wide-tele);
- Horizontal view angle of the camera: 65.1° ~ 2.34°;
- Aperture range: F1.6 ~ F5.0.

Pan and Tilt

- Preset positions: 256 Nos.
- The pan range: 360˚
- The tilt range: -15° ~ 90°

Infrared

- The IR camera range: min 120m;
- IR array LEDs: 6No.

Local Video & Audio

- The camera shall have 1 Mic in/line in interface with line input: 2 ~ 2.4V[p-p] and output impedance: 1KΩ, ±10%;
- The camera shall have 1 audio output interface with line level impedance: 600Ω.

Network

- The camera shall have 1 RJ45 10/100/1000Mbps ethernet interface;
- The camera shall follow these network protocols: IPv4/IPv6, HTTP, HTTPS, 802.1x, QoS, FTP, SMTP, UPnP, SNMP, DNS, DDNS, NTP, RTSP, RTP,TCP, UDP, IGMP, ICMP, DHCP, PPPoE;
- The camera shall be capable of 6 camera simultaneous live view;
- The camera shall be capable of configuring dual streams;
- The camera shall have 3 user levels: Administrator, Operator and User.

Integration

- The camera shall have authentication ID and PW user, MAC address host authentication;
- The camera shall have IP address filtering, an open-ended API;
- The camera shall support various protocols such as ONVIF, CGI, PSIA, etc.

General

- The power source used in the camera shall be 24VAC;
- The video output of the camera shall be 1Vpp, 75Ω;
- The power consumption: max 30 W;
- Ingress protection: min. IP66;
- The camera shall have TVS 4,000V lightning protection;
- The camera shall have surge protection, voltage transient protection;
- The camera shall have 1 BNC monitor output, SD card slot up to 128GB;
- Signal system of the camera shall be PAL/NTSC.

LED Commercial Display

The video output from the NVR/server shall be viewed through a dedicated LED monitor provided for the CCTV system. There shall be DVD-R/W for memory back–up. A DVD library shall be maintained for taking the back-up of recorded video. The recorded DVD can be played back in any location with the supported media player.

• Monitor	:	Minimum 48", High Definition LED Monitor (4K)
• Display	:	Resolution Full HD 1920X1080 pixels
• Backlight Module	:	Dynamic Edge LED
• Video	:	Signal 480/60i, 480/60p,1080/60i, 1080/50p (HDMI)
• MPEG noise reduction	:	Yes
• Viewing Angle (H/V)	:	BTA
• Response Time	:	8 ms (gray to gray, avg.)
• Computer Input	:	HDMI/Audio in, USB 2.0, Ethernet connection, HD15 PC Input
• Video Color System	:	NTSC (3.58 MHz, 4.43 MHz), PAL
• Power Supply	:	100V to 240 V AC, 50/60 Hz
• Power Consumption	:	Max.30W
• Panel Life	:	Min. 45,000 hours

Network Video Recorder

The network video recorder (CCTV server) shall be installed in the control room to allow the storage of time-lapse and time stamped digital video images from all cameras. Video images shall be stored on a RAID-1 hard-drive array unit with full watermarking and guarantees against tampered images.

The NVR / camera server(s) manage all camera operations during normal operation of the system. They shall be capable of supporting a large amount of disk space for online video storage and access to high capacity archiving mechanisms for the transfer of stored video to off-line media.

- The NVR shall support recording of MPEG-4 or a better source simultaneously. It shall support recording of video and audio. The NVR shall support triplex applications, recording, replay, and backup, simultaneously. It shall be compatible with Windows OS for the highest performance and reliability. The NVR shall operate on open architecture and require no proprietary hardware;
- Recorders shall be able to store video on Commercial Off-The-Shelf (COTS) equipment using hard drives as storage medium. They shall capture video from cameras through edge devices, and store it on their internal hard drives;
- The NVR shall provide network time server function to ensure synchronisation of the video servers and the recordings. The only signal connection to NVR shall be the network connection so that the NVR can be placed at any location which has network access;
- The NVR shall provide a status of available recording capacity as well as indication of the remaining possible recording time;
- Recorders shall have inherent logic so that if one fails, all assigned cameras are automatically transferred to another recorder or group of designated recorders;
- The distributed architecture must also allow for the recorder to operate in a standalone mode without interrupting the recorder function when the master server is not available;
- It shall be possible to search for recordings in the NVR by camera, date, and time. If date and time are specified, playback shall commence from that date and time. It shall be possible to playback more cameras simultaneously;
- The NVR shall be able to export sections of recordings to a separate windows folder, which can then be written to CVD ROM, DVD ROM or tape media to be played back at a location not connected to the NVR network. The export process shall make available a player application, which can be provided with the exported video.
- It shall be capable of all the functions listed below:
  - Video Management Software (VMS) recorder services;
  - recorder fail-over services;
  - recorder standalone mode for independent Recording function;
  - Video Management Software (VMS) Control Centre application;
  - Microsoft Operations Manager agent (MOM 2005);
  - all system camera video recording and indexing;
  - intelligent video grooming;
  - video motion detection;
  - continuous and event recording; and
  - attached to external storage.

Technical Specifications for NVR

Video	Input	24 IP Channels
	Compression	H.264,MPEG-4, Motion JPEG
	Output	1 VGA, 2 HDMI
Audio	Compression	G.711, G.726, AAC, PCM
	Input	1 Channel, RCA Port
	Output	1 Channel, RCA Port
Display	Split	Sequential
	Privacy Masking	As Per Camera Support

	Digital Zoom on Live	Yes
	Freeze View	Yes
	Snapshot	Yes
	Live View	Directly through NVR
	Multiple Camera Viewing	Through Cascading
	OSD	Channel Number and Name, Status, Video Loss, Motion Detection, Recording, View Tamper, Blocked View and Disabled Channel (As per camera support)
	Frame Rate	25fps @ D1 Per Channel
	Image Resolution	As Per Camera Support
	Pre-Record	Up to 30 Sec
	Post-Record	10-300 Sec
Recording	Recording Modes	Manual, Continuous, Scheduled, Alarm
	Auto Recycling Recording	Alert & Stop Recording Overwrite, Clean-up (Specified Percentage when HDD Full, Backed up Files, Older than Number of Days)
	Synchronous Playback	4 (minimum) or as required.
	Playback Modes	Fast Reverse, Fast Forward, Slow Forward, Slow Reverse Different Speed Control, Next-Previous Frame, smart Search, Back up
Playback & Backup	Backup	Manual Backup over USB,1-Touch Manual Backup, Scheduled Backup over USB, NAS/FTP
	Network Functions	Manual Backup over USB,1-Touch Manual Backup, Scheduled Backup over USB, NAS/FTP
	Remote Operation	Monitor, PTZ Control, Playback, System Setting, File Download, Log Information, Upgrade
	Trigger Events	Motion Detection, System Alarm Detection, Storage Alert, Disk Volume Full, Disk Error, Network Disconnected, Tampering, Connection Failure
Video Detection & Alarm	Actions	Recording on Selected Channel, Upload Images on FTP/Email server, Email Notification, TCP Notification, Recall PTZ Preset Position, Turn On/Off Alarm Outputs, Buzzer Notification, SMS Notification
	Motion Detection	Camera Dependent
	Connection Failure	Camera Dependent
	View Tamper	Camera Dependent
HDD	Hard disk Interface	Min. 2 SATA Port
	Hard disk Capacity	Min 4 TB Each Port or Better

	HDD Management	HDD Grouping & Quota, HDD hibernation & Faulty alarm, Back UP, Redundant for Each Channel or all Channel
	HDD Alarm Trigger	Disk Full, No Disk, Disk R/W Error, Redundancy Error
Interfaces	Network Protocol	TCP(IPv4,IPv6)/UDP/MULTICAST/UPNP/HTTP/DHCP/PPPoE/DDNS /NTP/ HTTPS/NFS/ FTP/RTSP/SMTP/HTTPS/SADP, Alarm Server, Auto Search same OEM Camera Series IP Camera
	Communication Interface	2xGigabit RJ45 Ethernet Interface
	USB	4 Ports(1xMouse, 2xScheduled and Manual Backup)
	IR	Extended IR
RAID	Support	RAID1
Storage	SATA Interface	2 SATA Ports (4TB Per Port)
	Processor	High Performance Embedded Microprocessor
System	OS	Linux
	Control Mode	Mouse, IR Remote Control, CMS and Web Client
Power	Consumption	Less than 100W

Desktop control PC for Server Technical Requirement:

- 3rd generation Intel® Core i7-3370/3370S processor;
- Windows 7 Professional preloaded licensed operating system;
- 2 DIMM,8 GB (DDR3) RAM;
- HDD 1TB 5400 RPM storage hard drive;
- Intel® HD integrated graphics card;
- Integrated 10M/100M/1000M gigabit ethernet card;
- 2 Front USB 2.0 ports, 4 rear USB 2.0 (default 6 USB 2.0), additional two USB 2.0 from internal header ports;
- 1 VGA Slot, 1 DVI support multi-display slot;
- DVD-ROM/DVD Rambo;
- 320W 90% auto-sensing power supply unit; and
- 17" LED colour monitor, keyboard, optical mouse, complete with all accessories, wires & cords with various interfaces as required.

Video Management Software (VMS)

- VMS architecture to support Windows OS with client side access with Windows OS;
- VMS shall also support SQL for database management of entire system;
- VMS shall come with the following modules with licenses;
  - management server: will primarily be responsible for managing entire system;
  - recording server: will primarily be responsible for recording streams coming to server;
  - IVA server: will provide all the process related to video analytics;
  - admin client: will be a tool for administrative purposes to manage and configure the entire system;
  - smart client: will be used by the user/viewer to monitor the system;
  - media client: will be responsible to play the recorded file on system as a media player;

  - multi-monitor: will enable the connection of multiple monitors to a single server by using a graphics card;
  - mobile client: will enable camera views to be viewed on mobile Phones;
- VMS shall come with the following license modules for IVA, developed by the same company;
  - license plate recolonisation: identify, recognise, store and export the number plate details with black list and white list feature;
  - face detection: detect face in camera scene and record the face snapshot;
  - loitering: prevent present in defined area for more than defined time period;
  - missing object: alerts on object moving from defined area in a scene;
  - intrusion detection: identify any intrusion inside or outside the defined region in a scene;
  - trip-wire detection: identify on crossing any virtual line drawn in a camera scene from either direction;
  - no motion detection: identify any marked area where no motion is found for a defined time;
  - camera tempering :identify blocking of camera view;
  - parking management: prohibited parking, wrong way detection, unauthorised parking, improper parking detection, vehicle counting;
  - crowd management: people counting;
- VMS platform license shall not be bounded with server hardware; it must be easily transferred to another server without any dependency on OEM;
- Each VMS platform must be scalable to at least 50 cameras from its base platform;
- Scalable with 10,000 recording devices and 1,00,000 cameras with various platforms;
- No license for recording server module in VMS which is additionally connected to system as new expansion;
- Provision to connect 1,000 simultaneous users with defined roles and rights with additional licenses;
- Push technology for auto-connect cameras and devices to central system;
- Multi-stream support;
- Min. 400 camera groups: cameras and multi-screen mode for operation display can be programmed and called up by manual or sequenced operation;
- Scheduled backup for retrieval of important events camera wise;
- Multi-monitor application for simultaneous centralised monitoring (up to 8 displays);
- Simplified event based monitoring using e-maps with multiple layers; Alarm notification: a pop-up alarm message is displayed or SMS, email, email with notification, audio alert, video pop-up alert;
- Database level integration with time-attendance and access control solution;
- Health monitoring facility for all connected devices, camera and server; also graphical representation of storage;
- 2-level data achieving for data backup to increase storage days with available storage space;
- 2-way audio support for cameras to connect microphone / speakers with the systems;
- Report generation of all the available IVA with the system for selected event and time;
- Real-time event based clip export to secure extremely critical data;
- VMS shall provide API for integration with other software to get data like snapshot, video clip, and bookmark, manage recording, etc. at any instance from SAMAS;
- Support of all on vif 2.0 and above camera with 20+ brands available with model number to connect;
- Edge recording support on devices and cameras to protect loss of data;

- VMS shall comply with any conventional storage technology like IDE, SATA, E-SATA, SCSI, RAID, NAS, SAN;
- VMS shall watermark each and every frame of the video files with watermarks to authenticate the source of the video;
- The system shall support port forwarding, which shall allow clients from outside of a Network Address Translation (NAT) firewall to connect to the system without using a VPN;
- VMS shall provide options for export format type (AVI/JPEG), timestamp, frame rate (full/half), digital zoom export, and AVI CODEC. Video clip may be exported to desktop/CD/DVD or a specific file path. All audio associated with the video being exported shall automatically be included in the AVI export;
- VMS shall support at least 3 levels of users with various privileges to access the system functionality. Each category of users shall have selectable rights to perform various operations like camera add/delete, recording server add/delete, change camera settings, configure storage, control PTZ cameras, user management, etc.;
- The vital system health status like server failure, camera disconnection, storage full, etc. shall always be displayed at health status page in Smart Client; and
- Free IVA on playback of videos recorded. (intrusion, missing object, trip-wire, camera temper).

Network Switch:

All network switches provided shall be of managed switches so as to manage the system bandwidth and avoid any flooding of signals in either unicast or multicast mode of operation:

- Up to 48 wireless AP direct/indirect connections;
- Mixed wired/wireless connection from any port;
- Expandable to 4 peer switches;
- 802.3af power over ethernet simplifies AP installation; and
- Redundant power supply support maximises network uptime.

Each Ethernet Switch shall support:

- simple Network Management Protocol (SNMP);
- IEEE 802.1D bridging capability and loop detection;
- IEEE 802.1Q tagged VLANs;
- IEEE 802.1p traffic prioritization for multiple Quality of Service levels;
- IEEE 802.1w rapid spanning tree with fast link support;
- IEEE 802.3ad link aggregation support;
- IGMP snooping for IP Multicast support;
- Multicast network traffic; and
- Non-blocking configuration capable of simultaneous wire-speed switching across all ports.

Data Sheet Ethernet Switch		
1	Device Interfaces	24 10/100/1000BASE-T Gigabit Ports With
		Integrated 802.3af PoE
		16 fiber ports 4 Combo SFP Slots
		RS-232 Console Port
		2 Open Slots for Optional 10-Gigabit Module
2	Redundant Power Supply	Connector for Optional External
		Standard: 802.3af

Data Sheet Ethernet Switch		
3	Power over Ethernet	Per Port Output: min 20 W
		Total Output: 450 W
		Auto Disable If Port Current Over 350mA
4	Performance	Switch Capacity: 88Gbps
		Maximum Forwarding Rate: 65.47Mpps
		Switching Method: Store and Forward
		Packet Buffer Memory Size: 750KBytes
5	Flow Control	802.3x Standard in Full Duplex Mode
		Back Pressure in Half Duplex Mode
6	Optional 10-Gigabit Uplink Modules	1-Slot 10-Gigabit XFP Module (For Fiber Backbone Attachment)
		1-Port 10-Gigabit CX4 Module (For Switch Cascading)
7	Optional 10-Gigabit XFP Transceivers	Transceiver (10GBASE-SR Standard, Up to 300 m Multi-Mode Fiber Distance, 3.3/5V Operating Voltage)
		Transceiver (10GBASE-LR Standard, Up to 10 km Single-Mode Fiber Distance, 3.3/5V Operating Voltage)
		Transceiver (10GBASE-ER Standard, Up to 40 km Single-Mode Fiber. Distance, 3.3/5V Operating Voltage)
8	WLAN Management Capability	Up to 48 AP (Directly Connected and Indirectly Connected Through LAN Switch)
		Up to 2,048 Wireless Users (1,024 Tunneled Users, 2,048 Non-Tunneled Users)
9	Roaming	Fast Roaming
		Intra-Switch/Inter-Switch Roaming
		Intra-Subnet/Inter-Subnet Roaming
10	Access Control & Bandwidth Management	Up to 16 SSID per AP (8 SSID per RF Frequency Band)
		AP Load Balancing
11	AP Management	AP Auto-Discovery
		Remote AP Reboot
		AP Monitoring: List Managed AP, Rogue AP,
		Authentication Failed AP
		Client Monitoring: List Clients Associated with
		Each Managed AP
		Ad-hoc Clients Monitorings
		AP Authentication Supporting Local Database and
		External RADIUS Server
		Centralized RF/Security Policy Management
		Automatic AP RF Channel Adjustment
		Automatic AP Transmit Output Power Adjustment
12	WLAN Security	WPA Personal/Enterprise
		WPA2 Personal/Enterprise
		64/128/152-bit WEP Data Encryption

Data Sheet Ethernet Switch		
		Wireless Station and AP Monitoring on RF
		Channel, MAC Address, SSID, Time
		Rogue and Valid AP Classification Based on MAC Address
		Encryption Type Support: WEP, WPA, Dynamic
		WEP, TKIP, AES-CCMP, EAP-TLS, TTLS, PEAP-
		GTC, PEAP-MS-CHAPv2, EAP-FAST
13	L2 Features	MAC Address Table Size: 8K Entries
		IGMP Snooping: 1K Multicast Groups
		Spanning Tree:
		8021.D Spanning Tree
		802.1w Rapid Spanning Tree
		802.1s Multiple Spanning Tree
		802.3ad Link Aggregation:
		Up to 32 Groups
		Up to 8 Ports per Group
		802.1ab LLDP
		Port Mirroring:
		One-to-One Port Mirroring
		Many to One Port Mirroring
		Jumbo Frame Size: Up to 9KBytes
14	L3 Features	IPv4 Static Route
		Routing Table Size: Up to 128 Static Routes
		Floating Static Route
		VRRP
		Proxy ARP
15	VLAN	802.1Q VLAN Tagging
		VLAN Groups: Up to 3965
		802.1V
		Subnet-based VLAN
		MAC-based VLAN
		GVRP
		Double VLAN
16	Quality of Service	802.1p Priority Queues (Up to 8 Queues per Port)
		CoS Based on: Switch Port, VLAN, DSCP,
		TCP/UDP Port, TOS, Destination/Source MAC
		Address, Destination/Source IP Address
		Minimum Bandwidth Guarantee per Queue
		Traffic shaping per port

Data Sheet Ethernet Switch		
17	ACL (Access Control List)	ACL Based on: Switch Port, MAC Address, 802.1p
		Priority Queues, VLAN, Ethertype, DSCP, IP
		Address, Protocol Type, TCP/UDP Port
18	LAN Security	RADIUS Authentication for Management Access
		TACACS+ Authentication for Management Access
		SSH v1, v2
		SSL v3, TLS v1
		Port Security:
		20 MAC Addresses per Port
		Trap Violation Notification
		MAC filtering
		802.1x Port-Based Access Control
		Denial of Service Protection
		Broadcast Storm Control in Granularity of 1% of
		link speed
		Protected Port
		DHCP filtering
19	Management Methods	Web-Based GUI
		CLI
		Telnet Server: Up to 5 Sessions
		Telnet Client
		TFTP Client
		SNMP v1, v2c, v3
		Multiple Configuration Files
		RMON v1: 4 Groups (Statistics, History, Alarms, Events)
		BOOTP/DHCP Client
		DHCP Server
		SNTP
		SYSLOG
		Dual Images
20	ACL (Access Control List)	ACL Based on: Switch Port, MAC Address, 802.1p Priority Queues, VLAN, Ethertype, DSCP, IP Address, Protocol Type, TCP/UDP Port
21	Power	AC Input Power: 100 to240 VAC, 50/60 Hz
		Internal Universal Power Supply
		Power Consumption: 460 Watts (max. with all PoE ports in operation)

Data Sheet Ethernet Switch		
22	Certification	UL/cUL, CB
		FCC Class A
		ICES-003
		VCCI
		CE
		C-Tick